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Original Article

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Practices in a forest kindergarten: a case study

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Abstract

Forest kindergartens are an alternative early childhood education model in which most educational processes occur outdoors. This study examines the practices of forest kindergarten over an academic year in terms of curriculum, educational processes, stakeholder relationships, and assessment dimensions. The research was conducted as an instrumental case study, a qualitative research design, at a forest kindergarten in Hamburg, Germany. Two teachers and six parents participated in the study. Data were collected through interviews, participant observation, documents such as the curriculum used in the forest kindergarten, daily and weekly lesson plans, project outputs, and photographs. The data were analyzed in two stages using the MAXQDA Analytics Pro 2022 software. The study yielded various findings related to the aforementioned dimensions. Firstly, it was found that the curriculum was implemented in forest and open-air settings and included regularly scheduled annual activities. An examination of the educational process revealed that routine activities and projects were emphasized in daily routines and weekly schedules. Secondly, family involvement and collaboration with stakeholders were found to be important components of the forest kindergarten program. Finally, it was concluded that portfolios, annual assessments, and school readiness assessments were used for evaluation in the forest kindergarten.

Keywords

Early childhood education
Alternative education
Forest kindergarten
Curriculum
Educational process
Assessment

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Introduction

Forest kindergartens are recognized as an alternative model in early childhood education, originated in the 1960s in Scandinavian countries and later spread throughout Europe (Schäffer & Kistemann, 2012; Sobel, 2015). This approach is rooted in the ideas of influential thinkers such as Froebel, McMillan, and Isaacs, who regarded nature as the ideal learning environment (Cree & Robb, 2021). The philosophy of nature-based education emphasizes that children are innately connected to nature and should remain in interaction with it, viewing the child not as separate from nature but as part of it. It embraces the idea that "the child is nature," focusing on a holistic and naturalistic approach (Cutter-Mackenzie-Knowles et al., 2019; Eroğlu, 2022; Waite et al., 2015). Forest kindergartens aim to connect children with nature by offering developmentally oriented educational programs in outdoor learning environments (Larimore, 2016). It can be argued that the experiences children gain in their educational journey are closely linked to the educational philosophy adopted by the early childhood

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institution they attend. In line with the adopted educational philosophy, it can be expected that core elements such as the curriculum, educational processes, teaching methods, stakeholder relationships, and assessment in forest kindergartens differ from those in other educational approaches.

The *curriculum*, as the most fundamental component of education, must be structured and function to support all areas of the learner's development and stimulate their motivation to explore and investigate (Kostelnik et al., 2019). Therefore, when the learners are young children, it is essential that the curriculum be child-centered and developmentally appropriate. Forest kindergarten curricula are designed to support children's experiential learning, emphasize exploration, and are grounded in a place-based learning approach (MacEachren, 2013). At the same time, they are guided by a play-based educational philosophy. According to Knight (2013), additional essential characteristics of forest kindergartens comprise of unconventional learning environments, a reasonable level of safety, a system developed over time, qualified educators, daily rituals for starting and ending the day and educational activities, and the necessity of child-led learning processes. Together, these features establish the intended learning environment in forest kindergartens and influence the overall educational process.

The *educational process* serves as the means through which the curriculum is implemented for children. The educational process entails selecting methods, techniques, and activities tailored to achieving the curriculum's specified learning outcomes (Akyol, 2020). In forest kindergartens, education takes place outdoors for 70% to 100% of the day, except for extreme weather conditions. Activities must be initiated and led by the children themselves (Knight, 2013; Larimore, 2016; Sobel, 2015). Decisions regarding the educational process as well are made in collaboration with children and families (Amus, 2022). Through nature-based activities, children are offered opportunities to explore the forest environment using all their senses, gain in-depth knowledge about wildlife, and engage in various discovery experiences (Cree & Robb, 2021).

Another key component in education is the *relationship* between the family, teacher, and child. In early childhood education, the impact of these relationships on learning is a widely accepted reality across most educational approaches (Bronfenbrenner, 1992; Sucuoğlu & Bakkaloğlu, 2018). These relationships must be respectful, accepting, open, inclusive, and tolerant (Göle & Temel, 2015). Trust-based relationships between teachers, families, and children play a significant role in the education process in forest kindergartens. Teachers trust that children will follow forest rules, while children also trust their teachers (Knight, 2013). To support the child in all developmental areas, interactive, collaborative, and strong communication between teachers and parents is prioritized (Murphy, 2020). Interactive social relationships are reinforced through family involvement activities, establishing a strong connection between school and home (Cohen & Anders, 2019; Toran & Özgen, 2018). In forest kindergartens, parents may take part in organizing the learning environment or provide support for various activities (Amus, 2013). Partnerships with families are formed in various ways, such as participating in school activities and exchanging information about the child. Considering the characteristics of forest kindergartens, children are expected to play an active role in various dimensions of information sharing, including assessments. At the same time, collaboration between teachers and families is also expected.

The final component of education, *assessment*, according to McAfee and Leong (2020), is beneficial in identifying children's needs, planning an appropriate educational process, and strengthening collaboration with families. Although the assessment dimension varies depending on the official preschool curriculum of the country in which the school is located, in forest kindergartens, teachers are expected to observe children and provide support when needed (Cree & Robb, 2021). It has been found that in these early childhood education centers, children not only achieve the outcomes outlined in the preschool curriculum but often exceed them (Cornell Card, 2014). Considering how assessment is carried out in the unconventional learning environment of forest kindergartens, Boyer (2020) noted, based on his observations, that learning is documented through photographs. However, it has been observed that there is limited research in the literature regarding assessment methods in forest kindergartens.

Many studies examine the quality of preschool education and explain its components (Canbeldek & Işıkoğlu Erdoğan, 2016; McLachlan et al., 2018; Sabol & Pianta, 2012; Toran & Özgen, 2018). Forest kindergartens, which have different characteristics from traditional kindergartens, are expected to exhibit differences in educational components. In the literature, some studies address some of these components from the perspective of forest kindergartens. For example, while Kane and Kane (2011) and Kimic and Kundziewicz (2020) focused on the educational process, Sobel (2015) further discussed the curriculum. This study will identify the entire range of educational practices carried out in a forest kindergarten from the beginning to the end of a school year, determining how educational components are addressed in these schools. This is anticipated to enable educators and researchers in preschool education to view the topic holistically. The holistic perspective is expected to assist in making informed decisions regarding practices. Furthermore, it can be said that the research findings will help raise quality awareness among preschool educators in Turkey and will enrich the Turkish literature on nature-based education. In this context, the study aims to examine the practices of a forest kindergarten over a school year with a focus on the components of preschool education. To this end, the following questions have been addressed:

1. What are the characteristics of the curriculum implemented throughout the year in the forest kindergarten?
2. In what way is the daily educational process structured in the forest kindergarten?
3. In what manner do families participate in the educational process in the forest kindergarten?
4. What are the nature of the stakeholder relationships in the forest kindergarten?
5. What is the nature of the assessment dimension in the forest kindergarten?

Method

Research Design

This research is a qualitative study conducted as an instrumental case study. Case studies are a qualitative research approach in which the researcher examines one or several bounded cases in depth over time through multiple data sources such as observations, interviews, visual and audio-visual materials, documents, and reports, where cases and case-related themes are identified (Creswell, 2020). In instrumental case studies, the examined case is not the purpose but a tool. The main objective is to obtain detailed information about the research questions and develop an understanding of the research topic (Stake, 1995). In this research, the instrumental case study design was selected because the purpose is to gain in-depth knowledge about forest kindergartens by examining the selected kindergarten.

Participants

In this study, purposeful sampling was used to select the sample. According to Merriam (2018), sampling in case studies involves two stages. First, the case to be studied is identified. In this research, the case is forest kindergartens. In the second stage, a sample from this case must be selected. At this stage, the criteria Stake (1995) defined for instrumental case studies were considered. According to these criteria, the sample should be chosen based on its potential to help better understand the phenomenon in line with the research purpose, and it should also be accessible. This study was conducted at the forest kindergarten where one of the researchers worked in Hamburg for six months during the academic year of 2021-2022. Germany was chosen as the site of the study as it has a long-standing tradition of forest kindergartens and is considered one of the leading countries in this area (Bundesverband der Natur- und Waldkindergärten, 2021; Häfner, 2003).

The forest kindergarten where the study was conducted operates under a nature-based preschool. Image 1 shows the cabin used as the meeting point for the forest kindergarten. This small, single-room structure is located right at the entrance of a large forest and is used exclusively by the class involved in the study. Inside the cabin, there is a toilet and a small kitchen. Parents take their children to this cabin four mornings a week. On one day each week, the meeting point is a different facility

belonging to the same nature-based preschool, located approximately 2 kilometers away, where other classes are also present.

Image 1. Forest Kindergarten Cabin

The forest kindergarten selected for this study includes 21 children aged between 3 and 6 years and two teachers. The study included two teachers and six parents who voluntarily agreed to participate. One of the teachers is a 39-year-old male, while the other is a 37-year-old female. Both teachers have eight years of experience working in a forest kindergarten. In addition to their formal education, they reported attending trainings related to forest pedagogy. The parents are between the ages of 35 to 41, all are female, and hold at least a bachelor's degree. Participants were coded using the letters "T" for teachers and "P" for parents, followed by a participant number.

Data Collection Tools

In this study, the primary data collection tools identified by Marshall and Rossman (2016) —in-depth interviews, participant observation, documents, and photographs—were employed. Observations were documented using the "Daily Educational Activities Observation Form" developed for the study. The interview questions were prepared in English and reviewed by experts. The interview forms, designed to understand the functioning of the forest kindergarten, were examined by two experts—one with a doctoral degree in early childhood education and one in the English language. Based on their feedback, revisions were made to improve the clarity of the questions and ensure comprehensive coverage of the subject. The parent interview form consists of 13 questions, while the teacher interview form consists of 10. Example questions from the parent interview form contain: "*What is your role as a parent during the kindergarten adaptation process?", "Do you regularly receive information about what happens in the kindergarten?"* and *"Do you participate in kindergarten and/or class-related decisions as a parent?"* The teacher interview form includes questions such as: *"Can you describe the orientation procedures?", "Could you walk me through a typical school day?"* and *"How is children's development and learning assessed in the forest kindergarten?"*.

Photographs were used to obtain visual evidence in line with the research questions. Additionally, existing official documents used at the kindergarten were incorporated. These documents were the kindergarten's brochures, project outputs, the school's annual activity program, photo archives, parent communication forms, assessment tests, the preschool education curriculum "Hamburger Bildungsleitlinien Kita" (Behörde für Soziales, Familie, Gesundheit und Verbraucherschutz, 2012a), and the state education regulations for governing the operation of all

kindergartens, including forest kindergartens "Richtlinien für den Betrieb von Kindertageseinrichtungen" (Behörde für Soziales, Familie, Gesundheit und Verbraucherschutz, 2012b). Some of these documents were obtained from the administration office, while others were sourced from the official websites of relevant ministries or state authorities. Finally, anecdotal records were kept in a "Researcher's Notebook" throughout the study.

Data Collection Process

Before starting the data collection process, ethical committee approval for the research, permission from the school administration, and consent from participants via an English-language consent forms were obtained. The form provided detailed information about the research and measures taken to protect privacy. The data for the research were collected over 3 weeks, including 2 weeks of observation. The process began with observation. The forest kindergarten included in the study provides 6 hours of daily education. Observations were conducted to examine the daily educational activities that lasted for 10 days, with 6 hours each day totaling 60 hours. The observations were conducted every day of the week to determine whether routine activities were held on different days of the week over the two-week period. After the observation period, interviews were conducted within one week. With the participants' consent, the interviews were audio-recorded and lasted an average of 20 minutes. After gathering the responses, short follow-up interviews were held with some participants to clarify any unclear or incomplete aspects. During this process, the necessary documents for the research were also obtained, and various photographic evidence was collected in line with the research questions.

Data Analysis

In this research, data analysis was conducted in two stages—first and second cycle coding—using the MAXQDA Analytics Pro 2022 software. In the first cycle coding, holistic coding was made to divide the data into broad topics in light of the literature, followed by provisional coding, which is also a first cycle coding method, to provide further detail. In the second cycle, axial coding was employed. Axial coding aims to organize the data, which has been divided and fragmented, around the categories that emerged during the first coding cycle (Saldana, 2022). Following this process, the findings were grouped under five themes: Curriculum, educational process, family involvement, interaction with stakeholders, and assessment.

Validity and Reliability

In this qualitative study, validity and reliability measures were considered based on the criteria specified by experts (Yıldırım & Şimşek, 2018; Yin, 2018). Firstly, during the planning phase of the research, data collection tools were determined by using multiple sources of evidence. Data were collected using multiple tools to ensure validity, including interviews, observations, photographs, and documents. The participants and the educational institution involved in the study were selected through purposive sampling as a validity measure, as they were considered the group most likely to provide the best answers to the research questions.

During the data collection phase, the method of prolonged engagement was taken into account, and data were collected over three weeks, including ten days of observation. Additionally, as an employee of the kindergarten, the first author had established a certain level of relationship with all participants and spent an extended period in the field prior to the research. Since the data obtained from the interviews were collected in English, to prevent misunderstandings, the conversations were summarized after data collection and presented to the participants for their approval, and participant confirmation was obtained. Throughout the research process, expert review was utilized at various stages, such as developing data collection tools and naming specific codes and categories. In reporting the research, the method of detailed description was considered by including direct quotations.

Results

In this study, the forest kindergarten was examined over the course of one year, focusing on the components of preschool education. The findings are presented under five themes, as shown in Figure 1.

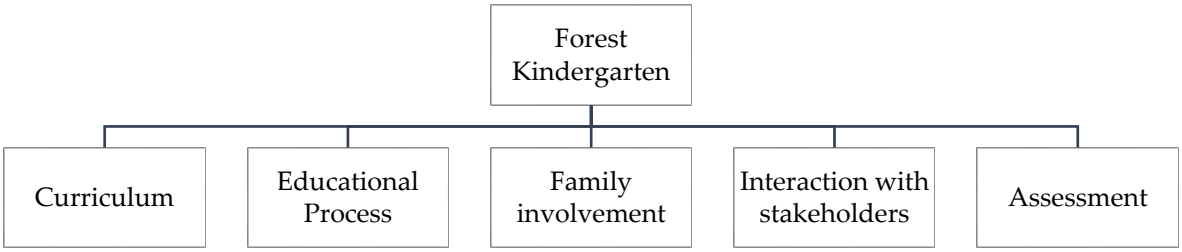

Figure 1. Hierarchical code-subcode model of the themes

1. Curriculum

According to the data obtained from documents and interviews, both traditional kindergartens and the forest kindergarten are required to implement the play- and project-based preschool education curriculum of the state of Hamburg. The curriculum comprises of learning outcomes from areas such as language, culture, social environment, health, physical development, mathematics, music, nature, art, and technology. However, since this research aims to reveal the specialized education and curriculum implemented in forest kindergartens, the state curriculum was not examined in detail.

Within this scope, the curriculum theme consists of two categories: Orientation and annual routine activities. The first category covers the details of the orientation process that initiates the academic year for the child. Subsequently, the routine activities implemented throughout the year in the kindergarten are addressed.

1.1. Orientation

The educational process for children begins with orientation. The subcategories of the orientation category are protocol, adaptation meeting, and responsibilities (see Figure 2).

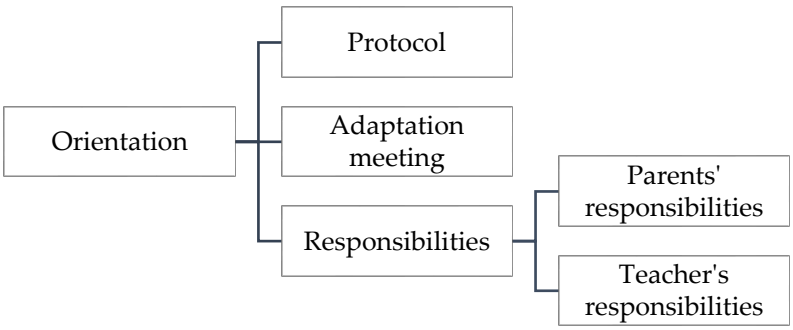

Figure 2. Hierarchical code-subcode model of Orientation

Protocol

Each family is given an appointment in a different week during the adaptation process. In this way, the attention given to the child during the adaptation process is not divided. There are two teachers in the classroom at the forest kindergarten, and one of these teachers is responsible for each child who begins the adaptation process. T2 summarizes the protocol related to the process as follows:

> *"The Berlin Model is used. The adaptation process is individually planned for each child and one parent. It basically lasts one week, and each day, the time spent is gradually extended until the child stays with the group for the entire day on their own. Under normal circumstances, the adaptation process is completed within two weeks."*

According to the school's information brochure, the Berlin Model consists of five stages. During the first three days, the child is accompanied by a parent. The first brief separation attempt takes place on the fourth day. The duration of separation is gradually extended over time. In the final stage, the parent can leave the child at school for the entire day, and the adaptation process is considered complete. T1 stated, "Sometimes a change of parent, a break, or an additional week is necessary. Due to the weather, we start the adaptation process between March and October…" indicating that orientation in the forest kindergarten is conducted between spring and autumn and that adjustments can be made according to the needs of the child.

Adaptation meeting

After the adaptation week, a meeting is held with the child's parents. P5 described this meeting as follows: *"…We had a parent-teacher meeting where we discussed with the educators how the adaptation process went and how they had evaluated our son up to that point."* There is a form used during the meeting, which contains questions about the adaptation process and the child's previous experiences.

Responsibilities

The final subcategory related to orientation is responsibilities. Interview and observation data revealed that parents and teachers have various responsibilities and roles during this process. The roles of parents include preparing the child, being present in the environment, providing reassurance, and answering the teachers' questions. Parents talk to the child before the adaptation process begins and explain what to expect. In the first days of the process, families are required to accompany the children but remain in the background without actively participating. The following is a quotation from the researcher's notebook related to the code of being present in the environment:

> *"Today was also an orientation day for a child. The mother was at the school all day but stayed 2-3 meters away from the children. The child joined the morning circle with the group and then participated in the playtime in the forest."*

P1 emphasized that another parent's responsibility is to provide reassurance to the child, stating, "*In fact, I can say that my main task was to give the child a sense of security simply by being there.*" Finally, during this process, parents are also expected to answer the teachers' questions about the child, which are aimed at getting to know the child better.

The responsibilities of teachers during orientation involved preparing the parents, creating a safe environment, providing reassurance, building a bond with the child, adapting to the child's rhythm, teaching the rules, facilitating communication with peers, and enabling parents to experience the process. T1 listed the actions taken to prepare parents and pointed out an aspect of the orientation process that they consider important:

> *"Before the child starts on the first day, we inform the parents and offer advice. We provide brochures and sometimes have a final phone call to answer any last questions... Most importantly, we create a safe and consistent environment."*

Participant P6 emphasized that the role of teachers in this process is vital and that stakeholders must trust each other, stating: "This is very important! There must be trust in teachers from both sides, that is, from the child and the parents." Examination of the interview data revealed that teachers use the adaptation process to build a bond with the child and expect the child to set the pace during this process. P1 highlighted this by stating: "…According to our experience, it is better if educators do not approach the child too actively but instead allow the child to set the pace when communicating." Another responsibility of teachers during the adaptation process is teaching the forest kindergarten rules to the child and facilitating the child's interaction with other children in the class. The final code, enabling parents to experience the process, was expressed by P5 as follows:

> *"Parents are also allowed to experience most aspects of daily life during this adaptation period so that they can gain a good perspective on the activities, risks, people, and environments with which the children are in daily contact."*

1.2. Annual routine activities

The annual activities routinely conducted in the forest kindergarten have been identified. These activities can be seen in Figure 3.

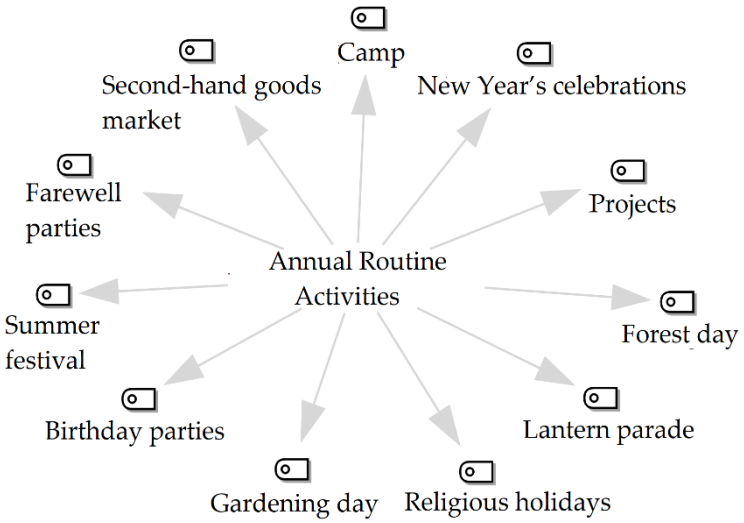

Figure 3. Code-subcode model for Annual Routine Activities

Projects are at the forefront of routine activities. Projects begin with a poster followed by various activities. For each project, a folder is created to store evidence related to the activities and activity plans. Projects are divided into class projects and school projects. School projects are carried out with the participation of the entire school, and the teachers at the school determine the topic. When examining the school's annual program, it is observed that a school project is conducted once every year. Teacher T1 explained how decisions regarding class projects are made as follows: "*We collect the children's ideas and write them down, and then we vote on these ideas*." It was also observed that teachers and children make joint decisions in cooperation when planning the activities to be carried out within the project's scope. Additionally, T1 shared details about the most recent project:

> *"Most recently, we carried out a construction project. Within this project's scope, we engaged in activities such as building tents, making houses and feeding stations for birds, and constructing a play kitchen. In addition, we created a temporary learning center and placed construction toys and books in this center."*

The construction project conducted during the observation period was decided together with the children and teachers during a morning circle. It was discussed that, if possible, children could bring books, toys, or tools related to the topic from home. One day after the project was decided, a poster was prepared using crayons, parents were informed, and support was obtained from the school administration to provide materials. Some of the materials used in the project can be seen in Images 2 and 3.

Image 2. Tools brought for the project

Image 3. Books and other materials

The construction activities continued in two dimensions, as shown in Image 4, and then in three dimensions, as shown in Image 5. The teachers decided some of the activities to be carried out within the scope of the project, while others were decided by the children.

Image 4. Two-dimensional building activity

Image 5. Three-dimensional building activity

The project lasted for two weeks, during which time a variety of activities were carried out, such as cutting branches in the garden using a saw, building structures with the branches, taking a field trip to a nearby construction site, learning new songs, and conducting various mathematics activities by examining buildings of different heights. Moreover, the play kitchen area shown in Image 6 was constructed and placed in the garden of the forest cabin with the participation of two parents.

Image 6. The play kitchen created within the scope of the project

Other routine activities include birthday parties, farewell parties for graduating children, New Year's celebrations, and religious holidays. Preparations for one of the religious holidays can be seen in Image 7. There are also routine activities that involve family participation. These activities are forest day, gardening day, camping, summer festival, lantern parade, and second-hand goods market.

Image 7. Decorations made outside the cabin for the Christmas party

2. Educational Process

The educational process consists of two subcategories: daily routine and weekly schedule.

2.1. Daily routine

The school provides education for approximately 6 hours a day, between 8:00 and 13:00 or between 8:00 and 14:00. Table 1 shows the general outline of the daily educational routine.

Table 1. Daily Routine

Activity	**Approximate timeline**
Drop-off time	08.00
Morning circle	08.30- 09.30
Breakfast and walk	
Free play	09.45
Return from the forest	11.30
Lunch	12.00
Free play around the cabin	12.30
Pick-up time	13.00 or 14.00

Except for Thursdays, each day begins at the cabin at the forest entrance. Details regarding the activities carried out upon arrival at school, as recorded in the observation forms, are as follows:

> *"T1 and the intern arrived at the cabin before eight o'clock. The first child arrived around 8:15. Until then, T1 checked the area and began preparations. He turned on the lights. The intern swept the area in front of the cabin. T1 brought the sitting cushions outside to the front of the cabin and took out the attendance list. The teacher greeted the child and the family when the first child arrived. The children continued to arrive one by one, and as they arrived, T1 marked the attendance list. The children who arrived went to play at the back of the cabin."*

After all the children arrive, around 9:00, the teacher rings a bell and calls the children to the front of the cabin for the morning circle, which serves as a starting ritual. The circle area is shown in Image 7. The activities in the circle are the same every day. The morning circle starts with a conversation, feelings are discussed, then one of the children counts the number of present children as a simple math exercise, and a song chosen by the children is sung. The place to be visited in the forest that day is determined by a vote in which teachers and children participate, and the circle ends. In the group, everyone, including the teachers, has one vote. The observation forms include an anecdote about the process of determining the place to visit:

> *"…The teacher asked, 'Where shall we play today?' She selected three children who raised their hands, and three different ideas were suggested. A separate vote was held for each of these three places. The results were 5, 7, and 12. They discussed which number was greater, and the option that received 12 votes won. In this way, the circle ended."*

In the daily routine, breakfast and a walk to the designated area take place after the circle. During the observations, breakfast was held in front of the cabin, which served as the meeting point on two occasions, while on the remaining days, the group went to the selected area with their lunchboxes and had breakfast there. All areas designated for play in the forest are approximately 15-20 minutes away from the cabin. After breakfast, free play time begins. An image taken during free play time in one of the areas visited in the forest can be seen in Image 8.

Image 8. Free play time in the forest

No planned educational activities are conducted during free play time in the forest. During the observation period, except for one day when cutting tools (such as peelers, knives, and protective gloves) were brought at the children's request, no materials were taken to the forest on other days. However, it was observed that teachers initiated various play activities or created play areas using materials found in the environment. For example, on one observation day, one of the teachers organized a mushroom-hunting activity with a few interested children; this activity emerged because a mushroom was found in the area. Similarly, the tent shown in Image 8 was built by the teacher and children using branches found in the surroundings on another day. According to the observations, children spent most of their free play time in the forest, engaging in risky play such as jumping, climbing, and running, as well as pretend play or exploring the area. During this process, it was observed that some of the games were construction-themed and influenced by the ongoing project.

On one of the observed days, the children wanted to spend the entire day around the cabin at the forest's entrance. In this case, they went for a walk in the forest and then returned to the cabin. An image taken during this walk can be seen in Image 9.

Image 9. A morning walk

Return from the forest takes place around 11:30 for lunch preparations. At noon, lunch is delivered from the affiliated nature-based kindergarten. Lunch is free of charge. After lunch, there is another playtime. During the observations, on four days, teachers conducted small group activities around the cabin during playtime. T2 stated, "*If there is an ongoing project or a special celebration, related activities are also carried out during the day*." According to the observation records, the small group activities conducted during this period were related to the newly started project. On other days, this period was spent in free play. Additionally, on one observation day, a child and a teacher carried out an individual activity inside the cabin in a quiet environment. This activity was aimed at assessing the child. This topic is explained in more detail in the assessment section. An image taken during playtime around the cabin can be seen in Image 10.

Image 10. Free play time around the cabin

Parents come to pick up their children between 13:00 and 14:00. While some children attend school for only 5 hours a day, for those who stay for 6 hours, the school day ends at 14:00. The daily routine of the four days spent in the forest at the forest kindergarten is as described above. However, for example, there are differences in this routine for children near the age to start primary school. On Tuesdays, these children enter the cabin and participate in the "bridge year" lessons, which are explained in detail in the next section, for one hour. The routine for Thursdays, when the children do not meet in the forest, is described in the next section as the day spent in the kindergarten building.

2.2. Weekly schedule

The weekly schedule comprises codes of the day at the kindergarten, yoga classes, field trips, and bridge year lessons. Most of the activities listed in the weekly schedule take place on Thursdays, designated as the kindergarten day. An annual fee of €50 is charged to families to cover all in-school activities and organizational adjustments within this subcategory, including yoga classes and field trips. However, parents with low incomes are not expected to make this payment. Bridge year lessons are offered free of charge.

The weekly schedule includes biweekly yoga sessions attended by the entire class. Additionally, a visit was made to a nearby construction site as part of an ongoing project observed during the study. Teacher T1 provided an explanation regarding the field trips in general as well as those conducted recently:

> *" For field trips to places such as museums and theaters, it is necessary to purchase tickets, inform parents, and notify both the kitchen and the kindergarten administration. Additionally, the public transportation schedule must be checked in advance. The field trips I recall include: A winter theater performance, children's gardens, an open-air museum village, the Elbe River, a fire station, and the public library…"*

Aside from additional activities such as yoga classes, field trips, and bridge year lessons, the daily routine at the kindergarten building follows a similar sequence to the one in the forest, primarily consisting of free outdoor play. A key difference is that there are no walks in the forest, and the time for free outdoor play is spent in the kindergarten's garden (Image 11). Children only go inside the building to have lunch, meet other needs, or participate in supplementary programs such as yoga.

Image 11. The kindergarten's backyard

According to the information brochure provided to parents at the school in Hamburg, when children turn 5 years old, families must make a decision. The child may attend a kindergarten class affiliated with a primary school one year before starting school or continue attending their current

kindergarten and participate in the primary school preparation classes. This year, when the child transitions from kindergarten to primary school, is called the bridge year. T2 explains the bridge year as *"The year in which the child participates in preschool lessons at kindergarten. These lessons are held on Tuesdays and Thursdays."* The study group consists of a mixed-age class of children aged 3 to 6. While the daily routine for the other children in the group continues as usual, the five older children participate in the bridge year lessons. When examining the weekly schedule for the bridge year, it can be seen that Tuesday mornings are dedicated to preschool lessons focusing on areas such as language and mathematics or field trips explicitly planned for this group of children. Thursday mornings are for music lessons, while Thursday afternoons are again allocated for preschool lessons. The bridge year lessons are conducted by a teacher different from the class teachers, and this teacher comes to the cabin on Tuesdays. Since the entire class is at the kindergarten building on Thursdays, the five children go to a classroom for their activities. Image 12 shows a letter activity conducted as part of the literacy preparation in the bridge year lessons.

Image 12. A letter knowledge activity conducted as part of the bridge year activities

According to the observations, when examining the curriculum and educational process implemented in the forest kindergarten, it can be said that the education is child-led, but that is not all. T2 emphasized this by stating, *"...The teacher and child are equal stakeholders and members of the group*." Therefore, in some situations and decisions, the children take the lead, while in others, leadership is shared by the adult or the entire group consisting of both children and adults. The other important stakeholder in children's education, the family, is discussed in the following section.

3. Family Involvement

The theme of family involvement is divided into three subcategories, which are support for activities, family participation in routine activities, and communication, as shown in Figure 4. Communication is examined in two groups: communication with teachers and communication with management.

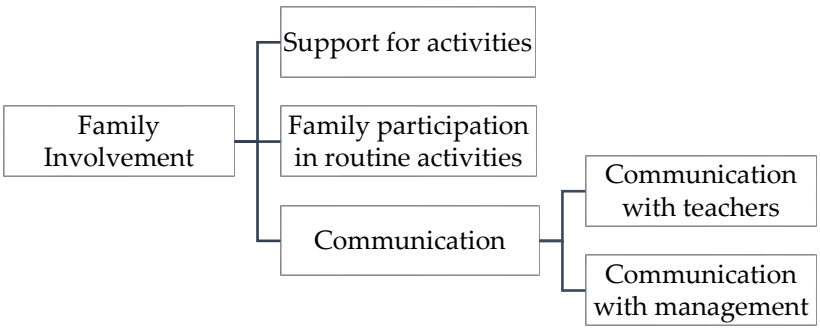

Figure 4. Hierarchical code-subcode model of Family Involvement

3.1. Support for activities

The findings show that families provided various forms of support for the activities organized at the school. This support included sending materials to the school, contributing to the planning of routine activities during parent meetings, and helping with preparations for special celebrations. For example, participant P4 stated they contributed to *"…preparing an Advent calendar for the whole group"*.

3.2. Family participation in routine activities

The annual routine activities previously mentioned—such as Gardening Day, Forest Day, camp, summer festival, lantern parade, second-hand market, and project presentations—are all events with family participation each year. Gardening Day refers to planting activities held twice a year, in autumn and spring. Forest Day was described by P5 as *"…Forest Day includes activities such as jointly repairing the outdoor play area around the cabin and constructing new play spaces*." During the observed project period, it was noted that two parents came to the forest to support the activities by building a kitchen area with the children. On Forest Day, children also show their favorite places in the forest to their families and engage in forest clean-up activities together. The dates and times of these routine events are shared with parents annually through an information letter distributed by the kindergarten.

3.3. Communication

An analysis of the data obtained from interviews, documents, and observations reveals that families maintain regular communication with both teachers and the school management.

Communication with teachers

Communication with teachers takes place through both direct and indirect means. Teachers can be contacted directly during drop-off and pick-up times, in individual meetings, at parent meetings, and via the classroom phone, which is available between 8:00 a.m. and 2:00 p.m. Participant P2 stated that they found the conversations during drop-off and pick-up times to be helpful:

> *"Conversations with educators at the door are possible during drop-off and pick-up times. This provides a valuable opportunity, as small matters can be briefly discussed without the need to schedule a formal meeting."*

Participant P3 elaborated on the parent meetings as follows: "Twice a year, there are meetings referred to as 'parent evenings.' All parents are invited to the kindergarten in the evening to receive updates, overviews, and general information about the class, activities, and projects."

Indirect ways of obtaining information about children involve the bulletin board and message board located in the cabin, the notification board displayed when a child is ill, and occasional notes posted at the entrance of the cabin. The illness notification board is used to inform parents when a contagious illness has been identified, serving as a reminder to watch for symptoms. Following privacy guidelines, the name of the sick child is not disclosed; only the name of the illness and the date the child last attended school are provided. Participant P2 explained the function of the message board, shown in Image 13, by stating: "*I can get information about what the group did that day from the board in the forest*

cabin. For example, one or two sentences are written, such as 'Today we were at the old stump's place and later played at the cabin".

Image 13. The message board located on the exterior wall of the cabin (English: *Today, we went on a long walk in a rainy forest and made a project poster*.)

Finally, the parents have a group on an instant messaging app. Although the teachers are not part of this group, parents and parent representatives share any important information they may have received during the day, allowing families of children who were absent to stay informed indirectly.

Communication with management

Communication with the management occurs both directly and indirectly. Parent representative meetings, postal mail, and emails are direct communication channels. Indirect information from the management can also be obtained through various brochures, such as the school introduction brochure, annual plan brochure, and bridge year brochure, which are provided before the child's orientation day. Participant P5, one of the class representatives, provides information about the representative meetings they attended:

> *"…When there is a parent council meeting, we exchange ideas with parent representatives from other groups and the management. These meetings occur approximately every two months. Example topics include: how the kindergarten allocates its funds, and what types of activities parents can organize to raise money and provide better financial support to the kindergarten. For instance, events like a second-hand goods market."*

Another parent representative, P1, stated that topics such as "…*job openings, available vacancies, and interns*…" are also discussed at these meetings.

4. Interaction with Stakeholders

This theme examines interactions in four categories: teacher-child, family-teacher, family-management, and teacher-management.

4.1. Teacher-child relationship

When the data obtained from the observation forms were analyzed, it was observed that teachers frequently conversed with the children throughout the day, occasionally joined in their games, or initiated play with them, and that the children trusted the teachers. When children encountered a problem they cannot solve, they turned to the teachers for help. The researcher's field notes contain an anecdote related to this category.:

> *"The communication between teachers and children here differs from what I am accustomed to. In Turkey, it is common to see teachers hugging children, but I have not observed random displays of affection here. Sometimes, for example, when younger children fall, teachers respond to their need for a hug, but other than that, I have rarely seen such behavior. From a distance, I often see small, fun conversations happening between the teachers and children. However, the children generally focus on their own play, with teachers remaining in the background."*

4.2. Family-teacher relationship

When the data were analyzed, it was observed that there was a respectful and sincere relationship between the families and the teachers. Parents trust and support the teachers, and their communication channels always remain open. Since the class consists of children of mixed ages, a child who starts kindergarten at the age of 3 spends several years in the same class with the same teachers. This continuity positively affects communication with parents and fosters a friendly atmosphere. Parent participant P3 expressed this as follows: "*If there is something I want to talk about, such as a behavioral change or a similar concern, I can easily talk to the teachers about my concerns."*

4.3. Family-kindergarten administration relationship

When analyzing the theme of interactions with stakeholders, it was observed that the kindergarten administrators also play a significant role in education and maintain intense communication with families. In the interviews, parents emphasized that they are in regular communication with the administrators. Parents first encounter the administrator during enrollment and continue to communicate throughout the school year. This relationship is particularly strengthened through parent representative meetings. When the interview data were examined, it was found that there is a respectful and open relationship, and parents trust the kindergarten administration and the decisions they make. P3 elaborated on this relationship: "Communication with the administration office is generally excellent. The principal knows us by name, and despite the kindergarten being quite large, she knows which children belong to us." Moreover, state regulations highlight that families, as stakeholders, have the right to participate in decision-making processes in the kindergarten administration, emphasizing strong communication with the administration.

4.4. Teacher- kindergarten administration relationship

The final category examined in this theme is the relationship between teachers and administrators. Upon reviewing the data obtained from interviews, documents, and observations, it was found that teachers frequently meet both with the kindergarten administrators and with other teachers in the school. T1 provided the following information about the meetings held during the year: "Twice a month, there is a meeting with all the teachers lasting a few hours. Additionally, there is a full-day meeting three times a year." The data from the observation forms show that communication with the administrators is friendly, respectful, and supportive, with problems being resolved based on mutual trust.

5. Assessment

In the forest kindergarten, as shown in Figure 5, assessment is carried out through annual assessments, portfolios, and school readiness assessments for children of a certain age.

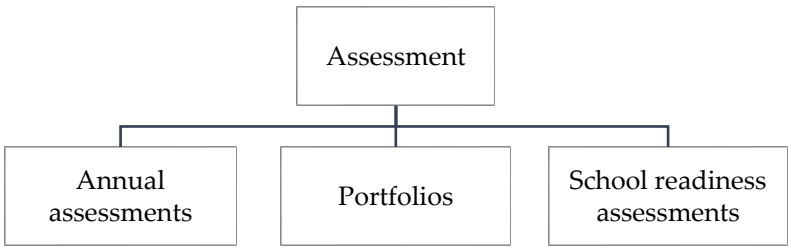

Figure 5. Hierarchical code-subcode model of Assessment

5.1. Annual assessment

In the forest kindergarten, starting from age four, each child is assessed once a year using a scale (mini-KEKS) developed by the Hamburg Institute for Educational Monitoring and Quality Development. P4 described this assessment as follows:

> *"There are scales provided by the kindergarten that educators use to assess various basic competencies of children, such as language and motor skills. This assessment occurs once a year and is presented to parents verbally by the educators as part of the parent-teacher meeting. The child's development and potential conflicts and challenges for the future are discussed."*

The "mini-KEKS" scale, developed for assessing competencies in the preschool period, enables the regular documentation of skills related to the learning areas in the preschool education program. It is conducted through observation and one-on-one activities with the child. If weaknesses or signs of talent are identified in certain areas, the aim is to provide support at an early stage. The scale has been developed in nine languages, including Turkish, to assess language skills in the mother tongue of migrant children.

After this assessment, individual parent-teacher meetings are held once a year. One of the parents, P2, expressed a desire for more frequent meetings by stating, "*I would like to receive more feedback. Perhaps routine meetings could be scheduled every three months to discuss the current situation. These meetings could be kept brief, canceled or postponed if there is nothing new to discuss*."

5.2. Portfolios

Another assessment tool used in the forest kindergarten is portfolios. P1 described this assessment tool as follows:

> *"Educators document matters related to the child in personal documentation folders belonging to each child. Children receive these folders at the end of their time in kindergarten before starting primary school. While they are still in kindergarten, they can look through their folders. However, as parents, we do not have the opportunity to see the contents, so I cannot comment on the specific content."*

Examining the contents of the portfolios reveals that each folder begins with a first-day photograph and a letter written to the child by the teachers. When reviewing the portfolio folders of children who have attended the kindergarten for several years, it is observed that they contain photographs from all of the child's birthday parties over the years, evidence of significant developmental milestones, as well as photos from routine activities and field trips. In addition, it is possible to find the child's drawings and their favorite songs in these folders.

5.3. School readiness assessments

This category includes the subcategories of 4.5-year-old assessments and the bridge year parent-teacher meeting. In Hamburg, preschool children are assessed in their kindergartens 18 months before starting primary school using a form developed for 4.5-year-old children (The 4.5-year-old skills assessment form). Since P5's child is five years old, they have gone through this process and described it as follows:

"At the kindergarten, we had a developmental discussion about my son's motor and cognitive abilities. A scale that is common to all 4.5-year-old children was used as a reference."

The 4.5-year-old skills assessment form is similar to the mini-KEKS and has also been developed in several languages. The form is prepared in line with the learning outcomes of the Hamburg education program. These assessments, conducted by teachers in the kindergarten, are sent to the primary school with parental consent, and a meeting is also held there. The kindergarten and primary school work together to ensure that the child starts primary school as prepared as possible. In this way, it is determined 18 months before school entry whether special preparations, such as support for German language skills, are needed for primary school, and the necessary steps are taken.

Meetings are also held for the parents of children who will start primary school within 18 months at the forest kindergarten. P3 described these meetings as follows: *"…Each term, a special evening meeting is organized within the kindergarten for the parents of children who do not leave the forest group to start the preschool class."*

Discussion, Conclusion, and Recommendations

In this study, the practices of the forest kindergarten during a one-year educational period were examined, and the findings were evaluated in the context of the components of early childhood education. The research resulted in the findings being grouped under five themes: curriculum, educational process, family involvement, interaction with stakeholders, and assessment.

In this study, the first prominent finding at the beginning of the school year was the strong emphasis on the child's orientation to the forest kindergarten, underscoring the priority and significance of the adjustment process. It was found that, in the forest kindergarten, the orientation process is not concentrated into a single week for all children but is spread out over time, ensuring that each child is given the necessary time and attention for orientation. This program, known as the Berlin Model and implemented throughout the state, aims to help children adapt emotionally and securely to a new educational environment and contribute to developing a secure attachment between the child and the teachers. This practice, which offers a flexible approach tailored to the individual needs of the child, focuses on minimizing separation anxiety and establishing strong cooperation between parents and teachers (Emre et al., 2018). From this perspective, it can be said that the process of adapting to school in the forest kindergarten is carried out gradually. In the initial stage, the child is brought to the school environment for short periods together with their parent to become familiar with the setting and feel safe. As the process progresses, the child stays at school for more extended periods, and adaptation is achieved by the end of the second week. As is well known, the school adaptation process is a stressful and challenging period for children (Brace, 2020). School often means separation or distance from the family environment for young children, making them anxious and vulnerable (Purtell et al., 2020). Furthermore, making new friends and finding a place within the group can be anxiety-inducing for some children. Adapting to new routines, the learning process, and encountering specific rules and expectations can also be challenging for certain children. This study observed that teachers created a secure environment during the adaptation process, established a secure attachment with the child, adapted to the child's rhythm, and provided opportunities for peer interaction. It was also found that families facilitated the adaptation process by preparing the child for school, being present in the school environment, and maintaining communication with the teacher. These results indicate that the orientation process in the forest kindergarten is managed collaboratively by teachers and families. The interaction between family and teacher is significant for children's adaptation to school, and various forms of support should be provided to help children overcome these challenges (Kaya & Akgün, 2016; Purtell et al., 2020). No studies have been found in the literature that specifically examine the school adaptation process in forest kindergartens. Since the Berlin Model is used throughout the state, it can be said that the adaptation process in this study is carried out similarly to other early childhood education institutions in Hamburg. No research has been found regarding whether there are differences in the adaptation process between forest kindergartens and traditional kindergartens in different countries.

An analysis of the forest kindergarten's educational program reveals that, in alignment with the state's early childhood education curriculum, it places a strong emphasis on play and project-based learning, alongside the consistent inclusion of routine activities each year. The most significant feature of German forest kindergartens is that the entire educational process is play-based and child-led (Fritz et al., 2014; Gall, 2018). In European implementations of the forest kindergarten approach, the program is carried out through projects, with teachers taking on a facilitative role by providing materials (Atkins, 2018). Amus (2013), reporting on observations from Finland, also noted that children participate in inquiry-based and project-based learning activities. Additionally, the educational program of forest kindergartens is shaped by the seasons, the environment, and cultural celebrations (Kruse, 2013). According to the results of this study, in addition to projects, children participate in activities such as gardening day, summer festival, second-hand market, and cultural and religious celebrations throughout the year.

According to the findings related to the educational process theme, children participate weekly in lessons such as language, mathematics, and yoga, which specialist teachers conduct. Regarding the educational dimension, the learning outcomes of early childhood education in the forest kindergarten are achieved through projects, routine activities, and weekly lessons included in the annual program. In the context of curriculum and educational process, the main significant educational method that distinguishes forest kindergartens from traditional kindergartens is their nature-based approach (Cordiano et al., 2019). In forest kindergartens, children acquire the desired skills through different methods. For example, while children in a traditional kindergarten learn addition using leaf drawings on paper, children in a forest kindergarten may learn this by collecting fallen leaves. Boyer (2020) also found that the curriculum implemented in forest kindergarten classrooms is the same as in traditional kindergarten classrooms, but the methods differ. This study's results also confirm the literature findings by showing that children achieve the program's learning outcomes through different methods.

When examining the daily routine in the forest kindergarten, it is observed that the schedule is planned as follows: Arrival at school, morning circle, breakfast, walk in the forest, playtime, return from the forest, lunch, playtime, and departure from school. Studies in the literature that focus on forest kindergartens report a similar daily schedule (Amus, 2013; Cevher Kalburan, 2019; Coe, 2013; Kane & Kane, 2011). According to the current early childhood education curriculum in Turkey, a typical day in kindergarten is shaped as follows: Starting the day, playing in learning centers, activities, time for reflection, and routine activities such as meals (MoNE, 2024). Notably, the difference in the daily routine from the forest kindergarten is that activity and play times are planned as separate time periods. As previously emphasized, forest kindergartens adopt a play-based educational approach, and play activities are child-led rather than teacher-led (Mackinder, 2023). Therefore, the second significant point distinguishing forest kindergartens from traditional kindergartens is the inclusion of teacher-led activities in the daily routine.

The findings related to the theme of family involvement and interaction with stakeholders provide strong insights into the importance of family cooperation and participation for quality early childhood education. In her book on forest kindergartens in Denmark, Williams-Siegfredsen (2017) emphasized that establishing an educational partnership with parents is a key factor in supporting children's development and learning. According to the results of this study, families contribute to the educational process in various ways, such as sending materials for activities, supporting the planning of routine events, and preparing for special day celebrations. In addition, families participate in most of the annual routine activities. They communicate regularly with teachers and administration through letters, message boards, and meetings. Williams-Siegfredsen (2017) also noted that similar methods are used to communicate with parents in forest kindergartens and that various social events, such as summer parties, weekend gatherings, and Christmas parties, are organized with parental participation. One of the key findings is that parents, children, and teachers in the forest kindergarten are in constant relationship and communication with each other. Schäffer and Kistemann (2012) reached a similar conclusion in their study of twelve kindergartens. They observed good relationships among teachers,

children, and parents in all the forest kindergartens in their study group, attributing this to a high level of parental involvement. Mackinder's (2023) research also highlighted the strong bonds between teachers and children.

Finally, at the end of the year, the assessment dimension was found to include annual assessments, school readiness scales, and portfolio-based assessments. In the annual assessment, starting from age four, children's skills related to learning areas are assessed using a scale, and the results are shared with the child's family in a meeting. The school readiness scale is applied to children of a certain age and mainly measures language skills. Portfolios are created throughout the child's time at school and are kept until graduation. In the literature, some studies assess various skills of children in forest kindergartens. For example, Sella et al. (2023) reviewed sixteen studies on the benefits of forest kindergartens and reported positive effects, particularly in motor development, physical development, creative thinking, psychological resilience, curiosity, and connection to nature. In her master's thesis, Cornell Card (2014) found that children in forest kindergartens developed communication, critical thinking, problem-solving skills, and a sense of self, place, and community. She, therefore, emphasized that forest kindergartens offer learning opportunities beyond the objectives of the curriculum. However, studies in the literature have not addressed how and by which methods these learning outcomes are assessed in the classroom, throughout the year, or during the child's entire early childhood education. It should be emphasized that these assessments are conducted by the curriculum of the state of Hamburg. In other states or countries, assessment methods in early childhood education or forest kindergartens may differ, or assessment may not be conducted.

In conclusion, this study has revealed the practices of a forest kindergarten in Germany throughout an academic year, from the orientation to the assessment. Although the same educational approach is adopted, it is recommended that the applicability of these findings in the Turkish cultural context be examined, as cultural differences may arise. The findings also highlight several implications that could be implemented in early childhood education institutions in Turkey. Initially, it is recommended to incorporate similar stages into the orientation process. Additionally, the current early childhood education curriculum in Turkey emphasizes outdoor learning and play, supporting the features of forest kindergarten practices. Therefore, increasing child-centered, outdoor play, and project-based activities are suggested. Two points should be addressed in this regard. First, it is recommended that the relevant ministries encourage all early childhood education institutions to connect children with nature, support efforts in this direction, and work to increase the number of nature-based educational institutions. Second, it is suggested that regulations be made to enable not only children from higher socioeconomic backgrounds (Koyuncu, 2019) but all children to benefit from the philosophy of forest kindergartens. Furthermore, based on the importance of family involvement in forest kindergartens, it is recommended that family participation be enriched with various annual routine activities and cooperation with families, as exemplified in this study. Finally, for researchers, it is suggested that future studies examine how this educational philosophy is reflected, particularly in the assessment dimension, through different research and in different countries.

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Original Article

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Teaching social skills in primary school: an action research *

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Abstract

The aim of this study is to identify the social skills that pose challenges for 4th-grade primary school students, implement an intervention program to support the development of these skills, and evaluate its effectiveness. In line with this aim, the research was conducted using an action research design. The study group consisted of fourth-grade students attending a public primary school in Ankara during the spring semester of the 2022-2023 academic year. Among the participants, 11 were girls, 17 were boys, and 1 student was receiving inclusive education support. The classroom teacher possessed 13 years of professional teaching experience. In the study, the "Social Skills Assessment Scale," for children aged 7-12, and a semi-structured interview form were utilized to identify the dimensions of social skills in which students experience difficulties. The Social Skills Assessment Scale was analyzed using frequency analysis, while the interview forms were evaluated through content analysis. The intervention program was designed to address the challenges faced by the students and included activities such as problem-solving wheels, story reading, and creative drama. The findings of the study revealed that the problem-solving wheel was identified as the most effective method among the intervention program activities designed to address the students' challenges related to social skills. The problem-solving wheel was found to contribute to the development of students' social skills in areas such as maintaining relationships, coping with aggressive behaviors, and solving problems. Another method employed in the intervention program, creative drama, was observed to have positive implications in areas related to initiating and maintaining relationships, collaborating and conforming within a group, coping with aggressive behaviors, and emotional skills. Story reading activities were found to contribute to the development of social skills such as coping with teasing, respecting differences, empathy, managing embarrassing situations, raising awareness about peer bullying, understanding others' emotions, dealing with exclusion, coping with group pressure, helping others, and respecting diversity.

Keywords

Social skills teaching
Action research
Problem-solving wheel
Creative drama
Storytelling

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Introduction

Social skills are one of the basic skills that should be acquired in primary school, which aims to improve children's lives, roles and responsibilities in society by imparting basic skills to them. Social skills are components of behavior that help an individual get along and adapt in a variety of social environments and they are defined as a set of competencies that allow an individual to initiate and maintain positive social relationships, contribute to peer acceptance and satisfactory school adjustment, and enable an individual to cope effectively with the larger social environment (Karataş, 2020). Social skills are skills that make our lives easier since childhood. Therefore, they form the basis of harmonious living in society, and when these skills cannot be developed sufficiently, individuals experience problems while communicating. Although the acquisition of social skills first begins in the family, educators can be very effective in helping children overcome social skill deficiencies that hinder the learning process when families are not available or cannot teach these skills at home. Therefore, schools are extremely important institutions for developing social skills (Karataş, 2020; Whitted, 2011). Data on social skill deficiencies can be collected through a variety of assessment methods, such as interviews, behavioral rating scales and surveys, direct behavioral observation, and sociometric measures that measure social status in comparison to peers (Spence, 2003).

Individuals with inadequate social skills encounter various problems throughout their lives in their interpersonal relationships, academic studies, emotional-behavioral areas and professional lives (Avcıoğlu, 2007). It is important to identify these problems and try to solve them with teaching methods that address social skills. Given that social competence is important, especially in school environments, it is clear that children who exhibit oppositional and antisocial behaviors need effective interventions to address their social skill deficiencies, taking into account their risk of facing educational and psychological difficulties (Gresham, 1998a). Deficiencies in social skills and competencies may be among the underlying causes of affective and behavioral disorders during childhood and adolescence. Therefore, people's ability to perform behaviors that are important for them to achieve social competence depends on their social skills. These skills develop during social interaction with people and include verbal and non-verbal reactions. These skills include a wide range of indicators ranging from individuals' eye contact, facial expressions, gestures, and mimics to tone of voice, speaking rate and the impressions left on others (Spence, 2003). Social competence plays an important role in interactions between people and is highly valued in both personal and professional life.

The development of social skills and the use of these skills help people improve their social competence. These micro-level skills can cause macro-level effects on individuals' social lives. The extent to which children can establish, develop, and maintain satisfactory interpersonal relationships and end harmful relationships with peers and adults is the essence of social competence (Gresham, 1998b). Research on the inadequacy of social skills has formed the basis for the preparation of training programs to develop and support these skills (Elliott et al., 1989; McClelland & Scalzo, 2006).

Literature Review

Social Skills

Social skills are socially acceptable learned behaviors that enable individuals to communicate effectively with others and avoid socially unacceptable behaviors exhibited by others (Gresham, 1998a). Social skills involve the ability to give and receive information, express, and share attitudes, thoughts and feelings. Therefore, an important function of social skills is to serve interpersonal interactions (Liberman, 1982). Social skills are important to the successful social and academic functioning of all students and play an important role in preventing negative reactions from others. These skills help students focus their attention and participate in classroom activities by interacting with their peers and teachers in a positive manner (Elliott et al., 2001; Lopes & Salovey, 2006). Social skills are a prerequisite for a harmonious existence in a social group and for successful socialization and to act effectively in a social environment (Jurevičienė et al., 2012).

Social skills have been addressed from different perspectives and with different approaches in the literature (Akçamete & Avcıoğlu, 2005; Akkök, 2006; Caldarella & Merrell, 2007; McGuire & Priestley, 1981; Riggio, 1986). In the current study, social skill dimensions defined by Akkök (2006) are used. Akkök (2006) discusses social skills, which are indispensable for an individual to adapt to social life, under six main headings:

1. Skills for Initiating and Maintaining Relationships: Include behaviors such as listening, initiating, and maintaining a conversation, thanking, introducing oneself, complimenting, asking for help, apologizing, giving instructions and persuading.
2. Skills for Conducting Tasks in a Group: Include the behaviors of trying to understand the opinions of others, taking responsibility, and communicating complaints.
3. Skills related to Emotions: Include the behaviors of understanding one's own emotions, expressing one's emotions, understanding the emotions of others, coping with the anger of others, expressing positive emotions and coping with fear.
4. Skills for Coping with Aggressive Behaviors: Include behaviors such as asking permission, sharing, helping others, and expressing or controlling anger.
5. Skills for Coping with Stressful Situations: Include coping with failure, coping with group pressure and coping with being left alone.
6. Planning and Problem-Solving Skills: Include the behaviors of gathering information from the environment, creating goals, and focusing on the task.

Social Skills Training

The origins of social skills training lie in Skinner's (1938) studies focusing on behavior and learning. In addition, social learning theory (Bandura, 1977) is the basis of social skills training. In this sense, learning behaviors through observation and modelling are among the primary techniques used in social skills training. The quality of relationships that an individual will establish within the environment that he/she is influenced by throughout his/her life is a good indicator of social skills. While social skills can be learned naturally by children through modelling and imitation, they are also taught in a planned and programmed way within the education system. In the education system, there is a need for social skills training in a completely planned and programmed manner, not in a haphazard manner (Samancı & Uçan, 2017). When the main goals of education are considered, it is clear that the main emphasis should be on the development of social skills to adapt to life.

Bacanlı (2020) stated that social anxiety is based on social skills training studies and that social anxiety is caused by a lack of social skills. Individuals worry about entering social environments as their social skills are inadequate. Therefore, these individuals need to be given social skills training to help them overcome their social anxiety. The goal of social skills training is to enable individuals to adapt to the society they live in, communicate effectively, and enjoy their lives. Children who lack the social skills necessary to initiate and maintain successful peer relationships are at risk of rejection by their peers when they enter primary school, especially when they exhibit problematic behaviors that are not approved by their peers (Spence, 2003). The basic rationale for social skills training is to increase the individual's quality of life and well-being. This healing-oriented mechanism is attempted to be operated through improved social relationships. When this mechanism is successfully operated, the individual can be taught how to interact with other people in a way that will be perceived as pleasant and attractive by these people, to develop relationships with them and to acquire the skills to communicate effectively (Segrin & Givertz, 2003). Social skills training usually involves a structured program with a limited number of sessions. Through such programs, skills such as non-aggressive modes of social perception, interpersonal problem solving, self-control, anger management and interaction skills can be taught (Lösel & Beelmann, 2003).

Many techniques can be used together in social skills training. These techniques include role-playing, children's games, drama, group work, cooperative teaching, active teaching, using stories and storybooks, telling social stories, theatre, travel, and clubs (Akkök, 2006; Bacanlı, 2020; Karataş, 2020). Social skills are tried to be developed through these techniques. It is emphasized that evaluation has a key role at every stage in social skills training (Segrin & Givertz, 2003). Therefore, it is deemed necessary to start social skills training with evaluation to follow a path that meets the needs of individuals. In social skills training, there are systematic instructions that include small group discussions, everyday language, and the effective use of different communicative behaviors. It is also important to discuss behavioral change by justifying it.

Teaching Social Skills in Primary School

Social skills are important skills that help individuals be successful in their social interactions and improve their relationships. Therefore, when the development of the individual is considered, it is possible to say that critical periods are also of critical importance for the development of social skills. Thus, it seems necessary to offer children experiences to develop social skills from an early age. In this way, the development of skills such as self-regulation skills, problem-solving skills and self-confidence can be achieved, and the development of social interactions also comes to the fore.

Gresham (1997) distinguishes between deficiencies in the acquisition of social skills and social skill performance. According to this perspective, which clarifies the understanding of social skills, the failure of a child's series of behaviors to correspond to a certain social skill is described as an acquisition-related deficiency, while the failure to demonstrate the skills in one or more social events is described as a performance-related deficiency (Spence, 2003). Considering this information, it is important for the teacher to make this distinction for his/her students in terms of the functionality of the social skills training process in primary school. At the primary school level, children are expected to exhibit new behaviors when they move from the home environment to the school environment. Elementary school is an important setting for children to interact with their peers. Children learn how to ask questions, express themselves and their feelings, listen to others, and deal with challenges (Akkök, 2006). Güner Yıldız (2017) revealed that there is a high level of correlation between teachers' knowledge of social skills and the social skill levels of normally developing students. Thus, teachers' knowledge and practices in this regard are very important in the development of students' social skills. Therefore, it is considered important to improve teachers' knowledge of social skills during their pre-service training (Dobbins et al., 2010). The process followed by teachers in teaching social skills must be carried out in a planned manner. When teachers emphasize social skills in the classroom and encourage cooperation with and respect for others, discipline problems and negative behaviors decrease. When rules of courtesy become an integral part of classroom life, conflicts and discipline problems decrease (Kuykendal, 1993, as cited in McArthur, 2002).

Many techniques are employed to help students acquire social skills. For example, Kaf (2000) examined the effect of the creative drama method to develop social skills in the context of greeting, protecting the environment, sharing and cooperating within the scope of the Life Sciences classes. The results of the study showed that the creative drama method is effective in the development of skills except for environmental protection. At the same time, group work in primary school is a tool that makes the greatest contribution to the development of social skills. Group work not only increases social interaction but also makes positive contributions to other areas of development. Group work provides children with opportunities to share, help each other, solve common problems, and make decisions within the group (Yüksel, 2003).

Experts agree that there are six basic methods for social-emotional evaluation of children and adolescents. These methods are behavioral observation, behavior rating scales, interviewing, self-report instruments, projective-expressive techniques and sociometric techniques (Merrell, 1999). Merrell (2001)

stated that natural behavior observations and rating scales constitute the most basic step in the evaluation of social skills. Interviewing and sociometric measurements should be included in the second step and attempts to evaluate children's social skills should be included in the third step. Social skills programs have many aspects. Teachers should ask the following questions when planning to teach students social skills: What are the deficiencies in social skills? Does the student have sufficient knowledge about the skill? Does the student have sufficient opportunities to use the target skills? Are reinforcement contingencies effectively arranged to promote the response? (Mathur & Rutherford, 1996, as cited in Johns et al., 2005).

The Purpose of Research

The purpose of the current study is to determine the social skills that 4th-grade primary school students have problems with and to implement and evaluate an intervention program that supports the development of social skills. In this research designed with an action research method, the following research questions have been sought:

Does the social skills intervention program prepared for primary school students support the development of social skills?

- Does the problem-solving wheel used in teaching social skills support students' social skill development?
- Does the creative drama workshop used in teaching social skills support students' social skill development?
- Does the storytelling technique used in teaching social skills support students' social skill development?

When considering that pre-intervention training was provided to the classroom teacher on social skills instruction, it is assumed in the study that the classroom teacher possesses a foundational level of knowledge regarding social skills.

Method

The current study was designed and conducted with an application-oriented action research method in which qualitative research methods were used to determine the problems experienced by primary school students in social skills and to improve their social skills. Action research is a process in which practitioners generate new ideas about how to improve practice and present these ideas as theories of practice in order to understand and improve the quality of actions and teaching (Johnson, 2014; McNiff & Whitehead, 2006). In the practical action research approach, the researcher and the practitioner come together to identify possible problem areas that arise in practice, possible factors that cause these problems and possible intervention methods (Holter & Schwartz-Barcott, 1993). The main goal of action research is to improve practice rather than to produce knowledge. Information production and use are determined by and dependent on this basic goal (Elliot, 2001). Action research is preferred in the current study, as the research model is oriented towards problem solving (Yıldırım & Şimşek, 2018), as it aims to help teachers improve their skills in the teaching process and at the same time improve their relationships with their students (Nelson, 2013), and as it aims to eliminate the gaps between theory and practice (Knight et al., 2000).

Role of the Researcher

In action research, researchers need to have certain equipment related to theory and practice appropriate to the research (Ataöv, 2007). In this study, one of the researchers has a bachelor's, master's and doctoral degree in Social Studies Education and teaches social skills teaching at the university level. The other researcher has a bachelor's and master's degree in Primary School Education. In the study, action research was carried out in which the researchers were also practitioners. The researchers took

the participant-observer role in the implementation process of the activities planned during the action process. They undertook the tasks of planning the action process, preparing and organizing the activities and evaluating the data at every stage of the research. The process was carried out in a controlled manner by discussing the action plans with the primary teacher before the implementation weeks and making preliminary preparations, and the teacher was guided during the implementation weeks.

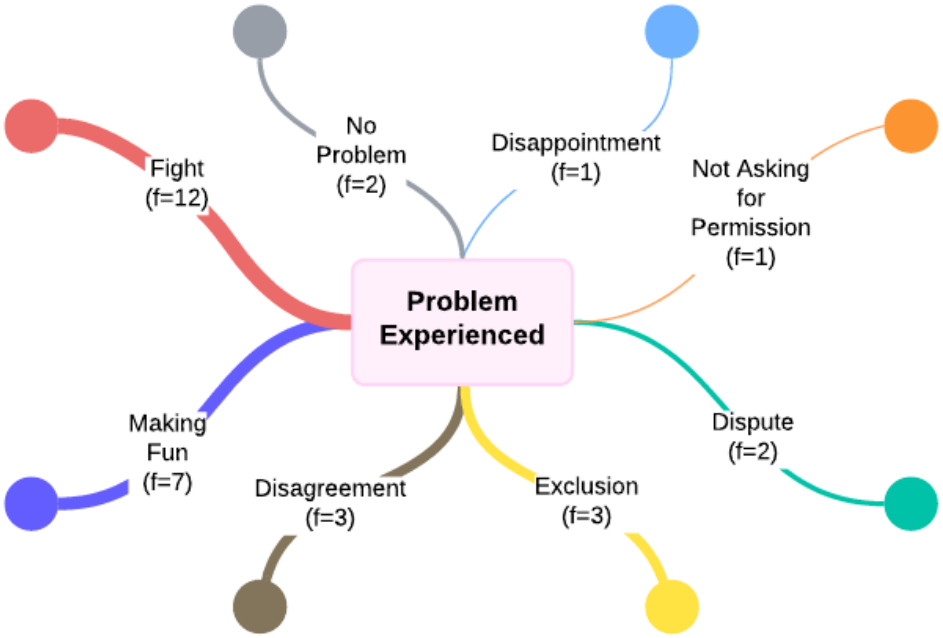
Action Research Process

All the steps followed in action research are followed systematically. As stated by Yıldırım and Şimşek (2018), action research consists of the steps of determining the problem, collecting data, data analysis, preparation, and implementation of the action plan, and turning to an alternative or new action plan. Fraenkel and Wallen (2006) defined the steps of action research as determining research questions and problem, obtaining, analyzing, and interpreting the information to find answers to the relevant questions and developing an action plan. The steps of action research are similar to each other in the definitions made. Therefore, the current study includes the steps of identifying the problem, gathering data, analyzing the data, creating an action plan, and implementing this action plan. As the current study started by determining the focus of the study, it seems to be compatible with the Mills (2014) action research process. Mills (2014) described action research as the "Dialectical Action Research Spiral", a process in which the research focus is first determined, and the next steps are carried out in the same way.

Determining the Focus of the Research

The first step of action research includes the process of the researcher identifying a topic in his/her field of expertise that he/she is curious about and wants to create a change in (Costello, 2011). In determining the research focus, Mills (2014) emphasizes clarifying the area of focus through researcher experience and the review of the relevant literature. In this step, it was seen that the primary teacher observed within the scope of the teaching practice course had problems with social skills exhibited by students in his/her class. As a result of the observation, it was decided to hold a preliminary interview with the primary teacher regarding the problems experienced in the classroom. During the preliminary interviews, the primary teacher was asked to fill out the Social Skills Evaluation Scale (7-12 years old) developed by Akçamete and Avcıoğlu (2005) for each student. With the data obtained from this scale, it was determined which social skills were the most problematic in the class. In the pre-test data of the relevant scale, it was determined that 17 students had problems in 10 dimensions of social skills. These dimensions are basic social skills, basic speaking skills, advanced speaking skills, relationship initiation skills, relationship maintenance skills, group work skills, emotional skills, self-control skills, skills to cope with aggressive behaviors, instruction-giving skills, and cognitive skills. In addition, the teacher's observations regarding the social skill problems he/she experienced in the classroom were also asked. In the preliminary interview form, the teacher defined social skills as "*Greeting, saying hello when you see your friends, playing games, speaking in front of the public, using polite expressions, showing respect*". The primary teacher stated that teaching social skills is important for primary school students, and that when students' social skills do not develop, they experience problems in in-class activities, have problems focusing on the lesson, and their academic success is negatively affected. The teacher also stated that some of the students had problems with their communication skills and that they displayed an accusatory attitude towards others when expressing themselves and therefore could not solve their problems. The teacher stated that students mostly preferred the complaint method to find solutions to the problems they experienced with their peers, and very few students tried to find solutions by talking. The teacher was asked the question, "Do you organize activities for teaching social skills in your classroom?" and she stated that she did activities both within the scope of the counselling classes and individually, that she encouraged students to re-enact the problems they experienced during the break and find solutions, especially through drama and role-play; however, although these drama and role-play activities seemed to work at that moment, students went on exhibiting the same behaviors afterwards. At the end of the interview, the teacher was asked whether she needed an intervention

program to teach social skills. The teacher answered this question: "*Yes, because sometimes I cannot find solutions. By using different methods, I can find solutions*." Thus, she indicated that she needed an intervention program. Student opinions were also used in determining the research focus. The findings obtained from student opinions are shown in Figure 1.



In the figure, the arrows of the codes with higher frequencies are shown as thicker, and the arrows of the codes with lower frequencies are shown as thinner.

Figure 1. Problems Students Experience in Their Friendship Relationships

Of the students who participated in the interviews, 12 stated that they have problems due to "fighting". One of the students (S3) stated, "We are fighting while playing football", while another student (S19) stated, "We are fighting while playing games". Seven of the students stated "making fun" as their problem. One of the students (S23) stated "They make fun of the team I support" while another student (S18) stated "They make fun of me". Three students stated the problem as "disagreement" and 3 students as "exclusion". One of the students (S8) explained his/her problem as "They are excluding me". Two students defined their problem as "dispute" while 1 student explained it as "not asking for permission" and 1 student as "disappointment". When the problems experienced by students are evaluated, it can be seen that they are associated with social skills dimensions such as maintaining relationships, carrying out tasks in a group, coping with aggressive behaviors, coping with stressful situations and problem solving.

By considering the data obtained from the researcher observations, primary teacher observations and student opinions, the focus of the study was determined as skills to initiate and maintain relationships, skills to carry out tasks in a group, skills related to emotions, skills to cope with aggressive behaviors, skills to cope with stressful situations and problem-solving skills.

Developing Action Plans (Make Plans)

Focusing on the problems identified during the application process within the framework of a systematic plan, the researcher takes some measures to minimize or eliminate these problems. In the action plans created in this sense, a path was followed based on the preliminary interviews held with the teacher and the students and the responses given to the scale items by the students. In this direction, a 12-week action plan was created.

Carrying Out the Application (Get into Action)

The research started with a preliminary interview in the first week in order to get to know the class where the application would be conducted and the students and was carried out for 12 weeks in total. Considering that the primary teacher would also take part in the implementation process, the teacher was given training on social skills. Table 1 gives the dates of the activities conducted within the action plan.

Table 1. Action Plan

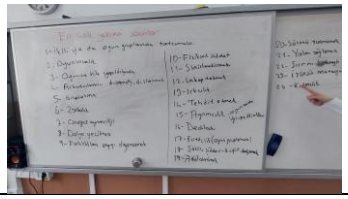
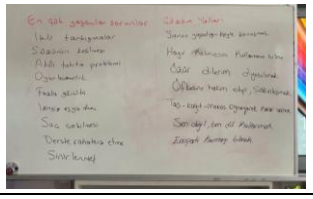
1st Week 6 February 2023	• Preliminary interview with the teacher (Revealing social skills perceived to be inadequate in students) • Administration of the social skills evaluation scale to the students by the teacher.
2nd Week 9 March 2023	• Training given to the teacher on the concept of social skill, teaching and dimensions of social skills was conducted on an online platform.
3rd Week 16 March 2023	• Meeting with the students • The problems most experienced by the students and the solutions to these problems were discussed. • Problem-Solving Wheel preparation process
4th Week 27 March 2023	• Problem-Solving Wheel and Activity (Alternative solutions to situations were asked from students in the activity)  
5th Week 13 April 2023	• Student opinions were taken on the functionality of the problem-solving wheel. • Books were determined for the storytelling activity, introduced to the teacher, and worksheets were prepared. 
17 April -23 April Midterm Break	
6th Week 25 April 2023	• Storytelling activity-1 • "Bob the Artist" book was read in the class and the activity worksheet prepared for the book was used.
7th Week 3 May 2023	• Creative Drama Workshop-1 application was conducted (3 hours - preparation – acting out - evaluation) 

Table 1. Continued

8th Week 10 May 2023	• An interim evaluation was made for the problem-solving wheel, storytelling activity and Creative Drama Workshop.
9th Week 18 May 2023	• Storytelling activity 2 • The book "I Walk with Vanessa (silent book)" was read in the class and the activity worksheet prepared for the book was used.
10th Week 22 May 2023	• Creative Drama Workshop-2 application was conducted (3 hours - preparation – acting out - evaluation). 
11th Week 29 May 2023	• The social skills evaluation scale was re-administered by the teacher.
12th Week 5 June 2023	• Student interviews - Semi-structured interview form was used. • Teacher evaluation - Process evaluation was carried out.

Observation of the Application (Make Observations)

The studies carried out to observe and evaluate the activities during the action process are given below.

- Field notes were taken by the teacher during the application process.
- Research team meetings were held every week. The process was evaluated in the meetings and the parts deemed necessary were reviewed.
- After each activity, interviews were held with the students to evaluate the activities.
- Activities with the students were audio recorded and these recordings were re-examined after the activity.
- After each activity, interviews were held with the teacher, and they were audio recorded.

Evaluation of the Action Plans (Criticize & Improve)

After each activity, teacher opinions and student opinions about the process and student products were analyzed in terms of the dimensions related to the questions specified below.

- To what extent do the activities support social skills development?
- Are the activities appropriate to the student level?
- What are the strong and weak points of the activities carried out? How can these activities be improved?

During the interviews and meetings, the activities in the action plan were evaluated within the scope of the questions above. As a result of the evaluations, it was determined that the students frequently used the problem-solving wheel. For this reason, it was decided that the problem-solving wheel would be retained and be used in the classroom throughout the term. In addition, in the meeting held in the 7th week, the primary teacher suggested that drama workshops should be given more place in the classroom. In this context, another drama workshop for social skills development was prepared and implemented in the 10th week.

Study Group

The study group consists of fourth-grade students attending a public primary school in the city of Ankara in the spring term of the 2022-2023 school year. Of the students in the study group, 11 are girls and 17 are boys and 1 is an inclusion student. In addition, the primary teacher took part in the study as a participant-observer. The primary teacher (female), graduated from the Department of Primary Teaching, has 13 years of teaching experience. The primary teacher has received training in storytelling, creative drama, and teaching with games. During the application process, she evaluated the practices carried out in the classroom and drama workshop with observation forms and interviews and implemented storytelling activities.

Data Collection Tools

Social Skills Evaluation Scale. Social Skills Evaluation Scale is a scale developed by Akçamete and Avcıoğlu (2005) to be administered to children between the ages of 7 and 12. The validity and reliability of this scale were calculated through an administration to 354 students. The content validity of the scale was ensured by seeking expert opinions. For the construct validity, a factor analysis was conducted on the scale items. In the reliability study of the scale, the lowest Cronbach alpha value was found to be .70 and the highest was found to be .98 in the constructs that make up the scale. The relevant data collection tool revealed with which social skills the participating students in the current action research had problems in the classroom. On the basis of the collected data, the students were found to experience problems with basic social skills, basic speaking skills, advanced speaking skills, relationship initiation skills, relationship maintenance skills, group work skills, emotional skills, skills to cope with aggressive behaviors, instruction giving skills and cognitive skills. In this connection, action plans were started to be prepared.

Semi-Structured Interview Forms (Teacher-Student). In the study, semi-structured interview forms were used to evaluate the opinions of the teacher and students. From these interview forms, the teacher interview form was administered twice, at the beginning and end of the application process. The student interview form was administered at the end of the application process. In addition, interim evaluations were made through the student interview form at the end of each activity in order to improve the activities in the intervention program. The teacher interview form administered at the beginning of the application process consists of seven open-ended questions and six open sentences and determines the current status of the primary teacher regarding social skills and activities. In the teacher interview form administered at the end of the application process, the teacher was asked 4 open-ended questions to evaluate the process. While preparing the interview forms, three faculty members and one primary teacher who were experts in their fields were asked to fill out the expert opinion forms. According to expert opinions, open-ended sentence completion items were edited in the semi-structured teacher interview form.

Researcher Field Notes: Observation enables us to infer information about people and events by observing them in their natural contexts (Koshy, 2005). There are two types of observation: participant observation and non-participant observation. Participant observation is a method where the researcher is directly involved in the situation under study and plays an active role as an observer (Vinten, 1994). Conversely, in non-participant observation, the researcher assumes a more passive role, observing the situation from an external standpoint. This study employed both types of observation. In the problem-solving wheel and creative drama activities, the researcher acted as a participant observer, as they were directly involved in the implementation, while the classroom teacher served as a non-participant observer, not directly interacting with the class during these activities. In the story reading activities, the classroom teacher led the process, thus acting as a participant observer, while the researchers assumed the role of non-participant observers. The researchers experienced the implementation process firsthand using an unstructured observation method and recorded their observations in the researcher field notes by reviewing audio recordings taken during the evaluation phase of the creative drama activity. Conversely, the classroom teacher utilized a structured observation method and documented her observations in her field notes.

Data Analysis

The content analysis method was used in the evaluation of the interview forms and field notes. As a result of the content analysis, sub-themes were created on the basis of having certain similar concepts obtained within the context of the main theme. There is an inference-based approach on the basis of content analysis techniques. It aims to provide an interpretation based on the elements observed and described in the messages. Content analysis is a method that focuses on processing the information contained in a message. The first step of the method is descriptive processing (Bilgin, 2014). In this context, during the analysis process, the data obtained were first coded and themes that could explain the codes in general were determined based on the coded data.

At the beginning of the application, the classroom teacher was asked to fill in the Social Skills Evaluation Scale individually for the students and the pre-test data of the study were formed. In the pretest data, it was determined that 17 students in the class had problems in at least one of the social skills dimensions, and at the end of the application, the class teacher was asked to evaluate these students according to the Social Skills Evaluation Scale. These evaluations at the end of the application constituted the post-test data. The pre-test and post-test data were analyzed by frequency analysis, one of the basic statistical methods.

Validity and Reliability

In qualitative research, credibility, transferability, dependability, and confirmability must be ensured for the research to be considered valid and reliable (Shenton, 2004). To ensure the credibility of the research, demographic information about the participants was first presented. Then, expert opinions were used in the preparation of the teacher and student interview forms (Merriam & Tisdell, 2015), and data sources were diversified by interviewing both the students and the primary teacher during the collection of the data. To ensure the transferability of the study, a purposive sampling method was used during the selection of the sample, the findings were supported with direct quotations from the participants, and the process of the action research was reported in detail. In order to ensure the dependability of the findings obtained in light of qualitative data, the research data were coded by the researchers conducting the research, and the "agreement" and "disagreement" frequencies were calculated for each code determined by the coders, using the Miles and Huberman's (1994) reliability formula (Reliability = Agreement) / [Agreement + Disagreement] x 100). The percentage of the agreement between the coders was calculated to be 100%, and since the agreement percentage was above 70%, it was concluded that the research data were reliable (Miles & Huberman, 1994). In order to examine the confirmability of the study, it is necessary to confirm whether the research results are compatible with the raw data by comparing them (Yıldırım & Şimşek, 2018). After the data of the study were coded, the compatibility of the raw data and codes was confirmed by a third researcher.

Results

1. Teacher Opinions on the Contribution of the Activities Conducted during the Action Process to the Development of Social Skills Field Notes and Social Skills Evaluation Scale

At the end of the action research process, two interviews were held with the primary teacher to evaluate the process. During the interviews, first, the following question was asked: "Do you think there are students with social skill deficiencies in your class?" What social skills do you think are inadequate?" The teacher's answer to this question is given below.

> *"I had students with social skill deficiencies in my class. I have students who cannot say no, who have problems communicating with their friends, who turn it into an argument while initiating communication. For example, my student S5 cannot say no, he/she cannot say no to anyone. Another student of mine constantly experiences conflict while talking with his/her friends. He/she cannot bring the conflict to a conclusion. Another student of mine cannot join any group; he/she is always alone, alone and does not take part in any group. Children behave like this; each has different characteristics."*

As a result of the pre-implementation observations, it was noted that there were frequent arguments among the students in the classroom, and that the students were unable to resolve these conflicts independently, often seeking the teacher's intervention. Additionally, significant groupings between girls and boys were observed during breaks. These field notes corroborated the teacher's perspective that issues of grouping, conflict, and relationship initiation were present in the classroom.

Secondly, the primary teacher was asked how the activities carried out throughout the process made a difference in these students. As a result of the data obtained, it was determined that a few students in the class improved in their ability to initiate and maintain relationships. The primary teacher explained these developments as follows: *"While S5 couldn't say no at first, I think these activities contributed a lot. S5 has now become a student who can say no. He/she has started to express his/her feelings to his/her own teachers by stating, 'I do not want to do this', 'I do not want to be a part of this group of students', 'the teacher is not suitable for me.', which I found very surprising and told to his/her family. I liked it very much. S5 gained self-confidence and this had very positive reflections in terms of communication",* and *"I think the activities we did were very effective for S2. He/she is now more outgoing. He/she had only one friend to play with, now he/she has started to communicate more with his/her other friends. It had a great effect on S2."* In the pre-test data of S5's Social Skills Assessment Scale, it was determined that the student infrequently exhibited the behavior of "saying no when asked to do something he/she does not want to do." However, the post-test data collected at the end of the intervention indicated an increased frequency of this behavior. There is consistency between the data obtained from S5's Social Skills Assessment Scale and the teacher interviews. According to the pre-test data of S2's Social Skills Assessment Scale, the student, who the class teacher noted became more extroverted by the end of the intervention, initially exhibited hesitance regarding relationship initiation and group work skills. However, post-test results showed that the student demonstrated behaviors supporting these skills more frequently by the end of the intervention.

During the interviews, it was determined that problem-solving wheel activity also contributed to the development of social skills to cope with aggressive behaviors. The teacher expressed her opinions as follows: *"My other student, S9, was fighting a lot and coming to me with a complaint every break. After the problem-solving wheel activity, they stopped coming to me for their problems. While S9 used to come to me 5 times a day, he/she started to come to me every 2 days, especially for problems he/she could not solve. Apart from this, S9 never comes to me to complain anymore. I heard them talking "Let's go to the wheel, let's not go to the teacher, let's solve this. I really liked this problem wheel, it was great."* When the pre-test and post-test data of S9's Social Skills Assessment Scale were examined, it was found that the student's tendency to perform behaviors related to self-control skills, such as "solving problems with others without harming them," increased after the intervention program. In addition, it was determined that not only the problem-solving wheel, but also other activities improved the ability to cope with aggressive behaviors. The teacher explained her opinions in this regard as follows: *"S4's behaviors were really problematic. Because she/he was a little bigger than his/her peers, he/she could not hold back in aggressive behaviors. I can say that S4 has almost never come to me to complain about the activities we did throughout this period. They were truly incredibly effective on S4. These activities were especially effective for children whose problems I could not overcome. S4 now comes to me and makes promises and does not take part in any fights. Negative things used to be said about S4 in every class. Now, for example, if I enter the classroom and something negative happens, his/her name would be the first to be mentioned, but it has never been mentioned this term. I was really surprised. It was so nice."* In the pre-test data of Ö4's Social Skills Evaluation Scale, an increase in the frequency of the behavior "associates with friends who are different from themselves" was observed, and it was concluded that the problem-solving wheel contributed to this increase, according to the teacher's views. Another finding supporting the teacher's statements about the problem-solving wheel was noted in the field observations. In the field notes taken by the researchers during the creative drama activities, it was recorded that during the warm-up activity, students referred to the problem-solving wheel to address the problems they experienced that week.

It has been determined that creative drama activities have contributed to students who experience problems in many areas of social skills. For example, the change in S10's social skills is clearly seen in the pre-test and post-test data of the Social Skills Evaluation Scale. While S10 experienced difficulties in nine different types of skills, including basic social skills, basic communication skills,

initiating relationships, and maintaining relationships, before the intervention, it was found that he showed a tendency to perform behaviors related to these skills after the intervention. The classroom teacher, who believes that drama activities played a significant role in this change in S10, expressed her thoughts with these words: *"For instance, my other student, who is usually alone and has a special condition but no official report, S10. This student was often not included in the group. But through these drama activities, he was especially included in the same group with others. By being in the same group with other classmates, the children got to know each other. Instead of always being in the same group, they had the chance to be in different groups and get to know each other. In this respect, drama was very effective."* In addition, the teacher explained her opinions about the drama workshop as follows: "*My other student S10, for example, is a student who is alone, has special conditions but does not have any diagnosis. They didn't accept this student of mine into many groups. But with these drama activities, they especially wanted to be in the same group with him/her. By being in the same group with other friends, the children got to know each other. Instead of always being in the same group, they had the chance to get to know each other by being in different groups. In this respect, the drama was very effective."* These explanations show that drama activities are effective in the social skills of doing and carrying out a task with a group. In addition, the teacher explained that the drama workshops made positive contributions to the development of initiating and maintaining relationships by saying, "*S24 is trying to put himself/herself at the forefront in the drama activity. For example, he/she became a more talkative child as a result of these activities. He/she used to keep silent but now has become a talkative child*." Upon examining the audio recordings taken during the creative drama workshop, it was found that the teacher stated, *"I wish these activities were implemented more often."* This finding supports the data obtained from the teacher interviews.

2. Student Opinions on the Contribution of the Activities Conducted during the Action Process to the Development of Social Skills

During the action process, a total of four different activities were conducted: the problem-solving wheel, storytelling activity of "Bob the Artist" book, storytelling activity of "I Walk with Vanessa" book and the creative drama workshop. The students were asked which of these activities contributed to the development of their social skills. Student opinions on the effect of these activities on the development of social skills are shown in Figure 2.

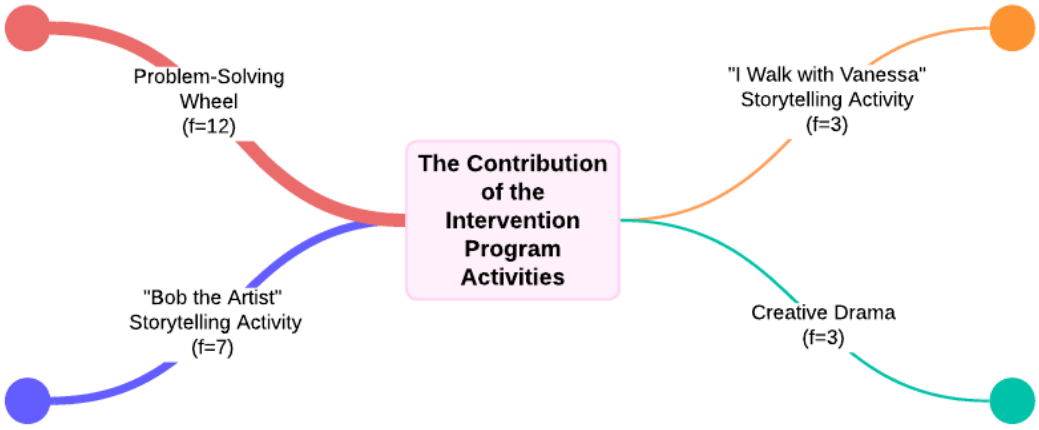


Figure 2. Student Opinions on the Contribution of the Activities Conducted during the Process

When Figure 2 is examined, it is seen that of the participating students, 12 students stated that the problem-solving wheel made contributions, 7 students stated that storytelling activity of "Bob the Artist" book made contributions, 3 students stated that the storytelling activity of "I Walk with Vanessa" book made contributions and 3 students stated that the creative drama workshop made contributions to the development of their social skills. It is thought that the fact that 12 students from the study group mentioned the problem-solving wheel is because this activity continued throughout the semester, and they used the problem-solving wheel constantly.

3. Findings on the Effect of the Problem-Solving Wheel on the Development of Social Skills

The study group was asked how the problem-solving wheel contributed to solving the problems they had with their peers. Findings from the students' answers are shown in Figure 3. In the figure, the arrows of the codes with higher frequencies are shown as thicker, and the arrows of the codes with lower frequencies are shown as thinner.

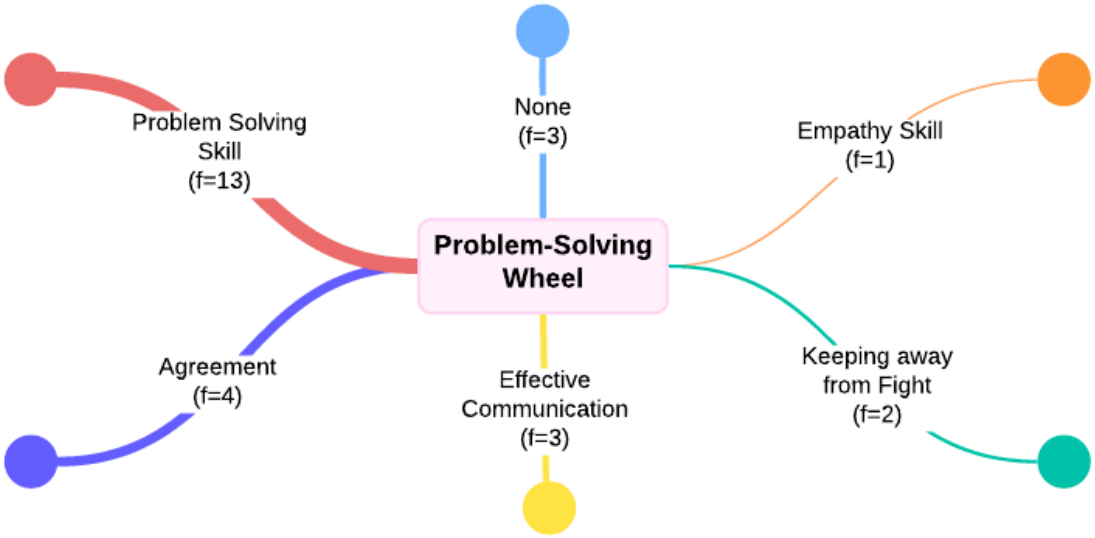


Figure 3. Student Opinions on the Effect of the Problem-Solving Wheel Activity on Solving the Problems Encountered

When Figure 3 is examined, it is seen that 13 students mentioned the contributions of the problem-solving wheel to problem-solving skills. S5 stated, *"It helped me solve problems better with my friends*." Four students stated that the problem-solving wheel contributed to their skill of agreeing. S13 stated, *"It helped me reach an agreement with my friends*." Three students mentioned the contribution of the activity to effective communication. One of the students (S3) stated, "*it helped us reach an agreement by talking to my friends and listening to them*." In addition, 2 students mentioned the contribution of the activity to the skill of keeping away from fights, and 1 student stated that it contributed to the ability to empathize. On the other hand, 3 students stated that the problem-solving wheel did not make any contributions to their social skills. It was seen that the problem-solving wheel contributed to the development of students' social skills such as maintaining relationships, coping with aggressive behaviors and problem solving.

After the problem-solving wheel activity, students were encouraged to use the wheel to address issues they encountered with their peers throughout the term. They were asked to place a sticker on the corresponding section of the wheel each time they utilized it for a specific action. According to the researchers' field notes, the number of stickers on the problem-solving wheel increased each week. The field notes also highlighted that girl students, in particular, experienced issues due to group dynamics during recess and frequently turned to the problem-solving wheel for resolution. When analyzing audio recordings from a creative drama activity, it was found that students were asked, "How do you resolve issues with your friends?" and they responded, "*We go to the problem-solving wheel.*"

4. Findings on the Effect of Creative Drama on the Development of Social Skills

Opinions of the students were received on the effect of creative drama activity on the development of social skills. The answers given by the students are presented in Figure 4. In the figure, the arrows of the codes with higher frequencies are shown as thicker, and the arrows of the codes with lower frequencies are shown as thinner.

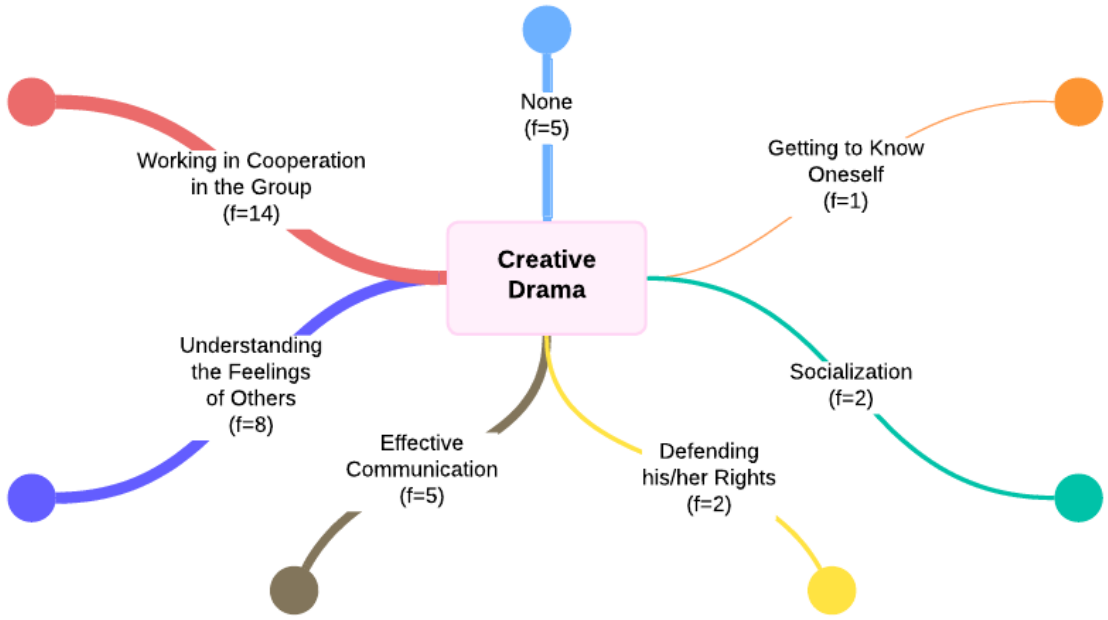


Figure 4. Student Opinions on the Effect of the Creative Drama Workshop Activity on Solving the Problems Encountered

Of the participating students, 14 stated that the creative drama workshop activity contributed to their ability to work in cooperation in the group. S15 expressed this effect as follows: "*We worked in harmony with my friends.*" On the basis of the opinions expressed by the students, one of the biggest benefits of creative drama was determined to be understanding the emotions of others. One of the students (S26) stated, *"I understood my friends' feelings. We learned to say no*." Another contribution of the creative drama workshop is related to effective communication. S5 explained his/her opinions as follows: *"It affected our social skills; we became closer to each other, our communication improved."* In addition, 2 of the students mentioned the sub-theme of protecting and defending rights, 2 students mentioned the sub-theme of socialization and 1 student mentioned the sub-theme of getting to know oneself. On the other hand, 5 students stated that the creative workshop activity had no contribution. When the opinions expressed by the students about the creative drama workshop are evaluated, it is seen that the creative drama workshop has an effect on the development of students' social skills such as initiating and maintaining relationships, working in cooperation in the group, emotional skills, and coping with aggressive behaviors.

In the first activity of the creative drama workshop, students were asked to form a circle by holding the hand of any friend. According to the researchers' field notes, students mostly chose friends with whom they did not have conflicts. In subsequent workshop sessions, students were asked to think about something they might want to say to a friend they had a conflict with, while music played. The field notes noted that when the music stopped, most students approached the friends they had conflicts with. Analysis of audio recordings from the creative drama activity revealed that one student acknowledged a misunderstanding with a friend and resolved the issue during this activity.

Groups were formed under the guidance of the classroom teacher for dramatizing scenario cards during the creative drama activities. Special attention was given to ensure that students who had conflicts were placed in the same groups. According to the researchers' field notes, the interactions between conflicting students were observed during the dramatization stage. Field notes on the group activity with the problem-solving wheel indicated that although students with conflicts experienced issues during the activity, they successfully completed the dramatization of the scenario cards without problems.

5. Findings Regarding the Effect of Storytelling Technique on the Development of Social Skills

During the action process, the students were involved in two storytelling activities of two different books called "Bob the Artist" and "I Walk with Vanessa". At the end of the process, the students were asked how these activities contributed to the development of their social skills. Opinions expressed by the students on the storytelling activity of "Bob the Artist" book are shown in Figure 5. In the figure, the arrows of the codes with higher frequencies are shown as thicker, and the arrows of the codes with lower frequencies are shown as thinner.

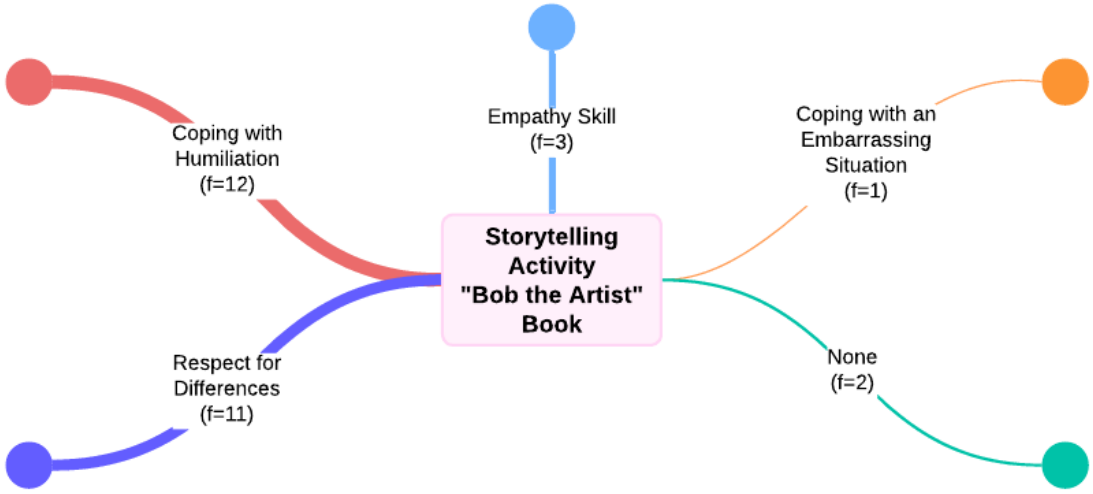


Figure 5. Student Opinions on the Effect of Storytelling Activity of "Bob the Artist" Book on Solving the Problems Encountered

When Figure 5 is examined, it is seen that the storytelling activity of "Bob the Artist" book contributed the most to the skill to cope with humiliation. One of the students (S16) stated, "*I realized that we should not be humiliated*." Another contribution of this activity is to foster respect for differences. S14 stated, "we learned not to make fun of anyone". In addition, 3 students mentioned the contribution of the activity to the development of empathy skills and 1 student stated that the activity helped them to cope with an embarrassing situation. Although most students thought that the activity made important contributions, 2 students stated that the storytelling activity did not make any contributions. Based on the opinions expressed by the students, it was determined that storytelling activity of "Bob the Artist" book contributed to the development of students' social skills such as coping with aggressive behaviors, coping with stressful situations, and respecting differences.

The students were asked how the storytelling activity of "I Walk with Vanessa" book contributed to the solution of the problems they had with their friends. Opinions of the students regarding the effect of this activity on the development of their social skills are presented in Figure 6. In the figure, the arrows of codes with higher frequencies are shown as thicker, and the arrows of codes with lower frequencies are shown as thinner.

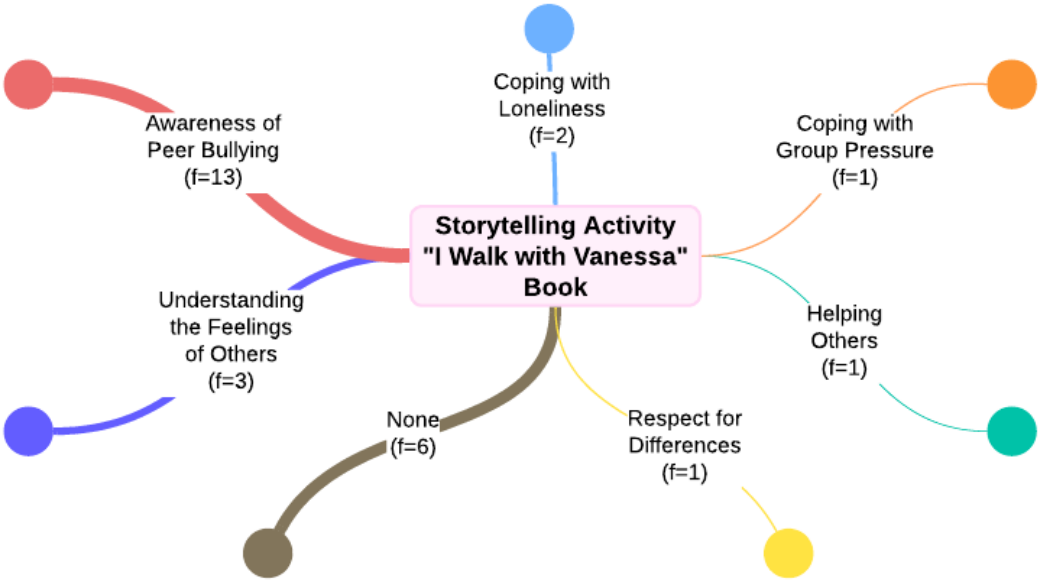


Figure 6. Student Opinions on the Effect of Storytelling Activity of "I Walk with Vanessa" Book on Solving the Problems Encountered

When Figure 6 is examined, it can be seen that the storytelling activity of "I Walk with Vanessa" book contributed the most to the sub-theme of awareness of peer bullying. One of the students (S14) stated, "*We should not bully anyone. We must help the person who is being bullied*." Three students mentioned the sub-theme of understanding the feelings of others. S8 expressed his/her views on the subject by saying, "*We need to support our friends by understanding what they feel.*" In addition, the sub-theme of coping with loneliness was mentioned by 2 students, the sub-theme of coping with group pressure by 1 student, the sub-theme of helping others by 1 student and the sub-theme of respect for differences by 1 student. On the other hand, 6 students stated that the storytelling of "I Walk with Vanessa" book did not make any contributions.

In the field notes of the classroom teacher in the story reading activity, it was stated that the students discussed how they would react to the situations they encountered in the books. It was determined that the majority of the class answered the book evaluation questions. It was noted that the students stated that bullying is a bad thing and that we need to empathize. The findings of the field notes in the story reading activity coincide with the findings obtained from the students' interviews.

6. Social Skills Assessment Scale Findings

At the beginning of the implementation, the Social Skills Assessment Scale was applied by the classroom teacher for each student in order to evaluate the social skills problems in the classroom and pre-test data were created. As a result of this scale, it was determined that 17 students had problems in some social skills areas. At the end of the intervention process, the class teacher was asked to evaluate the students again according to this scale and post-test data were obtained. It was accepted that students who tended not to do at least one of the behaviors in the social skills sub-dimensions at all or to do less were considered to have problems in the relevant social skills area. The evaluation data of the classroom teacher at the beginning and at the end of the implementation are presented in Table 2.

Table 2. Social Skills Assessment Scale Pre-Test and Post-Test Data

Social Skills Dimension	Frequency of Students Having Problems in Pre-Test Data (f)	Frequency of Students Having Problems with Post-Test Data (f)
Basic Social Skills	10	2
Basic Speaking Skills	2	0
Advanced Speaking Skills	3	0
Relationship Initiation Skills	4	0
Relationship Maintenance Skills	2	0
Group Work Skills	3	0
Emotional Skills	4	0
Self-Control Skills	3	0
Skills to Cope with Aggressive Behaviors	3	0
Instruction-Giving Skills	5	0
Cognitive Skills	8	1

In Table 2, the data of the social skills assessment scale before and after the intervention were compared and a significant improvement was observed in the problems experienced by the students in the social skills areas. While the number of students who had problems in basic social skills was 10 before the intervention, this number decreased to 2 after the intervention. Similarly, there was a significant decrease in the frequency of students' problems in the areas of basic speaking skills, advanced speaking skills, relationship initiation and maintenance skills, group work skills, emotional skills, self-control skills, coping with aggressive behaviors, giving instructions and cognitive skills. These results show that the intervention was effective in improving students' social skills and provided significant improvements in the social skills areas.

Discussion and Results

In the current study, it was aimed to determine the social skills that 4th grade primary school students have problems with, to implement an intervention program that supports the development of social skills and to evaluate the functionality of the intervention program. In this connection, the action research process lasted 12 weeks, and during this process, the opinions of the students and the primary teacher on the problem-solving wheel, interactive storytelling and creative drama techniques used in the intervention program were revealed. In the current study, the problem-solving wheel used to help students solve their social problems, creative drama activities in which they collaborated with the group members, and two story books and reading techniques were used to develop social skills such as coping with stressful situations and coping with loneliness.

As a result of the study, it was concluded that the problem-solving wheel, which is one of the activities in the intervention program applied during the action research process, was the activity that contributed the most to the solution of the problems experienced by the students regarding social skills. Teacher and student opinions about the problem-solving wheel are that it contributes to the development of social skills such as maintaining relationships, coping with aggressive behaviors and problem solving. Acquiring social problem-solving skills is of critical importance during childhood, as is the acquisition of many skills. Experiences lived during childhood form the basis of the child's social development (Uzunkol & Özdemir Yılmaz, 2018). Students in primary school begin to accelerate their personal and social progress by leaving anthropocentrism behind in this period. This period is a sensitive process for developing communication skills, adapting to social order, leading, adapting to social order and interacting with others (Kam, 2019). In parallel with this view, Ayvaz Tuncel and Demirel (2010) revealed that social problems among students are mostly caused by lack of communication. According to the Social Skills Assessment Scale pre-test data of the study, one of the most common problems encountered in primary school students is deficiencies in communication skills.

People need problem-solving skills to successfully overcome the social problems they encounter in their daily lives. Those who can use this skill naturally can handle any scenario with ease, while for others each step may be fraught with difficulties and these individuals may need direct training. Engaging in social interaction can be particularly challenging for individuals with communication disorders, which can interfere with their attempts to communicate effectively with others. Moreover, according to Pringle (2017), the lack of an effective problem-solving process can also cause difficulties in making friends and maintaining friendships. Within the scope of this study, it was determined that students' not solving the problems they experienced with their friends affected their relationships with their friends. The problem-solving wheel, which is used in the classroom to solve social problems and through which students express the problems they experience with their peers in the school environment, has many options from which the student can choose. For example, apologizing, calming down, being respectful, using "I" language. Having this wheel in the classroom throughout the semester helped minimize problems such as fights, arguments, and complaints.

When the opinions of the teacher and students on the contribution of the creative drama method used in the intervention program to the development of students' social skills were evaluated, themes associated with social skills such as initiating and maintaining relationships, carrying out tasks in a group, emotional skills and coping with aggressive behaviors were elicited. The creative drama workshop gave students the opportunity to establish new friendships by taking part in activities with different groups. On the other hand, some students had the opportunity to change their perceptions of their friends in the group. Drama makes a positive contribution to the social development of the individual by first allowing the individual to understand his/her own inner world and then to understand and cooperate with other people. Drama activities provide emotional relief and the opportunity to develop social skills, especially when they take place in a safe environment (Mantaş, 2014). There are many studies in the literature investigating the effect of the creative drama method on social skills (Abacı et al., 2015; Kara & Çam, 2007; Önalan-Akfırat, 2006). Sayim (2021) examined the effect of creative drama activities on social skills and empathic education of 4th-grade primary school students and found that creative drama activities are effective in improving social skills. Saygın and Karakaş (2021), in their study investigating the impact of social skills-based activities on the critical thinking and empathic tendencies of primary school students, emphasized the importance of these skills in terms of effective communication, adapting to society, demonstrating sensitivity to events and situations, and managing negative emotions as social skills. Similarly, during the action research period, it was determined that one of the most effective areas of creative drama activities was the development of students' empathy feelings. Also, Freeman et al. (2003) stated that the creative drama method improved self-concept, reduced problematic behaviors, and improved social skills in third and fourth-grade students. Abacı et al. (2015) investigated the effect of creative drama education on the social skills of adolescents and concluded that it was effective on the skills of doing and carrying out a task in a group, initiating and maintaining a relationship and self-control. Kara and Çam (2007) investigated the effect of the creative drama method on the social skills of pre-service teachers and found that it was similarly effective on their ability to do and carry out a task in a group, their ability to initiate and maintain relationships and their self-control. Similarly, Çalışkan Çoban (2007) used creative drama method in social skills training and according to teacher observation, improvement was observed in skills such as sensitivity, co-operation, self-control, social maturity in students' relationships with their friends. Arslan and Zengin (2016) investigated the effect of cooperative learning on scientific and social skills and found that cooperative learning had positive effects on social skills. Student opinions about the creative drama activities in the action research also support the findings of this study.

In the current study, students' opinions about the storytelling technique, which is another of the activities in the intervention program implemented during the action research process, are that it contributes to the development of social skills. The students participating in the study stated that story-reading activities contributed to the development of social skills such as coping with humiliation, respect for differences, empathy skills, coping with an embarrassing situation, awareness of peer bullying, understanding the feelings of others, coping with loneliness, coping with group pressure, helping others and respect for differences. Since a series of processes such as listening, thinking, asking questions, answering questions, and generating ideas come into play in story-reading activities, it is possible for students to gain new skills and activate different areas of development (Aksoy, 2014). Worksheets were prepared for the stories used in the study and questions were asked about the events and behaviors of the characters in the book. In the storytelling technique, the content of the stories read with children emphasizes the traits of the characters that solve problems effectively, behave positively and are helpful and sharing. Children are given the opportunity to share their feelings and thoughts, based on the problems experienced by the characters in the story, such as not being included in the game by their friends, wanting to be helped, helping others and coping with difficulties. No matter which story is used in the story-reading technique, the most important thing in the process is that the teacher takes every opportunity to encourage and reinforce the learning of social skills (Aksoy & Baran, 2020; Zhang, 2011). Aksoy and Baran (2020) concluded in their study that storytelling-based social skills training was significantly effective in the dimensions of communication and prosocial behaviors. Social stories emphasize cognitive development, social skills, emotional capacity, and self-regulation (O'Hara, 2010). Therefore, using the story-reading technique in the classroom also increases children's social competence. Social skills are fundamental competencies that facilitate individuals' lives and enable them to coexist harmoniously within society, starting from childhood. These skills are essential for individuals to navigate social interactions effectively within a community. Those with underdeveloped or inadequate social skills may face difficulties in maintaining societal harmony, potentially leading to communication breakdowns. Although the acquisition of social skills begins within the family, schools play a pivotal role in fostering and enhancing these skills (Karataş, 2020). Schools offer ideal settings for the acquisition and reinforcement of social skills. In this regard, the role of teachers is critically important. By designing programs and activities aimed at developing social skills, teachers can significantly contribute to students' adaptation to social life.

The findings of the study indicate that the intervention program implemented to enhance social skills was effective. Among the activities included in the program, the problem-solving wheel contributed the most to students' social skills, particularly in maintaining relationships, coping with aggressive behaviors, and solving problems. Creative drama activities showed positive effects on skills such as initiating and maintaining relationships, collaborating and conforming within a group, coping with aggressive behaviors, and emotional skills. Story reading activities were found to contribute to social skills such as coping with teasing, respecting differences, developing empathy, managing embarrassing situations, raising awareness about peer bullying, dealing with exclusion, coping with group pressure, and helping others. These findings highlight the significance and effectiveness of social skills education in the individual and social development of students. In conclusion, the intervention program developed in this study was found to contribute to addressing the social skill challenges faced by 4th-grade primary school students. It was also determined to be effective in improving students' communication, problem-solving, empathy, and emotional expression skills.

Suggestions

As a result of the research, the following recommendations have been presented to researchers and practitioners.

- In the final interviews with the teacher, it was stated that teaching social skills should start in the first grade. Considering that this study was conducted only with 4th-grade students, it is recommended that a similar study be conducted with 1st-grade primary school students as well
- According to the research findings, students used the problem-solving wheel when they experienced social problems throughout the term. According to the teacher, the application that contributed the most to the development of social skills was the problem-solving wheel. In this context, it is recommended that primary teachers use the problem-solving wheel starting from the 1st grade to support the development of students' social skills.
- The activity in which the inclusion student participated the most throughout the process is the creative drama activity. During this activity, it was observed that the student was involved in the process in harmony with his/her friends. The effect of creative drama on the development of social skills of inclusion students can be addressed as a separate study.
- The findings of the study are based on the opinions of the primary teacher and students. In future research, parents' opinions can be consulted to examine students' social skill development in environments outside the school.

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Appendices

Appendices 1. Student Final Interview Form

Name Surname:

Thinking about the problems you have experienced with your classmates in class, could you explain step by step the contributions of the activities we have done throughout the semester to your friendships?"

1. STEP:	2. STEP:	3. STEP	4. STEP:
What was your problem? Write it down below.	Which friend or friends did you have this problem with? Write the names of the friends you have problems with below	Think about the activities we have done throughout the semester below.	How did the activities you marked contribute to solving the problem you experienced? Can you explain
LIVED ISSUE:	**NAME/ NAMES:**	(He names of the activities are listed below)	The names of the activities / Its Contribution to me
		*Classroom problem Wheel	
		*Bob the Artist Book Story	
		*I Walk with Vanessa: A Picture Book Story	Its contribution to my friends: / What kind of contribution do you think you have made? Write Below.
		*Creative Drama Activities	
		(Have the activities above contributed to your experience of the problem? Circle the activities you think had an impact.	Write your friends' names below

Appendices 2. Storytelling Activity of "I Walk with Vanessa" the Silent Book Worksheet

Name-Surname: _____
Name of the Book: I Walk with Vanessa

Questions

1. You've read the book "I Walk with Vanessa". How do you think Vanessa felt in her first days at school? Please explain.

2. After school, you saw a student bullying Vanessa, who was new to the class, and upsetting her, have you ever experienced a similar situation in your school or elsewhere? Please tell us about it.

3. In the book you read, you saw a student who bullied, excluded, and hurt Vanessa, who was new to the class. You also saw a student who saw this situation and felt sorry for Vanessa.
What would you do if you saw someone else being bullied? Please tell us about it.

4. You have seen other children trying to support Vanessa by not being bystanders to her situation, how do you think this happened?
(How do you think this act of kindness started?)

Appendices 2. Continuous of Storytelling Activity of "I Walk with Vanessa" the Silent Book Worksheet

5. To behave aggressively towards another person, to make fun of them, to call them names, to put them in a difficult situation, to hurt them, to hurt them, all of these are called bullying.

Did you know that when you see someone being bullied, you can affect your other friends in the class or even other students at school with a single action?

6. Do you feel courageous about this? Ignoring someone who is being bullied or supporting them in a courageous way? Which do you think? Tick one of the following options.

- **I ignore it.**
- **I would be brave and support someone who is being bullied.**

7. When you see someone who is being bullied/hurt in the classroom, in the park, in your neighborhood or elsewhere, it may seem a simple act to act closer to them than usual, to put yourself in their shoes. However, did you realize how important it is for that person? By starting this act of kindness, you can influence your classmates and other students in your school and set an example for everyone.

List what you can do to save someone who is being bullied from that situation.

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Original Article

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Teaching cell division topic using computational thinking skills and determining its' impact on creative thinking skills and student perspectives *

Selen Şener Koruk [1], Elif Benzer [2]

Abstract

The aim of this research is to determine the impact of cell division teaching designed with computational thinking applications on the creative thinking skills and opinions of 7th-grade middle school students. The teaching design used in the research was created by taking inspiration from a study that provides application steps in the literature and was revised by the researcher. The research, which examines creative thinking skills in both quantitative and qualitative dimensions, was conducted based on the mixed methods design. The study group of the research consists of 39 students attending the 7th grade in two different classrooms of a state school located in the Kadıköy district of Istanbul province during the fall semester of the 2020-2021 academic year. Since the study was conducted during the pandemic period, it was carried out online. Throughout the implementing period, the teaching design integrated with computational thinking skills was done with the 21 students in the experimental group, while in the control group, consisting of 18 students, lessons were conducted according to the existing constructivist approach. Torrance Creative Thinking Test was used as the data collection tool in the quantitative dimension of the research, and a Creative Thinking Question and Semi-structured Interview were used in the qualitative dimension. The data obtained from the Torrance Creative Thinking Test were analyzed using the SPSS program, and it was determined that the implemented teaching design provided significantly enhanced creative thinking skills. Descriptive analysis was conducted on the data obtained from the creative thinking question in terms of flexibility, fluency, and lateral thinking, and it was observed that there was an improvement in students' creative thinking sub-skills and lateral thinking skills parallel to the quantitative findings. The data obtained from the semi-structured interview were analyzed using the MAXQDA program, and it was concluded that students found the teaching integrated with computational thinking skills more enjoyable and were able to easily integrate these skills into other subjects and daily life.

Keywords

Computational thinking skills
Creativity
Algorithm design
Cell division
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Introduction

Computational thinking has become a key competency in today's information-rich world, enabling individuals to tackle complex problems using strategies inspired by computer science. Throughout history, scientists have demonstrated forms of computational thinking as they systematically analyzed data, formulated hypotheses, and designed models to understand complex phenomena. Charles Darwin, for instance, employed such thinking in developing his theory of evolution; he meticulously collected data, identified patterns across species, and ultimately conceptualized the 'tree of life' to represent the branching relationships among organisms (Koruk, 2021). This historical example illustrates that computational thinking is not merely a contemporary skill, but one deeply embedded in scientific inquiry. Di Sessa (2001) exemplified Galileo's creation of the heliocentric view of the universe by dividing his ideas into sub-steps such as speed, time, and distance, which can be considered as instances of computational thinking skills. The utilization of computational thinking skills by scientists during significant historical discoveries highlights the importance of integrating computational thinking skill applications in science education. Furthermore, with the recognition of computational thinking skill (CTS) as one of the essential skills individuals should possess in the 21st century, the studies focusing on how to teach this skill and integrate it into the existing curriculum have gained significance (Voogt and Roblin, 2012).

Computational thinking can be defined as "a set of skills that assist in solving complex problems or designing large and complex systems" (Wing, 2006, p. 33). Based on this definition, it can be said that computational thinking processes involve the use of versatile sub-skills and the formulation of solution paths for problem-solving (Kert, 2017). The fundamental aim of teaching CTS is not to make individuals think mechanically like machines but to enhance their intellectual skills, enabling them to transfer this high-level skill to various areas of their lives and establish multidimensional thinking processes (Wing, 2010). Furthermore, Wing's (2006) assertion that biologists can benefit greatly from this thinking skill underscores the integration of computational thinking in the teaching of cell division, which is one of the points of support in this research. In this context, Peel et al. (2019) designed and implemented the teaching of the concept of natural selection using computational thinking skills, and as a result, they found that students were able to learn the concept of natural selection more profoundly, and misconceptions regarding the topic disappeared. This study by Peel et al. (2019) represents one of the significant works supporting Wing's claim.

Weintrop et al. (2016) discussed four different application paths for integrating computational thinking skills with science and mathematics disciplines. These paths include data applications, modeling and simulation applications, problem-solving applications based on computational thinking skills, and thinking practices related to systems. In this study, the teaching design was created by adding a data application step to the modelling and simulation-based lesson plan proposed by Peel and Freidrichsen in 2018.

There are both differences and similarities in the identification of the sub-skills, i.e., components, of computational thinking. The computational thinking sub-skills used in this study are abstraction, algorithmic thinking, iteration, branching, and variables. According to Wing (2010), the key skill of computational thinking is abstraction. Wing (2010) defined abstraction as the skill of identifying patterns in a problem, making generalizations from examples, and formulating data. Computing At School (CAS) described abstraction as the process of reducing unnecessary details to make a work more understandable (2015, p. 7). An example given for this process is the London Underground map: "London is a complex city. The London Underground map is a refined abstraction that allows travelers to navigate underground without unnecessary information such as distance and exact geographical location" (CAS, 2015, p. 7).

Wing (2006) claimed that within 50 years, computational thinking would become one of the essential skills that everyone should possess, similar to basic skills such as counting and reading. The computational thinking activities conducted from preschool onward, the announcement of the creation

of a subsection within the Programme for International Student Assessment (PISA) 2021 Mathematics section that includes questions involving computational thinking skills (The Organization for Economic Cooperation and Development [OECD], 2018), and the widespread integration efforts of computational thinking across various domains further reinforce Wing's claim. While studies focusing on computational thinking are increasing, they tend to primarily focus on coding, robotics, programming, STEM, and computer games (Akkaya, 2018; Altın, 2021; Bolat, 2020; Ceylan, 2020; Oluk et al., 2018; Şimşek, 2018). In this study, computational thinking skills are utilized in the context of scientific process explanations, and cell division teaching was designed with CTS applications. Thus, this research is expected to contribute to the literature by addressing an underrepresented area. Furthermore, the study proposes practical steps and a draft instructional design that allows science teachers to integrate computational thinking with topics and learning outcomes of their choice, indicating the practical relevance of the study in the field of education.

Creativity is a process that encompasses characteristics such as flexibility, the ability to see from different perspectives, sensitivity, awareness, and engagement with the environment and people, fluency, the ability to think and act flexibly, quickly, and independently, originality, and ability to arrive at different and diverse outcomes (Bilge & Erdoğan, 2011). De Bono (2003) defined creativity as a system that generates and structures knowledge in various ways. De Bono emphasized the importance of lateral thinking as an essential aspect of creative thinking. To De Bono, lateral thinking is the conscious and deliberate inclination to consider events from different perspectives and is closely connected to creativity (De Bono, 1986). On his website, which provides information about lateral thinking, De Bono described lateral thinking as a thinking style that recognizes the nature of one's own thoughts and explores a wide range of possibilities to discover the original. He emphasized the significance of lateral thinking over vertical thinking with the statement: "Digging the same hole deeper does not create a different hole (De Bono, n.d.).

Creative thinking skills, which are accepted as one of the 21st-century thinking skills, are sometimes expressed as part of computational thinking in some studies (Partnership for 21st Century Skills [P21], 2009). For example, Brennan and Resnick (2012) identified creativity as one of the six sub-skills of computational thinking. Additionally, Sternberg and Lubart (1993) mentioned that creative individuals enjoy formulating problems and deriving different rules, which can be directly related to the key computational thinking skill of abstraction. This study aims to determine the impact of computational thinking skill applications on creative thinking skills and test this inference.

Based on these considerations, this study aims to investigate the impact of teaching cell division using computational thinking skill applications on the creative thinking skills of 7th-grade middle school students, as well as evaluate the students' perspectives during this process. The research problem is formulated as follows: "What is the effect of teaching cell division using computational thinking skill applications on the creative thinking skills of middle school students?" The following research questions were addressed:

1. Does teaching cell division using computational thinking skill applications have an impact on students' creative thinking skills?
    a. Do the creative thinking skills of students in the experimental group, where teaching cell division is conducted using computational thinking skill applications, differ from those of the control group, where teaching is carried out according to the existing curriculum, in terms of groups (experimental-control) and measurements (pre-test-post-test)?
    b. What is the effect of teaching cell division using computational thinking skill applications on the creative thinking skills of students in the experimental group?
2. What are the perspectives of students in the experimental group regarding the teaching of cell division using computational thinking skill applications?

Method

Model of the Research

This research was designed in accordance with the triangulation design (combination) of the mixed method. The design of the research was designated as the combination (triangulation) design owing to collecting qualitative and quantitative data simultaneously and independently of each other, combining the data to comment, and attaching equal importance to both two types of data (Creswell & Creswell 2017). In the quantitative part of the study, the pretest-posttest quasi-experimental design with a control group was used. At this point, the independent variable of the research is teaching science which is integrated computational thinking skills. The lesson design planned for the development of computational thinking skills includes applications of abstraction, algorithms, programming and development, data collection and analysis, as well as modeling and simulation. These applications were implemented through designing Scratch blocks, algorithm design and branching, creating graphs, and conducting Lightbot activities. The dependent variable is creative thinking. At the same time, the creative thinking skill of the students was evaluated qualitatively with the creative thinking question and pre- and post-application. At the end of the application, an interview was done to pinpoint the experimental group students' views towards the application.

Study Group

This study was executed with 7-grade students in a government secondary school in the sub-province of Kadıköy throughout the 2020-2021 academic year. The available classes were randomly chosen as the control and the experimental group. Even though the population of the classes was equal to 30 students for each, the population of the experimental group decreased to 21, and the control group to 18 because of students' absence. The experimental group includes 10 girls (%48) and 11 boys (%58); the control group has 11 girls (%61) and 7 boys (%39). "The 'Creative Thinking Question' and 'Structured Interview Questions' were applied to 8 voluntary students from the experimental group, who were identified as having high, medium, and low levels of school achievement and attendance, using the maximum variation sampling method." The 8 students from different levels of success, who were asked about the creative thinking question, were chosen in view of their grade point average and the suggestion of the subject teachers. It is a great advantage that the maximum variance sample method provides describing the study problem from a greater perspective depending on different conditions (Büyüköztürk et al., 2008). Voluntary participation forms were received from the students and their parents for all of the qualitative and quantitative scales.

Data Collecting Tools and The Process of Data Collection

To evaluate creative thinking in this study, the **"Torrance Test of Creative Thinking: Verbal Form A"** and a **"Creative Thinking Question"** were administered as pre-tests to eight students from the experimental group. Following the pre-tests, the topic of **cell division** was taught to the experimental group using **computational thinking activities**, whereas the same topic was taught to the control group using **activities from the standard textbook**. This intervention continued for **18 class sessions**. At the end of the instructional period, the **"Torrance Test of Creative Thinking: Verbal Form B"** and the **"Creative Thinking Question"** were administered again to the same eight students in the experimental group as post-tests. Meanwhile, **"Semi-Structured Interview Questions"** were used to gather the students' opinions on the computational thinking-based instruction. The researcher ensured that all eight students completed the interviews individually and in written form. Details regarding the quantitative and qualitative data collection tools used in the study are provided below.

Torrance Creative Thinking Test

In the literature, various ideas, and methods for evaluating creative thinking skills are suggested and there are even some researchers who say that creative thinking skills should not be evaluated (Kaygın & Çetinkaya, 2015). These different ideas caused to emerge different methods and views towards evaluating creative thinking skills. In this study, to evaluate the creative thinking skills of the groups quantitatively 'Torrance Creative Thinking Test', which is mostly accepted, and was developed by E. Paul Torrance and published by the USA in 1966 (Kaygın & Çetinkaya, 2015). This test

composes of four forms, Verbal Form A, Verbal Form B, Modal Form A, and Modal Form B. Verbal Forms A and B are parallel to each other and include 7 activities, which are asking a question, estimating the reasons, estimating the results, developing a product, usual usages, and 'given that'. These 7 activities are evaluated in three dimensions; fluency, flexibility, and authenticity (Avcu, 2014; Gölcük, 2017).

Adaptation of the Torrance Creative Thinking Test into Turkish and validity and reliability studies were conducted by Aslan (2001). The test was applied to 922 people ranging from kindergarten students to adults and Cronbach Alfa internal consistency coefficient value was found 0.50 at the lowest and 0.71 at most. To determine the internal validity of the seven sub-activities of the Verbal Creative Thinking Test, total items, excluding items, and item distinctiveness analysis were committed. At the end of the analysis, a significant difference in the level of $p<0.01$ was obtained in all verbal creative tests at all ages. To determine external validity, a series of analyses of criterion validity was also done. These analyses showed that the whole of the test is both valid and reliable for all ages (Aslan, 2001). Before the test was used in this study, necessary permission was received. In the study, the reliability analysis of the scale was done, and the value of Cronbach Alpha was determined as 0,882, 0,799, and 0,751 in the order of fluency, flexibility, and authenticity. The total layer Cronbach Alpha value was found as 0,935. This situation shows that this test is reliable also for this study.

The Creative Thinking Question

To determine the development of the student's creative thinking skills qualitatively, the creative thinking question 'If you want to use your pencil in a different way, how would you do it? (You can write all the ideas coming to your mind. It is expected you write something new and different) was prepared. While preparing the question, the validity of the question was evaluated with the help of expert opinion. To see the reliability of the creative thinking question, a pilot scheme was applied to 4 students with the expert opinion again. The data of the pilot scheme was evaluated in the context of fluency, flexibility, and lateral thinking by committing descriptive analysis. It was obtained that students could read, understand, and answer the question and the given time (20 min.) was enough. Fluency and flexibility were used as subdimension in the Torrance Creative Thinking Test. For this reason, the context of fluency, flexibility, and lateral thinking to evaluate the creative thinking question. Lateral thinking, a problem-solving approach introduced by Edward de Bono, encourages individuals to think outside traditional linear patterns and explore alternative solutions by challenging established assumptions and employing creative, non-sequential thinking processes (De Bono, 1970). Even if authenticity resembles lateral thinking, they are not the same. Authenticity is the answers are statistically scarce and in Torrance Creative Thinking Test if an opinion is scarcely thought, it increases the point of authenticity (Kim, 2006). This authentic idea might be vertical or lateral thinking. Lateral thinking is naturally thinking out of the box and springs to rarely mind that's why the possibility of being authentic is high. However, an idea that is produced by thinking vertically is accepted as authentic if it was thought by few people. In these circumstances, a relationship can be built between lateral thinking and authenticity, but they don't meet each other. Lateral thinking is expressed as the core of creative thinking by Edvard de Bono (De Bono, 1970).

Semi-structured Interview Form

To find the students' opinions towards teaching science integrated with CTS, the semi-structured interview form was applied to the experimental group of students. The semi-structured interview form comprises 6 open-ended questions that were prepared by the researchers and were finalized by receiving one's opinion of who the expert in the field is. The expert made suggestions like taking out the questions meaning the same, decreasing the number of the questions, and adding the 'Can you explain your answer?' expression to the questions to supply students to express themselves better. When these suggestions are considered, the number of questions in the interview form, which was formed with 25 questions at first, was decreased to 6 questions which are not boring and provide students to express themselves, and these 6 questions were applied in the custody of the expert.

The Applied Lesson Design

Before the application, the necessary permissions were received from The Provincial Directorate for National Education which the school is inhered in, and an ethics committee from a university. After receiving the permissions, the essential training was completed to comment on the Torrance Creative Thinking Test. After the permissions and the training, quantitative data was collected from the control group students 2 weeks before and 2 weeks after the application. Students were given 35 minutes to answer the Torrance Creative Thinking Verbal Form. Creative Thinking Question, one of the qualitative tools, was applied by a researcher to 8 students by giving 20 minutes 7 days before and 7 days after the application. The other qualitative data collection tool, the Structured Interview Form, was applied by a researcher to 8 students giving 30 minutes on the day of ending the application to find the students' opinions towards the application.

The lesson designs were applied online in both groups during the distance education because of the pandemic. The lesson design which was applied to the experimental group was structured with CTS applications and activities in the context of the 'Cell and Divisions' unit of 'Living Things and Life' subject. In the lesson design, the steps of lesson planning that were structured by CTS and consisted of the algorithm, abstraction, reiteration, and branching steps suggested by Peel and Friedrichsen (2018), and data practices were added to these steps. According to the literature, data practices underlie the computational thinking skill practices (Weintrop et al., 2016). Moreover, the lesson design, formed by adding the step of data practices, happens to involve the whole of abstraction, algorithm, programming, and developing, data collection and analyzing, modeling, and simulation practices that were used for the standards of computational thinking skill of Computer Sciences and Digital Literacy by MIT (K-12 Computer Science Framework Steering Committee, 2016). The lesson design, which was planned as two lessons at a time for 9 days in total, includes the applications of story exposition, designing the scratch block, designing and branching algorithms, and creating graphics. The teaching design is comprised of 5 steps: respectively structuring the concepts about the subject, exploring computational thinking skills with the light bot game, developing algorithms of cell division, creating scratch block design with these algorithms, and data practices. In the first step of the practice, the students perceive and structure the concept of the subject. In the second step, the students are provided with learning the concepts of CTS, algorithm, abstraction, reiteration, and branching with the Lightbot game.

Table 1. Computational Thinking Skill Components and Samples

Computational Thinking Skill Components	**Definition**	**Sample**
Algorithm	A series of steps or a description to solve a problem.	A recipe that tells how to cook a meal.
Abstraction	Simplifying the information and choosing the necessary parts.	When someone asks you what you did yesterday, you talk about the film you watched on Netflix, not you woke up, ate, or took a shower.
Reiteration	Repeating a series of steps until a condition is met.	Chew the food while eating your meal and swallow it. Repeat this action till you finish your meal.
Branching	Selecting a way in the conditions of 'if'.	Crossing the road at the traffic lights: cross the road if it is green, stop if it is red.
Variances	The variable value that is used to make programs worldwide.	The algorithm of our morning routine is getting up, taking a shower, getting dressed, and having breakfast. Here, clothes are variances, and it changes according to what we wear every day.

(Peel & Friedrichsen, 2018)

The students provide to create cell division algorithms by exploring the concepts; of the algorithm, abstraction, reiteration, branching, and variance over the Lightbot and with the help of the teacher and using these concepts, of which explanations are in Table 1. While the students are playing Lightbot and evaluating each other's algorithms, the teacher makes the students find out abstraction and reiteration and note them down with the arguments that the teacher starts. Later on, the students continue playing the game and make comments on each other's algorithms. Examples related to the concepts of abstraction and repetition in Lightbot are provided below in Figure 1.

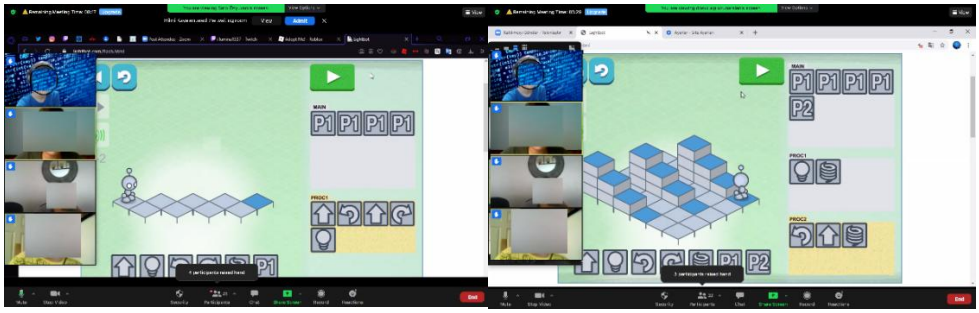

Figure 1. The Abstraction on Lightbot Game (P1 and P2 on the right) and Reiteration (P1 repetition on the left)

During the process of the teaching design, the lesson frame, which is applicable to every subject, of the teaching design, in which data practices were added, was formed, and this frame was shown in Table 2.

Table 2. The Lesson Frame Prepared by Using Computational Thinking Skill Applications

Day	Learning Activity	Objectives
1	Checking their prior knowledge, Implicating the concepts of the subject and teaching them.	The objectives of the subject area are acquired (subject area acquisition).
2	Prologuizing computational thinking with Lightbot game.	The students explore the concept of basic computational thinking skills, algorithm, abstraction, reiteration, and branching with the ways of problem-solving they use in a programming game (acquisition of computational thinking skills).
3	Application of computational thinking skill: Developing algorithms	The students develop the algorithm showing the process regarding the text or the video (acquisition of both subject area and computational thinking skills).
4	Application of computational thinking skill: Programming the algorithms with Scratch	The students design a program on Scratch to simulate the algorithm they developed (acquisition of both subject area and computational thinking skills).
5	Application of computational thinking skill: Data practices	The students collect data about the number of cells and chromosomes during and after division concerning the problem given. Then, they transform the data into tables and graphics to visualize data (acquisition of both subject area and computational thinking skills).

By adding the content of the Cell Division unit into the frame of the lesson shown in Table 2, this frame was structured going with the objectives of the program for both mitotic and meiosis division. This frame was applied for 18 lesson hours for 9 days in total. Since the 2nd step that the Lightbot game was used was headed in the mitotic division, this step was not given a place in the meiosis division lesson design. In the circumstances, 10 lesson hours for 5 days of mitotic division and, 8 lesson hours for 4 days of meiosis division were designed. The committed teaching design was given in detail in Table 3.

Table 3. Cell Division Teaching Design Prepared by Using CTS Applications

Day	Teaching Design of the Experimental Group
1	Introduction to mitotic division, providing students to explore the concepts about the importance of mitotic division from a text and a visual.
2	Introduction to computational thinking with Lightbot game, the student levels up some in the game. Then, the teacher gives the samples and definitions which are stated in Table 1. By creating a discussion platform with the students, they are supplied with exploring the concepts of algorithms, abstraction, and reiteration in the game. The teacher gives the samples. The students continue playing, they create different algorithms and comment on each other's algorithms. While the game is going on, the teacher starts a debate about the concepts of computational thinking skills from time to time. The students are asked to give samples from their daily life. (Introduction to the algorithm, abstraction, reiteration, and branching concepts)
3	The students are divided into groups. The teacher reminds the students of the variable concepts, algorithm, abstraction, and branching done in the previous lesson, with the brainstorming technique. Later, every group is delivered a text telling the mitotic division procedure and the students create their own algorithms by using the computational thinking skill concepts, which they have learned, and show these concepts in their algorithms. In the remaining time, they comment on each other's algorithms.
4	The mitotic division algorithms that they created before are programmed with Scratch, like continuing the group work, and simulation is formed.
5	In the step of data practices of the mitotic division, the teacher provides the students use the skills of reading graphs, obtaining the formula inside the data (abstraction), and graphs reading with the activities and questions the teacher prepared beforehand. In this part, it is important to make homogeneous groups.
6	Introduction to the meiosis division, the importance of the meiosis division, and providing exploration of the relevant concepts.
7	The students are divided into groups. The teacher reminds the concept of the computational thinking skill, which the students explored with the Lightbot game, with the questions and answers technique. Later, the teacher plays the video talking about the meiosis division and shared the link to the video. The groups create their own meiosis division algorithms by using the concepts of the computational thinking skill, which they have learned for 40 minutes. In the remaining time, they comment on each other's algorithms. (The used video: https://www.youtube.com/watch?v=mF3HnE5eOUw&t=70s)
8	The meiosis division algorithms that they created before are programmed with Scratch, like continuing the group work, and simulation is formed.
9	In the step of data practices of the meiosis division, the teacher provides the students use the skills of reading graphs, obtaining the formula inside the data (abstraction), and graphs reading with the activities and questions the teacher prepared beforehand. In this part, it is important to make homogeneous groups.

In the control group, as in the experimental group, student-centered teaching was done for 18 lesson hours based on the objectives of the 2018 Ministry of National Education Science studies program. With the control group, brainstorming, group work, Web 2.0 tools (Learning apps), modeling practices, and solving skill-based questions were used and qualified teaching was planned to apply. In Table 4, the applications maintained for 18 lesson hours during 9 days with the experimental and the control group were given comparatively.

Table 4. The Applications Done with the Experimental and Control Group

Day	The Experimental Group Applications	The Control Group Applications
1	Introduction to the mitotic division, providing the exploration of the importance of the mitotic division and its concepts over a text and visual.	Introduction to the mitotic division, providing the exploration of the importance of the mitotic division and its concepts over a text and visual.
2	Introduction to computational thinking with Lightbot game (introduction to algorithms, abstraction, branching, reiteration, and variance concepts.)	To provide ordering the phases given tangled in the order of happening by using a certain logic in group work.
3	With reference to the text, the students create mitotic division algorithms by using the concepts they learned with the Lightbot game.	Forming the mitotic division phases over the Learning apps.
4	Programming the obtained mitotic division algorithms with Scratch.	The mitotic division deepening activities
5	The mitotic division practices (data collection, creating tables and graphs)	The course book evaluation work
6	Introduction to the meiosis division, providing the exploration of the importance of concepts about the mitotic division.	Introduction to the meiosis division, the importance of the meiosis division, providing the exploration of the related concepts
7	With reference to the video, the students create meiosis division algorithms by using the concepts they learned with the Lightbot game.	Providing an explanation of only the phases of which photos are given in the group work.
8	Programming the obtained meiosis division algorithms with Scratch.	The meiosis division deepening activities, modeling of the meiosis division by using waste materials from home.
9	The meiosis division practices (data collection, creating tables and graphs)	Solving skill-based problems of the Cell Division Unit

As stated in Table 4, with the applications done with the experimental group, students are provided to explore the computational thinking skills, algorithm, abstraction, reiteration, branching, and repetition sub-dimensions. Later, they are provided to reach the objectives of the cell division unit by using these sub-dimensions. With the applications done with the control group, acquiring only the objectives of the cell division unit was done by using the constructivist approach.

Data Analysis

Torrance Creative Thinking Test Analysis

The analysis of the Creative Thinking Test was conducted quantitatively with the help of the SPSS program. To determine the tests to be used in the program, the condition of normal distribution of data was first analyzed. Since the greatness of the group is less than 50, Shapiro-Wilk test results were given a place in Table 5.

Table 5. The Results of Normality Analysis of Torrance Creative Thinking Test Data of the Groups

Group	Test	Shapiro Wilk (p)
Experimental Group	Torrance Total Points Pretest	0,006
	Torrance Total Points Posttest	0,238
Control Group	Torrance Total Points Pre-test	0,515
	Torrance Total Points Posttest	0,467
Experimental Group	Torrance Total Points Pre-test	0,019
	Torrance Fluency Posttest	0,031
Control Group	Torrance Total Points Pre-test	0,311
	Torrance Fluency Posttest	0,323
Experimental Group	Torrance Total Points Pre-test	0,006
	Torrance Flexibility Posttest	0,224
Control Group	Torrance Total Points Pre-test	0,374
	Torrance Flexibility Posttest	0,513
Experimental Group	Torrance Total Points Pre-test	0,003
	Torrance Authenticity Posttest	0,111
Control Group	Torrance Total Points Pre-test	0,336
	Torrance Authenticity Posttest	0,242

As seen in Table 5, it was confirmed that the p values of flexibility and authenticity sub-dimensions in the experimental group creative thinking posttest and p values in every dimension of the control group pretest and posttest are greater than 0.05 and so the test data range normally. However, the experimental group's Torrance creative thinking skills pretest total point, fluency, flexibility, and authenticity sub-dimensions data does not show normal distribution. Considering this data, it was specified whether there is a significant difference between the points of the pretest of the experimental and the control group or not by committing 'The Mann Whitney U Test for Independent Groups'. It was specified if there is a significant difference between the fluency sub- dimension test points of the control group and the experimental group by committing again 'Mann Whitney U Test for Independent Groups'. Considering there is a significant difference between pretest points in the authenticity sub-dimension of the control and experimental group and do not range normally, it was specified if there is a significant difference between posttests of them by applying the 'ANCOVA Test'. It was determined if there is a significant difference between the points of other sub-dimensions in the control and experimental group posttests by applying the 't-Test for Independent Groups'. It was again specified if there is a significant difference in every dimension between the points of the pretest and posttest in the control group by using 'The Wilcoxon Signed Rank Test for the Dependent Group'. Considering the data in every sub-dimension of the control group showing normal distribution, the comparison of the points of the pretest and posttest was done by using 'the t -Test for Relevant Groups'.

Creative Thinking Question

The creative thinking question (If you wanted to use your pencil in a different way, how would you do it?) was analyzed by an expert lecturer excluding the researchers in the context of fluency, flexibility, and lateral thinking. Fluency represents the number of ideas produced by the student and is a sub-dimension used in the evaluation of the Torrance Creative Thinking Test. Every idea produced by the students was evaluated as 1 point and the total number of the ideas was accepted as fluency score. Flexibility represents how many different categories/fields the students produce ideas from and is again one of the dimensions used in the evaluation of the Torrance Creative Thinking Test. The ideas produced by the students were categorized and the number of the different categories was accepted as flexibility. Lateral thinking is a tendency of taking a different approach to events voluntarily and is closely related to creativity (De Bono, 1986). Here, the ideas of not tagging the pencil as just a lead pencil but using different kinds of pencils or using lots of pencils instead of one and using the inner side and outer side of the pencil separately are defined as lateral thinking ideas, and each of these ideas was evaluated as 1 point. Students' points of fluency, flexibility, and lateral thinking were compiled by

making tables and analyzed integratively. Before and after the application, students' answers to the creative thinking questions were evaluated and compared in the determined categories. And their progress in creative thinking skills was obtained and explained qualitatively.

Semi-structured Interview Question

The content analysis of the form containing 6 open-ended questions was done by using the MAXQDA program. The Word files including the students' answers to the interview form one by one were uploaded to the program and first, the codes about which the researchers come to an agreement, then the themes were determined. After that, the shapes showing the codes and themes in the creative coding part were organized and presented in the findings.

In Table 6, each measurement tool with the research questions, the research method, and the analysis method of the data were matched and summarized.

Table 6. Research Question and The Period of Data Analysis

Research Question	**Study Group**	**The Measurement Tool**	**The Research Method**	**The Analysis Method**
Research Question 1: a) Does it differentiate the creative thinking skills of the experimental group which was taught cell division subjects integrated with computational thinking skills and the control group which was taught in the existing teaching program according to the groups (control and experimental) and evaluations (pretest and posttest)?	The Experimental and Control Group	Torrance Creative Thinking Scale	Quantitative Research	t-Test for Independent Groups t-Test for Independent Groups Mann Whitney U, Wilcoxon Signed Ranks Test, ANCOVA Test
"What is the effect of integrating cell division instruction with computational thinking skills on the creative thinking abilities of students in the experimental group?"	8 students chosen from the experimental group	Creative Thinking Question	Qualitative Research	Descriptive Analysis
Research Question 3: What are the experimental group students' views towards the lesson design done by integrating the cell division subject into the computational thinking skills?	8 students chosen from the experimental group	Semi-structured Interview Form	Qualitative Research	Content Analysis

In Table 6 the research question and research method were displayed separately but explained by correlation in the 'Result and Discussion' part. The findings of 1st and 2nd research questions which requires evaluating creative thinking skill qualitatively and quantitatively were interpreted in the same context. Besides, the Findings of the Semi-structured Interview Form in the Result and Discussion part were explained with its relationship with the other research questions. Grover et al. (2015) stated the necessity of using more than one data collection method while evaluating complex upper-level skills. In the study done by taking this suggestion into consideration, the 'Creative Thinking Question', which was analyzed with a qualitative method and creative thinking test, was used to evaluate the progress of creative thinking skills.

Internal and External Validity of the Research and Ethics

First, the necessary permissions were received from Marmara University Ethical Committee to commit the research and with this permission, to apply the data collection tools to secondary school 7th-grade students, the necessary permissions were obtained by the İstanbul Provincial Directorate of National Education. This study was based on voluntary and highlighted by the researcher frequently. The Participation Form based on both students' and parents' declarations was prepared and delivered to the students who took part in the research and their families. Within the form, the aim of the research was clearly stated. The students' faces were not included at all in the research. The analysis of reliability and validity of all the data collection tools used in the research were given below the data collection tools heading of the method part.

Results

In this part, the results of the analysis done for pretest points of the groups were given in Table 7 with the aim of determining whether the pre-application creative thinking skills of the experimental group and control group vary between the groups or not. Later, the obtained findings in accordance with the research questions were displayed.

Table 7. Fluency, Flexibility, Authenticity and TYDT Pretest Points of the Experimental and Control Groups Mann Whitney U Results for Independent Groups

Type and Dimension of the Test	Group	N	Mean Rank	Rank Sum	U	p
Verbal A Form Fluency	Experimental group	21	18,48	388,00	157,000	0,366
	Control group	18	21,78	392,00		
Verbal A Form Flexibility	Experimental group	21	17,93	376,50	145,500	0,219
	Control group	18	22,42	403,50		
Verbal A Form Authenticity	Experimental group	21	16,60	348,50	117,500	0,043
	Control group	18	23,97	431,50		
Verbal A Form Medium Creativity	Experimental group	21	17,45	366,50	135,500	0,131
	Control group	18	22,97	413,50		

With reference to the data of the TYDT pretest in Table 7, it is seen that there is not a significant difference between mean creativity points and points of fluency and flexibility sub-dimensions of the experimental and control group students ($p_{fluency,\ flexibility,\ creativity}>0,05$), besides, between the points of authenticity sub-dimension points, a significant difference is seen for the good of the control group ($p_{authenticity}<0,05$).

The findings of the research question 'Do the creative thinking skills differ according to the measurements (pretest and posttest) and the groups (experimental and control), which the experimental group is taught cell division subject with a lesson design integrated with computational thinking skills and the control group is taught with the existing teaching program?' were presented in four tables for the tests are different from each other. For the comparison of the experimental and control groups, the findings of the general result of TYDT and flexibility sub-dimension were shown in Table 8, the fluency sub-dimension was in Table 9, and the authenticity sub-dimension was in Table 10. For the comparison of the evaluation within the groups, the experimental group comparison was given in Table 11, the control group comparison was in Table 12.

Table 8. t-Test results for the independent groups about the Experimental and Control Group Students' TYDT Verbal Form B Posttest Flexibility Sub-dimension and Their Mean Points

Type and Dimension of the Test	Group	N	$\bar{x}$	S	sd	t	p
Verbal B Form Total Point	Experiment	21	21,92	11,52	37	2,90	0,00
	Control	18	13,33	5,25			
Verbal B Form Flexibility	Experiment	21	17,90	8,44	37	2,25	0,03
	Control	18	12,88	4,57			

While the experimental group TYDT mean creativity point is $\bar{x}$=21.92, the control group's is $\bar{x}$=13.33. The mean point of flexibility is $\bar{x}$=17.90 for the experimental group and $\bar{x}$=12.88 for the control group. In Table 8, concerning TYDT post-test data, it is seen there is a significant difference for the good of the experimental group between the experimental and control group students in the mean creativity points ($p<0.05$) and flexibility sub-dimension points ($p<0,05$).

Table 9. The Mann Whitney U results for the independent groups about the Experimental and Control Group Students' TYDT Verbal Form B Posttest Fluency Sub-Dimension Points.

Group	N	Mean Rank	Rank Sum	U	p
Experiment	21	22,55	473,50	135,50	0,13
Control	18	17,03	306,50		

In Table 9, with the reference to TYDT posttest fluency data, it is seen there is not a significant difference between the experimental and control group students' fluency sub-dimension points ($u=135,500$, $p>0,05$).

Table 10. The Ancova Results of Authenticity Sub-dimension Posttest Points Arranged According to the Experimental and Control Group Students' TYDT Verbal Form B Pretest Points

Source of the Variance	Sum of Squares	sd	Mean Squares	F	Significance Level (p)
Pretest	2300,901	1	2300,901	34,725	,000
Group	2300,901	1	2300,901	34,725	,000
Fault	2451,665	37	66,261		
Total	4752,565	18			

The experimental group authenticity posttest mean of the total point is $\bar{x}$=17.61, and the control group authenticity posttest mean point is $\bar{x}$=6.27. In Table 10, with the reference to TYDT posttest authenticity data, it is seen there is a significant difference for the good of the experimental group between the experimental group and control group's fluency sub-dimension point of creative thinking ($F= 34.725$; $p<.05$).

Table 11. The Results of Dependent Groups Wilcoxon Signed Rank Test related to the Experimental and Control Group Students fluency, flexibility, authenticity and TYDT Pretest- Posttest Points

Sub-dimension		N	Mean Rank	Rank Sum	z	p
Fluency	Positive order	20	11,50	230,00		
	Negative order	1	1	1.00	3,981	,000
	Equal	0				
Flexibility	Positive order	19	11.87	225.50		
	Negative order	2	2.75	5.50	3.830	,000
	Equal	0				
Authenticity	Positive order	21	.00	.00		
	Negative order	0	11.00	231.00	4,015	,000
	Equal	0				
Medium	Positive order	20	11.50	230.00		
Creativity	Negative order	1	1.00	1.00	3,980	,000
	Equal	0				

With reference to the TYDT data in Table 11, between the pretest and posttest points of the experimental, in every sub-dimension (fluency, flexibility, authenticity) and its mean creativity points, it is stated there is a significant difference for the good of the posttest ($p_{all}<0.05$). According to the data obtained from the test, in the experimental group fluency sub-dimension, 20 students increased their pretest points, and only one student decreased them. There is a significant difference between fluency posttest and pretest points for the good of the posttest (z=3,981, p<,05). In the flexibility sub-dimension, 19 students increased their pretest points, and 2 students decreased them, and there is a significant difference between the experimental group flexibility pretest and posttest points for the good of the posttest (z=3,830, p<,05). In the authenticity sub-dimension, 21 students increased their pretest points and there are no students who decreased them. There is a significant difference between the experimental group authenticity pretest and posttest points for the good of the posttest (z=4.015, p<0.05). When the mean creativity points are considered, 20 students increased their pretest and 1 student decreased them, and there is a significant difference between the experimental group mean creativity pretest and posttest points for the good of the posttest (z=3.980, p<0.05).

Table 12. t-Test Results for Related Groups Related to The Control Group Students' Fluency, Flexibility, Authenticity and TYDT Pretest -Posttest Points

Sub-dimension	Measurement	N	$\bar{x}$	S	sd	t	p
Fluency	Pretest	18	16,05	6,91	17	2,426	0,027
	Posttest	18	20,83	9,01			
Flexibility	Pretest	18	11,38	4,57	17	1,374	0,187
	Posttest	18	12,88	3,98			
Authenticity	Pretest	18	8,77	5,53	17	1,917	0,316
	Posttest	18	6,27	3,87			
Medium Creativity	Pretest	18	12,07	4,98	17	1,033	0,316
	Posttest	18	13,33	5,25			

Considering TYDT data in Table 12, it is stated there is a significant difference between fluency pretest and posttest points of the control group for the good of the posttest (p<0.05), and there is not a significant difference between pretest and post-test points of flexibility, authenticity and mean creativity (p>0.05). The mean of the fluency post-test ($\bar{x}$=20,83) in the control group is found higher than the mean of the pretest ($\bar{x}$=6,91) and according to the result of the committed t-test, the significant difference was found for the good of the posttest (t=2.42; p=0.027). The mean of the flexibility posttest of the control group ($\bar{x}$=12,88) is greater than the mean of the pretest point ($\bar{x}$=11,38); however, the difference is not significant according to the result of the committed t-test (t=1,37; p=0,187). The mean of the authenticity posttest in the control group ($\bar{x}$=6,27) is less than the mean of the pretest ($\bar{x}$=8,77); however, the difference is not significant according to the result of the committed t-test ama (t=1,91; p=0,316). The mean of the average creativity posttest points of the control group ($\bar{x}$=13,33) is greater than the mean of the pretest ($\bar{x}$=12,07); however, the difference is not significant again according to the result of the committed t-test (t=1,03; p=0,316).

The answers that were given to the research question ''What is the effect of the lesson design created by being integrated the computational thinking skills with the cell division subject on the experimental group students' creative thinking skills?'' and "If you wanted to use a pencil in a different way, how would you do it?'' (Table 13) and the analysis of it in terms of creative thinking (Table 14) was given in the following.

Table 13. The Students' Answers to the Question Before and After the Application

Student	The Answers Before the Application	The Answers After the Application
S1	• Making an item searching for fingerprints by mixing some graphite with some iron filling	• As a dart by sharping the penpoint • Transforming the graphite into graphene and using it in nanotechnology • An electrolyze experiment with pencils • As a chair by using many pencils
S2	• Sculpture study • A monument made with ink	• As a statue • Producing new colors with the color of the pencil • As a computer mouse
S3	• A lantern	• Being able to write both on a piece of paper and a computer • As a camera • As a visual image opener
S4	• Lamp	• Christmas tree ornaments • As a pencil box by breaking some pencils and then joining them with the help of silicon
S5	• A cable	• I would use it as a smart pen like a smartwatch • As a sheet of paper
S6	• A hairclip • A ruler	• As a hairclip • As a measurement tool
S7	• Shape of a rose	• As a pencil including lots of different colors • As a box that can be opened from both sides
S8	• A pencil that has its point inside	• As a pencil that has one side of a pen and the other side of a pencil • As a pencil that has one side of a pen and the other side of a pen eraser

In Table 13, it is seen that the students cannot produce many ideas, and lateral thinking skill is used little before the application. It is seen that the students can produce more ideas comparing the period before the application and lateral thinking skill is again used more than the period before the application.

To create a clear image, the answers given before and after the application were handled in the context of fluency, flexibility, and lateral thinking one by one, and Table 14 was formed.

Table 14. The Analysis of the Students' Answers in the Context of Fluency, Flexibility, and Lateral Thinking Dimensions of Creative Thinking, Before and After the Application

Student	Before the Application			After the Application		
	How many ideas did she produce? (Fluency)	How many different dimensions did she think of? (Flexibility)	Using the inner and outer sides of a pencil for different purposes, dividing a pencil, or using more than one pencil (Lateral Thinking)	How many ideas did she produce? (Fluency)	How many different dimensions did she think of? (Flexibility)	Using the inner and outer sides of a pencil for different purposes, dividing a pencil, or using more than one pencil (Lateral Thinking)
S1	1	1	+	4	4	+2
S2	2	1	+	3	3	+
S3	1	1	-	3	2	-
S4	1	1	-	2	2	+
S5	1	1	-	2	2	-
S6	2	2	-	2	2	-
S7	1	1	-	2	2	-
S8	1	1	-	2	1	-

It was seen that 6 students out of 8 produced 1 idea, and only 2 of them could produce 2 different ideas before the application. It was found that 1 student out of 8 could produce 2 different ideas in the flexibility category and the other 7 students could produce only 1 idea in the flexibility category. Besides, only 2 students used expressions including lateral thinking once for each. After the application, it was seen 1 of the 8 students produced 4 ideas, 2 of them produced 3 ideas each, and the left 5 students produced 2 ideas each. It was decided that one of the students produced ideas in 4 different flexibility categories, one produced idea in 3 different flexibility categories, 5 of them produced in 2 different flexibility categories, and 1 of them produced in 1 flexibility category. Besides that, 1 student used expressions including lateral thinking skills twice, and 3 students in total used an expression including lateral thinking skills.

The findings regarding the interview question asked in the research ''What are the experimental group students' ideas about the lesson design created by being integrated the computational thinking skills with the cell division subject?'' are as the following.

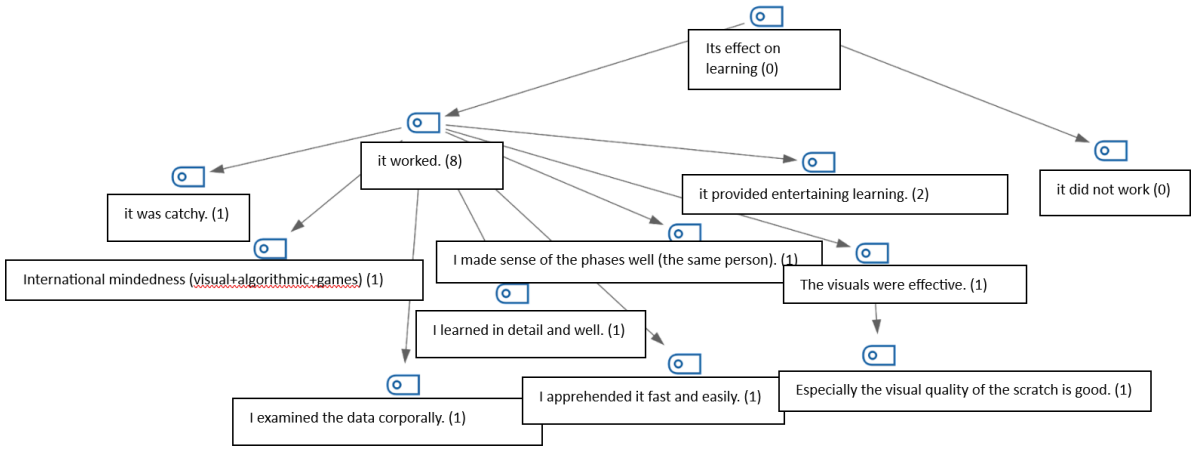

Figure 2. It shows the Views Towards the Lesson Design Created by Being Integrated with CTS According to the Number of the Coded Parts

All 8 students who were interviewed stated that the lesson design contributed to their learning of the subject. The students explained this positive effect in the context of making learning persistent, providing international mindedness, providing examining the data corporally, making learning the subject in detail and well, making sense of the phases of division better, happening learning fast and easily, providing entertaining learning, and the effect of the visuals.

"Would you like the whole science lessons to be taught over the applications focused on computational thinking skills? Whatever your answer is, can you explain your reason?'' The students' answers towards implementing science lessons with computational thinking skills and their views about the reason for the answers are as the following.

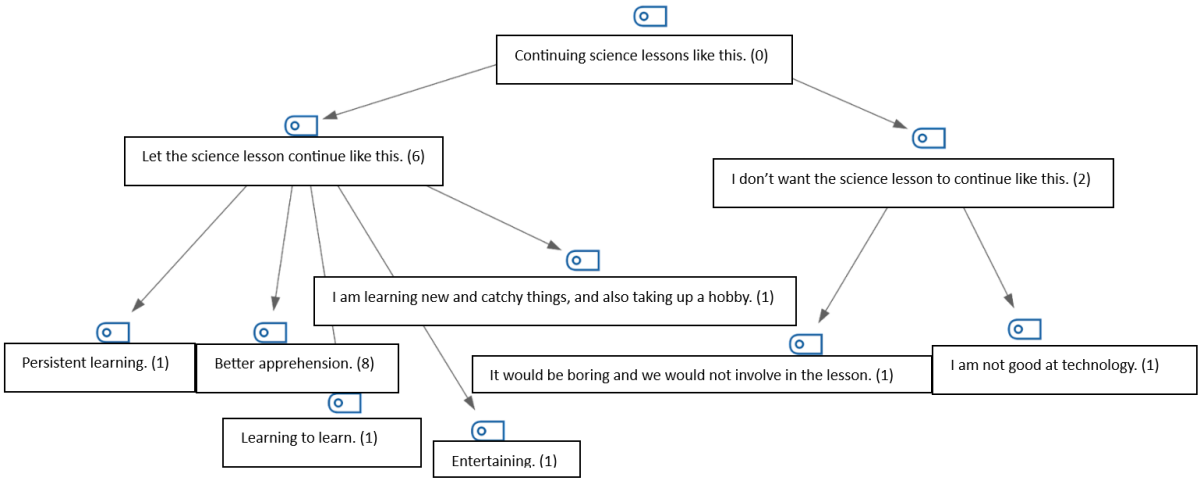

Figure 3. It shows the views towards using CTS design in science lessons continuously according to the number of coded parts.

6 students of 8, who were interviewed, stated that they would like the science lessons to be implemented over the applications focusing on computational thinking skills, but 2 of them wouldn't. the 6 students, who would like the science lessons to be done with these applications all the time, stated their reasons as the topics become catchier and apprehension gets easy, providing learning how to obtain data, becoming the lessons more enjoyable, learning interesting new concepts, providing taking up new hobbies. The students, who would not like the lesson to be implemented with these applications, explained their reasons as they are not good at technology, and thinking of using the same application continuously can make it boring.

"What is your favorite feature of the lessons focused on computational thinking skills? Why? The students' views towards their favorite feature of the lesson focused on computational thinking skills and what are their reasons as follows.

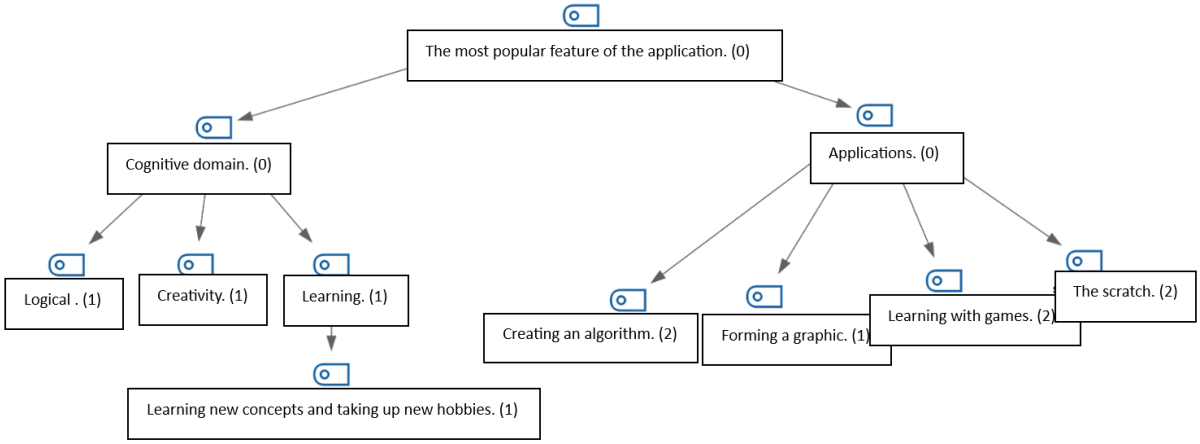

Figure 4. It shows the views towards the popular features in CTS design according to the number of coded parts.

The students stated their favorite features of the lesson design focusing on computational thinking as; having a more enjoyable lesson for two students, creating algorithms makes learning easier for two students, involving the usage of Scratch for two students, involving creativity, and forming graphics for one student, providing obtaining new hobbies and concepts for one student. When the students' comments are classified, the most highlighted features are the applications that take place in the lesson design and the cognitive effect of the lesson design. Hence, it can be deduced that the students could absorb the applications in the lesson design and acquire the facts and concepts of science lessons by using these applications.

"Would you think that you will be able to use a program like Scratch to learn Science lessons?" The students' answers to the question if they think of using a program like Scratch to learn Science lessons or not beforehand are presented in Table 15.

Table 15. Expecting the Use of the Scratch in Science Lessons in Advance

Views	**The number of individuals (Frequent)**
I expected.	6
I didn't expect it.	2

6 students out of 8 who are interviewed stated they expected the usage of the Scratch program in science lessons, and 2 of them didn't expect it. One of the students who expected the usage of the Scratch program in science lesson learning stated the lesson happened more useful and more enjoyable. This shows us that the students had already used the scratch program before the application.

"Before and after this application, did any changes happen in your thoughts about scratch block-based coding program? If you answer yes, can you explain the reason?" The students' point of view about these changes in their thoughts towards the Scratch program and what the change is, are as follow.

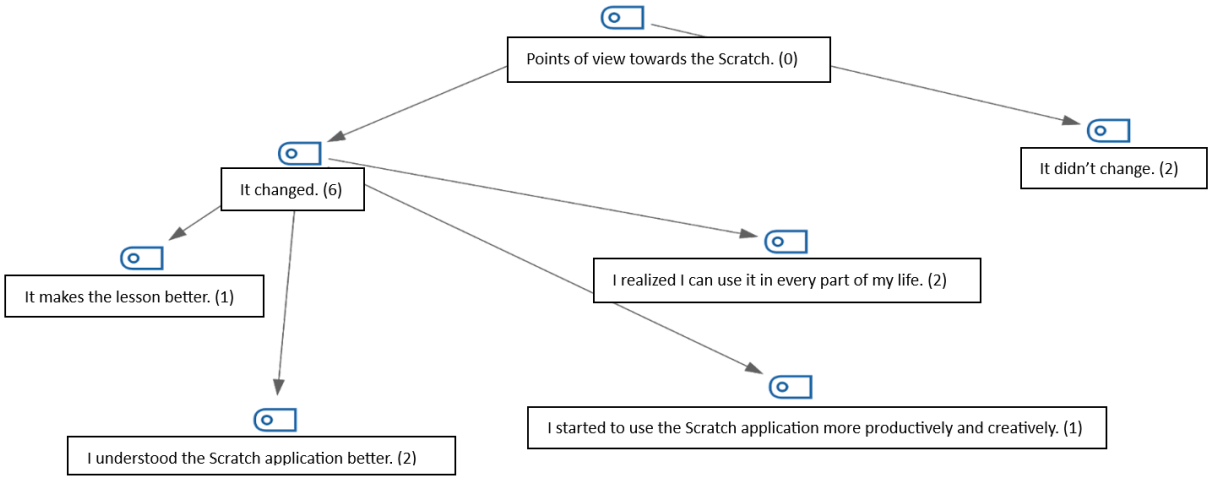

Figure 5. It shows the changing point of view towards the Scratch program according to the number of coded parts.

6 students of the 8 who were interviewed stated their point of view towards the Scratch program has changed. One of the students remarked this change made the lesson better, 2 of them understood the application better by force of the lesson, 2 students learned that they benefit from the application in many parts of their life, and 1 student stated using the program provides them to be creative and productive. The 2 students, who said it did not change, stated they had been using the application intensely and actively before.

"Have you ever thought, recalled, or associated the algorithmic designs that we did in the lesson design based on computational thinking in the other subject or daily life events? If you did, can you explain these events and lesson subjects?'' In Table 16, students' answers if they transferred the algorithmic designs, which were used during subject teaching based on computational thinking skills, to the other lessons or daily life or not, and if they did it, which lessons or events they transferred to were given.

Table 16. Transferring The Algorithmic Designs Used in the Application to the Other Lessons and Daily Life

Views	**The Number of People**
I started to use algorithmic designs in my daily life and other lessons.	3
I use algorithmic designs in my daily life.	1
I use algorithmic designs for science lesson revision.	1
I did not use algorithmic designs in my daily life and other lessons.	3

3 students of 8, who were interviewed, stated that they use the algorithmic designs both in their daily lives and the other lessons, 1 of them uses them in their daily lives, and 1 of them uses them while revising science lesson subjects. 3 of the students said that they could not associate the algorithmic designs with their daily lives and the other lesson subjects. One of the students who stated that they use them in their daily lives told that she creates an algorithm for the things to do after the lessons. One other student told she discovered that every action has its own algorithm. One student expressed the use of algorithms in daily life '*I tried to create an algorithm of the way to reach home by stairs.'* One of the students who stated that she uses the algorithmic designs with other lessons told '*I used them in finite verbs subject of Turkish lesson, with present perfect-past simple tenses and subjects which take have or has in English lesson.* The other one stated her usage in the drawing lesson as writing *'' the phases of drawing''* in the interview form. One student only stated that she started to use algorithmic designs in the other lessons.

Results, Discussion, and Recommendations

- Does teaching cell division using computational thinking skill applications have an impact on students' creative thinking skills?

Results and Discussion related to the research question:

Based on the data from the Torrance Creative Thinking Test, it was determined that teaching designed with computational thinking skills positively influenced students' creative thinking skills. Significant increases were observed in the flexibility and particularly originality sub-dimensions of creative thinking in the experimental group, indicating that these improvements could not be achieved through the existing constructivist approach. The International Society for Technology in Education (ISTE) and the Computer Science Teachers Association (CSTA) have stated that computational thinking may not encompass creative thinking skills but can contribute to their development (Seehorn et al., 2011). Similarly, this study found that computational thinking skills applications enhance creative thinking skills. Acar (2022) also concluded in their study that computational thinking-based science activities enhance students' scientific creativity.

No significant difference was observed in the fluency sub-dimension of creative thinking between the experimental and control groups. It was determined that fluency, which refers to generating a large number of ideas rapidly, can be developed through both the existing constructivist system and teaching designed with computational thinking skills. However, it should be noted that the development of fluency alone is not sufficient for the enhancement of creative thinking skills. In this context, De Bono (1986) emphasized the importance of lateral thinking, which involves exploring the different instead of the existing, for creative thinking. Lateral thinking is closely associated with the originality and flexibility sub-dimensions of creative thinking.

The data obtained from the creative thinking question were analyzed in terms of flexibility, fluency, and lateral thinking. It was found that teaching designed with computational thinking skills improved students' flexibility in terms of generating thoughts from different categories. Additionally, there are other data obtained regarding that students also showed improvement in fluency. These quantitative findings align with the qualitative data. Lateral thinking, which focuses on discovering new and different ideas instead of existing ones, was evaluated in terms of responses that transcend boundaries, such as the use of the inside and outside of a pen, breaking the pen, and using multiple pens. Prior to the implementation, it was determined that students had weak lateral thinking skills and could hardly generate ideas. After the implementation, although more responses were produced in terms of lateral thinking, it was found that many students still struggled to generate ideas. This indicates the need for more studies that focus on lateral thinking.

Both qualitative and quantitative findings indicate that teaching based on computational thinking skills enhances creative thinking skills. Ogegbo and Ramnarain (2022) analyzed all studies that utilized computational thinking skills in science education and found that such teaching methods attracted students' interest and led to engagement in creative activities. This finding aligns with the results of this research. The literature also emphasizes the key role of creative thinking in Scratch applications, which are known for their focus on analysis (Romero et al., 2017). In this study, a modeling activity was conducted using Scratch, and significant improvement in algorithm writing, Scratch design, and graphic creation skills was observed by the researcher during the topic transition from mitosis to meiosis.

- What are the perspectives of students in the experimental group regarding the teaching of cell division using computational thinking skill applications?

Results and Discussion related to the research question:

Based on the Semi-structured Interview data, all students stated that teaching designed with computational thinking skills facilitated a better understanding of the topic. They mentioned that they

learned cell division thoroughly, comprehended the stages of division more easily, and enjoyed faster learning. İskender (2007) found in his study on teaching mitosis and meiosis using animations that students perceived the lessons as enjoyable, interesting, and more understandable. Similarly, the utilization of Scratch animations in this study may have contributed to similar results.

A majority of the interviewed students expressed a desire for all science lessons to be conducted in the same enjoyable manner, as they believed that this teaching style facilitated better learning. A small number of students preferred the traditional teaching method, and these students were characterized by low-class participation and inadequate academic performance. They attributed their disinterest to their poor relationship with technology. A significant number of students mentioned that they transferred the algorithm design skills they learned through the application to other subjects and daily life. Those who transferred the skills mentioned using them to determine verb tenses and suffixes in their English lessons, such as distinguishing between "have" and "has." Students who applied the skills in their daily lives mentioned creating algorithm designs to navigate their way home from stairs. The ability of students to transfer knowledge demonstrates the successful conceptualization of computational thinking skills through the implemented teaching (Doruk & Umay, 2011).

The current research has two main limitations. The first limitation is that the research was conducted in a public middle school located in the Kadıköy district. Therefore, it is unknown whether the results would be valid in schools with students from different socio-cultural backgrounds. The second limitation concerns the implementation process of the study, which was carried out online. It remains uncertain whether similar effects would be observed if the implementation were conducted in a face-to-face educational setting.

International exams like PISA, which assess higher-order thinking skills, often reveal that our students do not perform as expected and usually excel only in knowledge-based questions. By enhancing students' thinking skills, we can enable them to achieve more meaningful results in such exams and in their lives. Based on the results obtained from the research and the observations made by the researcher during the implementation, the following recommendations are provided for future researchers:

1. Teaching complex topic contexts, particularly those that are difficult to comprehend, using teaching methods designed with computational thinking skills can enhance topic clarity.
2. The most challenging part for students in the implemented teaching design was the data applications step, particularly activities involving graph reading and data visualization. It would be beneficial to ensure students' readiness in graph reading and data visualization prior to data applications.
3. The implemented teaching design incorporates computational thinking skills, and CTS are high-level skills. While this motivates academically strong students who are proficient in thinking skills, it can cause disengagement in academically weak students. To address this, level classes can be implemented initially to support students who are struggling.
4. There is a lack of studies that evaluate creative thinking in terms of its product context in science education, and further research in this area is recommended.
5. Students were found to have insufficient lateral thinking skills. Rapid implementation of lateral thinking-based activities in education can bring about differentiation.
6. Creativity and computational thinking encompass numerous sub-skills involving complex thinking systems, and their development requires a significant amount of time. Selecting elective courses or domains that allow for longer periods of such applications can be beneficial.

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Original Article

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Social skill development of individuals with special needs: the effect of creative drama

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Abstract

Social skills that are acquired are an important criterion for the individual to establish healthy relationships and be accepted in society. In this sense, this study aimed to examine the effects of creative drama activities on the social skill acquisition of individuals with special needs. The study was carried out with 2 special education teachers and 8 students, 4 females and 4 males, with moderate intellectual disability, in Karaman Special Education Practice School in Karaman. This is a qualitative study with a case study design. In the study, criterion sampling, which is one of the purposive sampling methods, was used. All data were collected through observations, interviews, researcher notes, pre- and post-tests, and the creative drama technique. The data were analysed with inductive data analysis, content analysis, and descriptive analysis methods. As a result, both significant and non-significant results were obtained within the scope of the themes determined as a result of the applied creative drama activities. In the scope of the study, though it was determined that the students with moderate intellectual disabilities had a low level of social skills before starting the creative drama activities, it was determined that the creative drama technique contributed positively to the development of the social skills of the students with moderate intellectual disabilities.

Keywords

Creative drama
Social skills
Moderate intellectual disability
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Student

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Introduction

Disabled individuals' participation in daily living is limited due to their characteristics. Having limited physical and mental activity causes the disabled individual to be evaluated with a different perspective by society (Karaç Öcal et al., 2021). Individuals with special needs display differences from what is expected from their peers regarding developmental characteristics and educational competencies (Avşaroğlu & Güleş, 2019). The main purpose of the education of individuals with special needs is to get them to gain independent life skills and help them increase their quality of life. Independent life skills encompass social skills based on basic skills for success, adaptation skills, and daily living skills (Cavkaytar, 2000).

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Social skills are behaviours that maximize reinforcement and increase social acceptance in social contexts. A lack of learning outcomes that the individual does not have knowledge about or obstacles such as motivation and anxiety limit the demonstration of the skill. According to the purposes of social skills teaching, it is important to determine the type of current social skills deficiency (Radley & Dart, 2022). In other words, social skills are defined as behaviours that are socially acceptable and the ability to interact appropriately with others (Gresham, 2016). Actions aimed at improving competence in social skills can contribute to the development of social networks. Interpersonal relationships that are desired and understood as meaningful relationships, affect all areas of people's lives and are a key factor in social participation (Diaz-Garolera et al., 2022).

Learning and development is a dynamic and interactive process for individuals. Schools are not only for young people's success experiences, but also a product development capacity, opportunities, and supportive school conditions available to develop their capacity for growth and social and emotional competences. Schools are learning ecosystems made up of system leaders, staff, and youth, a set of interrelated, relational, and structural processes. The relational processes between these actors form learning conditions that involve subjective experiences and objective safety, commitment and belonging, academic challenge and participation, inclusion, equality, and social and emotional support measures (Berg et al., 2022).

Social skill is the general name of the attitudes, behaviours, and thoughts that affect individuals to behave in accordance with the social environment they are in, to have a place in society, and to realize their interpersonal communication in a positive way. Social skill acquisition starts from the early years of life and continues throughout life. The learning of social skills, which is very important for the strength of the social structure, should not be random. Social skills should be taught in a planned and programmed way within the education system, and individuals should be given opportunities to transform these skills into practice (Samancı, 2017). Long-term goals should be addressed in the activities to be carried out for individuals who need special education. These goals aim to improve some aspects of people with disabilities. These are positive self-concept, social competence, development in motor skills, physical and motor fitness, leisure time skills, tension relief, game skills, and creative expressions (Koparan, 2003). One of the methods that can be used in presenting these opportunities is the planning of creative drama for individuals with special needs within the education system.

Creative drama is not based on a written text, and it is performed mostly in group works and sometimes individually in its natural course (Briones et al., 2022). Creative drama offers students a "pretended" environment and helps them feel safe. Thus, students can express themselves without feeling any psychological pressure on them (Hong & Hong, 2022; Kasilingam & Ajitha, 2022). In creative drama, instead of evaluating students by comparing them with others, the teacher makes personal evaluations by analysing the students' dramatic movements, teamwork and timing in the animations (Önalan Akfırat, 2004). Başbuğ and Adıgüzel (2019) state that creative drama is one of the methods that renders students active in a learning environment and helps to achieve permanent learning. Creative drama method is an instrument that makes universal, ethical, moral, and abstract concepts meaningful (San, 1990). In other words, creative drama is closely associated with the life practice and personal development of an individual. It helps individuals gain life skills such as solving problems and making plans by enabling them to acquire thinking, listening, speaking, and communication skills (Adıgüzel, 2013). Within the framework of these acquisitions, creative drama allows individuals to travel between the real world and the fictitious world through animations, thus aiming to raise individuals who can establish and develop communication with the environment, express themselves well, and think imaginatively (Adıgüzel, 2020). Because, creative drama is a process by which we extract a model of life and allows us to better understand life, in which participants learn the problems and values of people who are different from themselves, in which they take on roles that they are sensitive to and at the same time learn to work in a group, in which they have the opportunity to understand what others are doing in the same situations by observing and that brings together many artistic skills as well (Önalan Akfırat, 2006).

Some studies conducted in Turkey (Arbay & Akfırat, 2012; Kaya & Eratay, 2009) have demonstrated the effectiveness of the creative drama method in the social skills development of individuals with special needs. Önalan Akfırat (2004) found that the social skills training program prepared by the creative drama method is effective for hearing impaired people aged 10-12 in learning social skills. Arslan (2019) determined that positive changes occurred in the social skills of these individuals after the creative drama program they applied to individuals with mental disabilities, and that they could meet their needs more easily without help. Sevgi-İçyüz (2019) found that the creative drama method was effective in the development of social skills and the acquisition of new skills by students with autism. Boran (2010) emphasized that in children with mild mental disability, creative drama had an improving effect on the development of basic social skills, coping with aggressive behaviours, cognitive skills, and relationship initiation skills. Baysan (2014) concluded that the creative drama method contributed to the development of students' communication skills, their appropriate response according to their emotional state, and the development of their social skills. Bilgiç and Alımterim (2024) stated that, in the process of integration applications of students with special needs, they participated in classes more effectively, their learning was more permanent, a positive contribution was made to their language development, and they acquired social skills and language skills with the creative drama method.

In international studies, the contributions of creative drama to social skills development have been evaluated. Wright (2008) found that children's empathy skills improved in the studies he conducted on creative drama. Roy (2007) determined that the lives of children with special needs changed, and they felt happy with creative drama practices. George (2000) found that through his creative drama studies with children with special needs, these individuals' low academic achievement and self-confidence increased, and they felt more valuable. Mentzer and Boswell (1995) demonstrated that creative drama-based teaching practices in children with mental and behavioural disorders made important contributions to children's social development.

It is thought that creative drama activities that will be applied to reflect these differences in educational environments and for social skills education will play a role in contributing to the development of individuals with special needs. For this reason, activities to be carried out in order to provide opportunities for individuals with special needs to acquire social skills and to activate the educational environment are important. Children with intellectual disabilities are classified in two ways, with psychological and educational classification approaches according to the degree of their severity (Ersoy & Avcı, 2000; Işıkhan, 2005; Yanardağ, 2001, cited in Avşaroğlu & Okutan, 2018). In both classifications, it is necessary to prepare them for life by providing education and development services according to their disability. Moderate intellectual disability refers to the individual who needs special education and support education services intensively in the acquisition of basic academic, daily life, and work skills due to limitations in cognitive functions and conceptual, social, and practical adaptability skills (Resmi Gazete, 2006, cited in Sevimli, 2022). In other words, it is a retardation that occurs due to delayed speech and language development, social, emotional, and behavioural problems, and the acquisition of basic literacy and counting skills (Oyal, 2022). Although the children with intellectual disabilities are the most common group in the group of children with disabilities, there is misinformation about children with intellectual disabilities. There are misconceptions that children in this group cannot overcome their obstacles. Approximately 85% of children with intellectual disabilities can be educated, and when necessary, opportunities are provided, they will have the chance to overcome this disability (İlhan, 2009). It is thought that the results of this study will play a role in contributing to the social skill development of individuals with special needs. With this approach, answers were sought for the following questions to determine the effect of creative drama on the development of individuals with intellectual disabilities in acquiring social skills and using these skills:

1. What are the social skills of students with moderate intellectual disabilities before they start creative drama activities?
2. What are the social skills of students with moderate intellectual disabilities after their participation in creative drama activities?
3. What are the opinions of the researcher after the observation, the notes of the researcher, and the creative drama lessons to be held with students with moderate intellectual disabilities?

Method

The research process followed within the scope of the qualitative approach in line with the determined research purpose is given in Figure 1.

Figure 1. The Research Process

Research Design

This study was planned around accepting the events that exist in society, developing an appropriate perspective thereagainst, designing the current study, collecting data, analysing the data, and interpreting the data. In this context, this is a qualitative study. The number of participants in qualitative research depends on what the researcher wants to learn, the researcher's purpose, what is reliable and useful, and what can be done with the time and resources available.

Since it is aimed at determining the effect of creative drama activities on providing social skills to individuals with intellectual disabilities and on using these skills, the research was designed as a case study. In this design, many situations, current events, groups, and social and political events are examined in depth (Creswell, 2013, Merriam & Tisdell, 2015, Patton, 2014). Case study in qualitative research is related with studying an event intensively (Glesne, 2013). In education, answers are sought for "why" and "how" questions. There are different types of case study. A holistic single-case design was adopted in this study. The holistic single-case design is used in the study of extreme, contradictory, or idiosyncratic situations that do not meet general standards. The following were indicative in choosing the holistic single-case design in the research: 1) The process of developing social skills in students with moderate intellectual disabilities through creative drama was accepted as the situation examined in the research. 2) It is intended to confirm or refute this situation.

Also, criterion sampling which is one of the purposive sampling methods was used in this study. Purposive sampling enables the in-depth study of situations that are thought to have rich information. The researcher tries to understand natural and social events or phenomena in the context of selected situations, and to discover and explain the relationships between them. In research where criterion sampling is used, observation units can be formed from people, events, or situations with certain qualifications. In this case, units that meet the criteria (basic qualifications) determined for the sample are included. In this study, it was considered that the participants were moderately intellectually disabled and that they are receiving a 3rd grade education.

Ethical Approval

This study was approved by the decision numbered 01-2022/08 of the Scientific Research Publication Ethics Committee of Karamanoglu Mehmetbey University. The necessary permission has been obtained from the Karaman Provincial Directorate of National Education in order for the study to be carried out (Date and number: 11.03.2022 - E-99371540-605.01-45541391). In addition, the necessary written permissions were obtained from the participants and their parents for the study with the ”enlightening consent form“ and the ”parent consent form".

Study Group

In line with the purpose of the study, it was necessary to create two different study groups. At first, two special education teachers who are responsible for the student group where creative drama activities will be applied were determined. In determining this situation, it is an important criterion that they can convey the most accurate information about the students in the study group. Obtaining information about the behaviour of the students was considered a priority stage in the study. Because before the students in the scope of the study acquire the necessary and new social skills, it was adopted that having knowledge of their current behaviours would provide a more accurate and realistic approach in terms of study.

At another stage, the study was limited to students diagnosed with a moderate intellectual disability. In this context, the study group in which the creative drama activities will be implemented consists of 8 students with moderate intellectual disabilities, 4 male and 4 female, between the ages of 15-19, who are studying at Karaman Special Education Practice School. Age criteria and mental disability levels were determined to be important criteria for the applicability of the research in the determination of the research group. In addition, the fact that all of the students in the research group included in the study were in the same class and were educated by common special education teachers was accepted as a necessary criterion for the healthy conduct of the activities.

During the study to be carried out with the participants, the study was carried out with special education teachers. Due to the moderate intellectual disability of the participants, a clear and understandable explanation about the nature of the research was excluded from the scope. Students with moderate intellectual disabilities, who are in the 3rd level and who can participate in the creative drama activities to be applied, were included in the study. The fact that these individuals can be trained according to their disabilities and are able to give feedback on their targeted social skill acquisitions has created the thought that this will affect the work positively. Apart from that, students with autism at 1st Level (primary school), 2nd Level (secondary school) and in all three levels were excluded from the scope of the research, considering their age criteria and disabilities. In order to keep the names of the students with moderate intellectual disabilities and special education teachers participating in the research confidential, separate code names were given to them. The “K” code corresponding to the participant expression was used for students, and the “T” code was used for special education teachers.

Table 1. Personal Information of the Participants

Participant	**Gender**	**Age**	**Disability Type**
K1	Male	15	Moderate Intellectual Disability
K2	Female	14	Moderate Intellectual Disability
K3	Female	19	Moderate Intellectual Disability
K4	Female	17	Moderate Intellectual Disability
K5	Male	17	Moderate Intellectual Disability
K6	Female	18	Moderate Intellectual Disability
K7	Male	14	Moderate Intellectual Disability
K8	Male	17	Moderate Intellectual Disability
Participant	**Gender**	**Professional Experience**	**Graduation**
O1	Female	9	Hearing-impaired Teacher
O2	Female	3	Psychological Counselling and Guidance

When Table 1 is examined, it is seen that 4 of the 8 participants in the research are female and 4 are male; their ages range from 14 to 19 years; and all of them have moderate intellectual disabilities. It was determined that all of the participant teachers are female and have professional experience between 3 and 9 years, and their field of graduation is different.

Researchers and Their Roles

1st Researcher: The researcher has a creative drama teaching certificate. The researcher teaches creative drama in both undergraduate and graduate education at the institution he/she works for. The researcher determined creative drama activities suitable for the study group and carried out the activities with the group under his/her leadership.

2nd Researcher: contributed to the preparation of the interview questions before the data collection phase. Also, the researcher took part in the creation of the research data as a participant observer during the interviews with special education teachers and the implementation of the eight-week creative drama activities.

Research Environment

The practice house, music workshop, and school's garden in the Karaman Special Education Practice School, where the research was carried out, were used in the implementation of creative drama activities. The practice house has a home environment that is necessary for students to be prepared for their normal lives outside the practice school and to adapt to their social lives more easily. The existing equipment enabled the researcher in the implementation of creative drama activities.

Collection of Data

The data of the research were collected in the Karaman Special Education Practice School in Karaman Province in the second semester of the 2021-2022 Education and Training year. Social skills are classified differently by many researchers. Since the level of intellectual disability, age, adaptability of creative drama, and activities of the study group were taken into consideration in this study, Caldarella and Merrell's (1997) study, in which they determined the dimensions of social skills and classified them in detail, was taken into account for the acquisition of social skills based on the creative drama method.

The study consists of five stages in collecting data. In the first stage, the researchers participated in a total of two lesson hours (80 minutes) to meet and socialize with the study group before creative drama activities.

The second stage is the interview method with the special education teachers of the class belonging to the determined study group. In this method, a semi-structured interview technique was used in order to gather information about the current situation of the students in the study group before the implementation of the creative drama activity. Interviews with two different special education teachers of the participant students were carried out on different days, outside of class hours, and in a suitable environment determined by the school administration at their own workplaces. The interviews took an average of 30 minutes for each student and the interviews were recorded with a voice recorder.

The third stage is to fill out the social skill level determination form that is prepared by the researchers and evaluated by the special education teachers in order to determine the social skill levels of the participant students. Caldarella and Merrell (1997) determined five dimensions in child and adolescent social skills as a result of their meta-analysis (Önalan Akfırat, 2006). The social skill level determination form used in the study was prepared based on these five dimensions and the skills they cover. The related form consists of five sub-dimensions, which are "peer-related skills", "self-control skills", "academic skills", "adaptation skills" and "assertiveness skills", and there are 31 items in total within the sub-dimensions. In order to determine the level of each expression that presents the behaviour pattern, the numbering is prepared in a decimal Likert format from low to high (from 1 to 10).

The fourth stage is the realization of the activities in which the course environment is used, and the creative drama technique is applied by the researcher. In the preparation of the activities, the improvement of social skill deficiencies was taken as a basis. In addition, the duration of the event has been planned taking into account the creative drama stages (warm-up-preparatory studies, animation, evaluation-discussion) and the social skills areas that are intended to be acquired. At this stage, it is essential to ensure that special education teachers are sometimes in the position of participant and sometimes observer of the event, according to the social skill aimed to be acquired. Creative drama activities were carried out twice a week for one lesson (40 minutes). Creative drama activities were planned as two days in a week and one class hour for eight weeks. In the planning of the creative drama activities, the disability status of the participant students, their current social skill levels, and the targeted social skill levels were taken into account. In addition, the second researcher, who is a participant observer, kept field notes by observing within the scope of each activity.

While developing creative drama activities, activities that were thought to support social skills development were planned. Certain issues were taken into account in determining the skills needed by individuals with special needs. These can be summarized as determining the order of teaching social skills and planning creative drama activities (the name of the activity, the purpose of the activity in getting individuals to acquire social skills, the environment in which the activity would be carried out, the duration of the activity, the repetition status of the activity, and the materials required for the activity). During the activity, the guidance (giving instructions, approval, reinforcement) of the researcher who assumed the role of the activity leader was included. Certain concepts were addressed as a basis for revealing creative drama-based social skills development. These subheadings were (a) peer-related skills, (b) self-control skills, (c) academic skills, (d) compliance skills, and (e) assertiveness skills.

Creative drama activities aiming to support and enforce social skills development were designed and carried out separately for each skill. In the implementation of the activities, the study groups' level of mental disability, age, and compatibility with the applicability of creative drama activities were taken into consideration and the creative drama stages were carried out in this direction. In other words, creative drama activities were planned to make all participants active. Mentally handicapped participants were frequently supported during creative drama work and the reward method (applause, appreciation) was used for encouragement purposes. As the study was carried out with a group that might have difficulty in focusing, the materials used in the activities were selected in a way that would not distract them. In addition, while performing creative drama activities, stages such as warm-up-preparation studies, animation, and evaluation-discussion (Adıgüzel, 2006) were taken into account. Activities involving group work were preferred for peer-related skills. Creative activities in which the individual could reveal his/her awareness were included for the self-control skill. For academic skills, an individual working environment was created. Activities containing instructions that the individual could fulfil were preferred for their compliance skills. For assertiveness skills, both individual and group activities were planned in accordance with the content. Improvisation, role playing, role cards were among the method used. All creative drama activities were applied in the practice house, music workshop, and school garden as required by the type of activity.

Field notes were collected based on the observation technique. The participant observer was at the back in order not to negatively affect the creative drama application process and kept research notes based on the attitudes and behaviours of students with moderate intellectual disabilities. The field notes also include the observation period, history, environment, and characteristics of the participants. It is thought that the observer researchers taking notes during the implementation process and recording the notes in detail contribute positively to the interpretation of the research findings (Merriam, 2009).

In order to determine the social skill developments of the participant students after the creative drama activities, the social skill level determination form, which was evaluated by the special education teachers, was filled in as a post-test in the last stage.

Data Analysis

Data were synthesized by inductive reasoning. Inductive data analysis is an analysis method done by bringing together the data collected through observations, interviews, artifacts, and research journals (Bogdan & Biklen, 2007). The analysis of the data started with the analysis of the unstructured interviews with the special education teachers in order to gain general information about the participant students, and the data obtained in this way were analysed with the content analysis technique. The basic process in content analysis is to gather similar data within the framework of certain concepts and themes and to interpret by organizing them in a way that the reader can understand. Data obtained in content analysis is analysed in four stages namely, coding the data, finding the themes, organizing the codes and themes, defining, and interpreting the findings. The analysis of the research data in line with the data obtained was continued by using the descriptive analysis technique. In descriptive analysis, the data obtained are summarized and interpreted according to predetermined themes. Direct quotations are included in order to reflect the views of the individuals interviewed or observed dramatically (Yıldırım & Şimşek, 2013). In the semi-structured interview technique, the researcher has a list called the interview form that contains questions related to the subject (Türnüklü, 2000). Five different themes were determined for classifying the social skill dimensions of the participant students in detail. The analysis was completed with the qualitative data, which included participant observer notes reflecting the researchers' observations.

Validity and Reliability

In this study, where the qualitative research approach is adopted, it would be a more correct approach to use the concepts of trustworthiness, transferability, consistency, and confirmability instead of the concepts of validity and reliability (Mills, 2003). The criteria determined by Guba and Lincoln (1982) about trustworthiness, who drew attention to the concept of trustworthiness were taken into consideration. About trustworthiness, data diversity was provided by using different data collection techniques in the research. In-depth observation, reducing researcher biases, long-term interaction, and expert review were also used in this study. The researchers need to give readers enough details to decide whether similarities in application and content are transferable. Therefore, in the methodology section of the study, information on the participants, explanations about the place, time, and content of the research were provided. The first researcher kept the observation notes after the activity, and the second researcher kept them during the activities. After each activity, the notes of the two researchers were compared, and the consistency was determined. In order to increase the consistency of the research, the findings obtained in the study were presented directly to the reader without generalization. Besides, all the data obtained during the research process were evaluated by different researchers, in addition to the researchers, and a general consensus was achieved. The consistency of the codes used independently by the researchers was determined by marking them "consensus" or "disagreement.". A consensus of 87% was achieved accordingly. Reliability calculations obtained above 70% are considered reliable for research (Miles & Huberman, 1994). In order to ensure the confirmability of the research, how and at what stages the data were collected and how the data were recorded are explained in detail.

Findings

In this chapter, as a result of the data about the participants and the findings obtained from the interviews with the special education teachers, the findings related to the social skill levels of the participants with moderate intellectual disabilities before and after the creative drama activities are included.

Table 2. Findings on Special Education Teachers' Comments on Students' Behaviours at School

Interaction Type	Behaviour Patterns	Comment of T1	Comment of T2
Individually	Silent	K1, K4	K1, K4
	Persistent	K3, K1, K2, K5	K1, K2, K5
	Individuality comes first	K1, K6, K2, K7, K4	K3, K1, K6, K2, K7, K4
	Jealous	K6, K3	K3
	Abstain	K3, K4	K3, K4
	Lack of self confidence	K3	K3
	Having an anger problem	K2, K3, K5, K7	K3, K5, K7
	Not accepting failure	K6	K6
	Overconfident	K6	K6
	Easily distracted	K2, K7	K2, K7
	Calm	K2, K4	K2, K4
	Inability to balance behaviour	K6, K2	K6,
	Inability to innovate	K7	K7, K3
	Humane	K8, K6	K8, K5
	Low openness to criticism	K1	K1
	Inability to express oneself	K3, K5, K4	K3, K5, K4
In terms of the group	Closed to communication	K1, K3, K4, K8	K1, K3, K4, K8
	Failure to follow directions	K1, K6, K2, K4	K1, K6, K2, K4
	Following directions	K5	K5
	Being prone to group activities	K5, K8	K5, K8
	Reluctance to group activities	K3, K4, K7	K7, K3, K4,
	Being overly social	K6, K5	K6, K5
	Having communication skills	K6, K8	K6, K8
	Leadership	K8, K6	K6
	Having a desire to contact people	K6, K2	K6, K2
	Tendency to people who make them feel good in communication	K6, K2, K5	K6, K2, K5
	Not appreciating others	K3, K2, K7	K7

When Table 2 is examined, it is seen that there are different types of behaviour within the scope of two different types of interaction. It was determined that there are sixteen different types of behaviour in terms of individual behaviour and eleven different types of behaviour in terms of group behaviour. When T1 and T2's comments on students' individual behaviours at school are examined, it was determined that the most common behaviours are; “individuality”, “persistency”, "having an anger problem”, “closedness to communication” and “not following the directions” and the least possessed behaviours are "lack of self-confidence", "not accepting failure", "overconfidence", "not being open to innovations", "low level of openness to criticism" and "following instructions". When the comments of T1 and T2 on the in-group behaviours of the students at school are examined, it is seen that the most common behaviours are "being closed to communication", "inability to follow directions", "reluctance to group activities", "tendency to people who make them feel good in communication" and "not appreciating others". The least visible in-group behaviour was determined to be "following directions". Another finding is that the participant student who has the most different behaviour patterns is "K6", and the participant student who has the least different behaviour patterns is "K8".

Table 3. Findings Regarding the Pre-Test and Post-Test of Participating Students According to the Theme of "Peer Related Skills

		Participants																													
		K1				K2				K3				K4				K5				K6				K7				K8			
		T1		T2		T1		T2		T1		T2		T1		T2		T1		T2		T1		T2		T1		T2		T1		T2	
		Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test	Pre Test	Post Test
		Low (1)								→																				High (10)		
Peer Related Skills	Appreciating friends	1	2	1	2	1	5	2	3	2	2	1	2	1	2	1	2	1	3	2	3	6	9	8	9	1	1	1	5	3	4	6	7
	Inviting friends to play	1	2	1	2	3	4	3	5	1	2	1	2	1	2	1	2	1	4	3	4	7	9	8	9	1	2	1	6	3	4	5	6
	Speaking with friends	2	3	1	3	2	4	3	4	2	2	2	2	1	1	1	1	3	5	4	5	8	8	10	10	3	5	2	6	4	5	9	9
	Participating in discussions	1	1	1	2	1	1	2	3	1	3	3	3	1	1	1	1	1	5	2	3	2	8	8	9	1	1	1	5	4	5	2	3
	Defending friends' rights	1	3	1	1	1	3	2	3	1	3	2	3	1	1	1	1	1	4	2	3	6	8	7	8	1	2	1	5	4	4	2	2
	Taking the Leadership	1	1	1	2	1	4	3	4	1	3	3	3	1	2	1	2	2	3	2	3	7	9	9	10	2	3	2	5	3	7	7	9
	Making friends	1	3	2	3	1	4	3	4	2	3	1	3	1	3	1	3	3	4	3	4	7	8	10	10	2	4	2	5	3	5	6	8
	Having a sense of humour	1	4	3	3	2	3	3	4	2	2	2	3	1	2	1	2	2	5	4	5	8	9	8	9	2	4	3	5	3	5	7	9

When Table 3 is examined, it is seen that a total of eight codes were created under the theme of "peer-related skills" and the participants' pre-test and post-test results were evaluated by two special education teachers ("T1" and "T2") within the scope of the study, according to the determined codes. Accordingly, as a result of the statements of two special education teachers, a difference was found in the codes of appreciating friends, inviting friends to play, taking leadership, making friends and having a sense of humour between the pre-test and post-test of the participating students. On the other hand, no difference was found between the pre-test and post-test findings in terms of creative drama activity in participants with the codes "K3", K4, and "K6" according to the code of "talking to friends", and in the participant with the code "K4" according to the code of "participating in discussions," in the "K4" and "K8" coded participants, according to the code of "defending the rights of your friends".

Table 4. "Findings Regarding the Pre-Test and Post-Test of Participating Students According to the Self-Control Skills" Theme

		Participants																													
		K1				**K2**				**K3**				**K4**				**K5**				**K6**				**K7**				**K8**			
		T1		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**	
		Pre Test	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**
		Low (1)								→																					**High (10)**
Self-Control Skills	Anger control	2	3	2	3	2	4	3	4	1	2	1	2	2	3	4	5	2	3	2	3	3	6	5	6	1	2	1	4	2	3	3	4
	Being calm in problematic situations	1	2	3	3	2	3	3	3	2	2	1	2	4	5	4	5	1	3	2	3	5	5	4	5	1	2	1	3	2	3	4	4
	Following rules	1	5	3	4	1	4	3	4	5	5	5	7	5	5	4	5	5	5	3	3	4	7	4	5	1	2	1	4	4	5	8	8
	Compromise where appropriate	1	4	3	4	1	3	3	4	1	2	3	3	1	4	4	5	1	4	3	5	5	6	4	5	2	3	1	4	4	5	5	5
	Accepting the criticism of others	2	4	2	2	1	3	3	3	1	2	3	3	1	3	1	2	2	3	3	4	3	5	4	6	2	3	1	4	4	5	4	6
	Getting good criticism	1	3	3	4	2	3	2	5	2	2	3	4	3	3	1	2	1	3	3	4	4	4	5	6	2	3	2	5	4	5	5	6

When Table 4 is examined, it is seen that a total of six codes were created under the theme of "self-control" and the participants' pre-test and post-test results were evaluated by two special education teachers ("T1" and "T2") within the scope of the study, according to the determined codes. As a result of the comments of two special education teachers, a difference was found between the pre-test and post-test in the codes of anger control, being calm in problem situations, following the rules, compromising where appropriate, accepting the criticism of others, and getting good criticism. On the other hand, according to the code of following the rules, no difference was found between the pre-test and post-test findings in terms of creative drama activity in the participant coded as "K5".

Table 5. "Findings Regarding the Pre-Test and Post-Test of Participating Students According to the "Academic Skills" Theme

		Participants																													
		K1				**K2**				**K3**				**K4**				**K5**				**K6**				**K7**				**K8**			
		T1		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**	
		Pre Test	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**
		Low (1)								→																				**High (10)**		
Academic skills	Working independently	1	2	2	4	2	3	3	4	3	5	3	4	1	3	1	2	1	4	2	4	3	7	7	8	3	6	2	4	3	5	9	9
	Accomplishing tasks independently	1	2	2	3	3	4	3	4	2	4	3	4	1	3	1	4	1	4	3	3	3	6	7	8	4	5	2	4	3	6	8	9
	Listening and following directions	3	5	3	3	4	5	3	4	6	6	4	6	6	7	4	5	4	5	4	5	6	6	6	7	4	5	4	5	4	8	9	10
	Proper use of free time	1	1	2	4	1	2	2	5	2	4	3	4	1	3	1	2	2	5	2	6	5	5	5	6	3	3	1	2	3	5	4	5
	Seeking help when needed	2	4	3	4	1	2	3	3	3	7	4	5	1	3	1	3	1	4	4	5	2	5	4	5	4	8	3	4	3	6	5	6

When Table 5 is examined, it is seen that a total of five codes were created under the theme of "academic skills" and the pre-test and post-test results of the participants were evaluated by two special education teachers ("T1" and "T2") within the scope of the study, according to the determined codes. As a result of the comments of two special education teachers, when all codes determined as working independently, accomplishing tasks independently, listening and performing directions, proper use of free time, and seeking for help when necessary were taken into consideration, it was determined that there was a difference between the pre-test and post-test in terms of creative drama activity in all participants.

Table 6. Findings Regarding the Pre-Test and Post-Test of Participating Students According to the "Adaptation Skills" Theme

		Participants																													
		K1				**K2**				**K3**				**K4**				**K5**				**K6**				**K7**				**K8**			
		T1		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**	
		Pre Test	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**
		Low (1)								→																				**High (10)**		
Adaptation Skills	Following directions	3	5	3	5	3	4	4	5	5	7	5	6	7	7	3	3	5	5	3	4	5	6	8	8	3	5	4	4	7	7	9	9
	Following rules	2	4	3	5	2	3	3	4	4	5	4	5	3	5	1	2	3	5	3	4	6	7	7	8	3	4	3	4	5	6	8	9
	Sharing belongings	1	4	3	4	1	3	3	4	4	5	4	5	2	3	1	2	2	4	3	5	5	8	6	7	2	3	2	4	2	3	2	5
	Doing homework	2	3	3	5	1	3	2	4	7	7	4	6	2	3	3	3	5	5	4	6	7	9	9	9	2	5	4	4	4	6	7	8
	Fulfilling responsibilities	2	3	3	5	2	3	3	5	5	6	3	5	1	3	3	4	2	4	3	6	6	7	8	9	2	3	3	4	4	7	8	9

When Table 6 is examined, it is seen that a total of five codes were created under the theme of "adapting skills," and the participants' pre-test and post-test results were evaluated by two special education teachers ("T1" and "T2") within the scope of the study, according to the determined codes. As a result of the comments of two special education teachers, a difference was found between the pre-test and post-test among the participating students in the codes of following directions, following the rules, sharing belongings, doing homework, and fulfilling responsibilities. On the other hand, there was no difference between the pre-test and post-test in terms of creative drama activity among the participants coded as "K4" and "K8" according to the code of "following directions".

Table 7. Findings Regarding the Pre-Test and Post-Test of Participating Students According to the "Assertiveness Skills" Theme

		Participants																													
		K1				**K2**				**K3**				**K4**				**K5**				**K6**				**K7**				**K8**			
		T1		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**		**T1**		**T2**	
		Pre Test	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**	**Pre Test**	**Post Test**
		Low (1)								→																					**High (10)**
Assertiveness Skills	Attempt to talk to others	1	2	1	3	1	3	3	4	1	3	2	2	1	1	1	1	1	4	3	5	9	10	10	10	4	6	5	5	4	7	8	9
	Inviting friends to play	1	2	1	3	1	4	3	4	1	2	1	2	1	1	1	1	1	4	3	5	6	7	8	9	2	2	1	4	3	4	5	6
	Saying nice things about self	1	2	1	4	2	4	2	4	2	4	2	3	1	2	1	2	4	7	4	5	6	8	7	8	4	6	1	4	4	8	5	6
	Asking about the rules they don't know	1	2	2	2	1	3	3	3	1	4	3	4	1	2	1	2	1	6	3	4	3	8	9	9	4	5	2	3	3	6	6	7
	Introducing oneself	1	2	1	2	1	3	2	3	2	3	3	4	1	3	1	2	2	6	3	4	7	9	8	9	4	5	2	4	4	5	4	5
	Expressing emotions	1	2	2	3	1	3	3	4	1	4	4	5	1	4	1	2	1	5	3	5	3	7	6	8	3	5	1	3	3	7	7	8
	Participating in group works	2	5	2	6	2	4	3	6	2	4	4	5	3	5	2	5	2	6	3	6	4	8	8	9	3	4	2	4	4	8	9	10

When Table 7 is examined, it is seen that a total of seven codes were created under the theme of "assertiveness skills," and the pre-test and post-test results of the participants were evaluated by two special education teachers ("T1" and "T2") within the scope of the study, according to the determined codes. As a result of the comments of two special education teachers, there was a difference between the pre-test and post-test among the participating students in the codes of attempting to talk to others, inviting friends to the game, saying nice things about oneself, asking about rules they don't know, introducing oneself, expressing feelings, and participating in group work. On the other hand, no difference was found between the pre-test and post-test in terms of creative drama activity in the participant coded as "K4" according to the code of "attempt to talk to others" and "invite friends to the game".

Table 8. Findings Regarding the Researcher's Field Notes

	Participant characteristics	Environment	Observation period
K1	Stay silent during events, adapts to group work, follow the guidelines	Implementing house	Period of a lesson (40 min.)
K2	Has trouble following the instructions, has lack of self-confidence		
K3	Language development features are insufficient, has communication problem		
K4	Language development features are insufficient, has communication problem, has focusing problem	Music workshop	
K5	Follow the rules, excited, impatient, hasty, quite active during events, quite keen on music events		
K6	High peer-related skills	School playground	
K7	Willing to be at the forefront, not keen on group work, has behaviours to attention-seeking		
K8	Has behavioural and cognitive limitations, language development features are insufficient, has focusing problem		

When Table 8 is examined, according to researcher's field notes, participant characteristics of a total of 8 participants (K1, K2, K3, K4, K5, K6, K7, K8) are seen. It has been determined that these behaviours belonging to the participants are both positive and negative behaviours. In addition, information about the environment in which the observation was made and the observation period are other findings that have been identified.

Discussion

In this study, it was aimed to examine the impact of creative drama activities on the social skills acquisition of individuals with special needs. In this context, creative drama studies were designed as pre-stage, while-stage, and post-stage. In the pre-stage, (a) acquaintance-blending, (b) interview with special education teachers, and (c) determination of students' social skill levels were carried out. In the while-stage, (d) the planned creative drama activities were implemented. In the post-stage, (e) it was evaluated whether there was social skills development after creative drama activities. Each of these stages was designed, applied, and interpreted separately by the researcher within the framework of the findings obtained.

When the findings of the study are examined, findings about the personal information of the participants, the special education teachers' comments on the behaviour of the students at school, and the pre- and post-tests of the participant students on different themes are determined.

When Table 1 is examined, it is seen that both participating teachers and individuals with moderate intellectual disabilities constitute the study group. It can be stated that one of the participant teachers is a hearing-impaired teacher and the other is a PCG (psychological counselling and guidance) and that the participant students consist of individuals with moderate intellectual disability. It was stated earlier in the method part of the study that certain priorities were determined as criteria in the formation of the study group. Starting from this point, the fact that the participant teachers were experts in their fields was important for the reliable execution of the process, which included the application part of the study. According to Akyıldız (2017), special education teachers have the potential to be effective in eliminating the problems and negative perceptions that may be encountered in ensuring the integration of those who have disabilities in society. Furthermore, these teachers can also play an important role in the implementation of policies addressed at the macro level regarding the social integration of individuals with disabilities. The other study group, consisting of individuals with moderate intellectual disabilities, consists of equal numbers of men and women. Although it is not a specifically determined criterion, this equality is due to the fact that there is only one class that meets the determined criteria in the environment where the study was carried out. In his study, Yılmaz (2018) determined that special education teachers believed that creative drama was effective and practical in developing the basic skills of students with mental disabilities.

In Table 2, the findings obtained from the thoughts of special education teachers about the behaviours of students with special needs at school were categorized according to interaction types in terms of individual and group, and twenty-seven different behaviour styles were identified under these two categories.

Two special education teachers (T1, T2) within the scope of the study stated that before the creative drama activities, the most individual behaviours exhibited by the participant students in the school were "persistency, anger problems, individuality, closedness to communication, and not following directions." On the other hand, the most common in-group behaviours were found to be “closedness to communication”, “inability to follow directions”, “reluctance towards group activities”, “tendency to people who make them feel good in communication,” and “not appreciating others”. Within the scope of the findings, the answer to the research question regarding the level of social skills of students with moderate mental disabilities before starting creative drama activities was found as low level in these participant individuals. It is thought that the reasons for these negative the behaviours that are seen more frequently are low mental capacity, social rejection, limited communication skills, an inability to improve oneself in society, having experienced failures, and inability to express emotions and thoughts correctly. According to McIntyre et al. (2006), individuals with intellectual disabilities have more teacher-reported problem behaviours as well as weaker communication and social skills. According to Özen et al. (2002), disabled individuals exhibit many problem behaviours such as not being able to fulfil the desired instructions in daily life. Research on people with intellectual disabilities reveals that individuals with disabilities exhibit less prosocial behaviours, a lack of initiation in peer interactions, a low rate of reward when they are with their peers, and less cooperative behaviours (Gresham & Elliot, 1993).

As a result of the findings of the study, five themes were obtained as "Peer-Related Skills Theme", "Self-Control Skills Theme", "Academic Skills Theme", "Adaptation Skills Theme," and "Assertiveness Skills Theme". In line with these themes, it was determined that the social skills of students with moderate mental disabilities after their participation in creative drama activities increased from low to above the moderate level, and it was revealed as a result of the findings obtained from these five themes that creative drama contributed positively to the development of social skills. Eldeniz Çetin (2005), in his study on mentally disabled students, concluded that creative drama was effective on the social skills curriculum.

In Table 3, a total of eight codes were created within the framework of the findings related to the pre-test and post-test of the participant students in the theme of peer-related skills. A difference was determined between the pre-test and post-test among the participating students in the codes of appreciating their friends, inviting their friends to the game, leadership, making friends, and having a sense of humour. Regarding each code in terms of before and after creative drama activities, it can be said that there is a positive development in peer-related skills in participant students. Creative drama aims to enable easy expression of emotions, imagination development, and cooperation. Starting from this, creative drama activities were planned and implemented to solve the problems that were determined before the activity about the moderately intellectually disabled individuals forming the study group as "persistency, having anger problems, individuality, closedness to communication, not following directions, and reluctance towards group activities". It was prioritized that the implemented activities mainly included the state of being in contact with another person. There are different studies in the literature that support our findings. According to the results of the study, Eldeniz Çetin (2005) stated that drama was effective in developing basic skills, basic speaking skills, initiating a relationship, maintaining a relationship, group work skills, emotional skills, self-control skills, giving instructions skills and cognitive skills. Kaya (2011) concluded that the creative drama method is effective for individuals with intellectual disabilities in controlling themselves and coping with aggressive behaviours. Avcıoğlu (2012) found that drama has a positive effect on peer relations. Taylor (2011) found that creative drama improves self-worth, confidence, communication, and speaking skills. Liu (2020) mentioned that for children with special needs achieving active and positive development can be

easier through creative drama. Papaioannou and Kondoyianni (2022) found that the use of drama in educating students with special educational needs improves teamwork and social skills as well as language skills.

In Table 4, according to the findings of the pre- and post-tests of the participant students, a total of six codes were obtained under the theme of self-control skills. As a result of the comments of two special education teachers, a difference was found between the pre-test and post-test in the codes of "anger control, being calm in problem situations, following rules, compromising where appropriate, accepting the criticism of others, and getting good criticism". It is thought that this difference comes from creative drama activities that support problem solving, improve participation skills, and promote self-control. Different studies on creative drama activities also support our study finding. In the study conducted by Çorbacı Serin (2012), it was concluded that as the social skill levels of intellectually disabled adolescents increase, their behavioural problems decrease. Ilgaz (2014) stated that drama studies enable learning of the concepts of emotion at the highest level.

In Table 5, a total of five codes were obtained according to the findings related to the pre-test and post-test of the participating students on the theme of academic skills. When all the codes determined as “working independently”, “achieving tasks independently”, “listening to and performing the directions”, “proper use of free time” and “asking for help when necessary” were evaluated, it was determined that there is a difference between the pre-test and post-tests of all participant students in line with the creative drama activity. Creative drama is an effective method in teaching many social skills. In view of this reality, information about the social skill levels of the participating students was collected before the implementation of the creative drama activities, and the necessity of supporting the academic skills of the students came to the forefront. In other words, when designing drama activities, this situation was taken into consideration, and the activities offered the students with moderate mental disabilities the opportunity to work independently as well as in groups. Thus, the participant students took an active role in the learning process within the scope of the creative drama activities, and they were particularly able to effectively work independently. Within this scope, it was concluded that creative drama activities are an effective method in improving the academic skills of individuals. Sucuoğlu and Özokçu (2005) also emphasize that when students with disabilities learn the necessary social skills their academic skills increase accordingly. In their study, Yücesan and Şendurur (2018) demonstrated that creative drama improved the academic self-esteem of individuals.

A total of five codes were obtained in Table 6, according to the findings of the pre-test and post-test of the participant students in the theme of adaptation skills. As a result of the comments of two special education teachers, a difference was found in the codes of following directions, following the rules, sharing belongings, doing homework, and fulfilling responsibilities between the pre-test and post-test among the participating students. In many studies about mentally disabled individuals, it has been mentioned that these individuals have maladaptive behaviours within the framework of their mental competence levels. For this reason, it is more difficult for them to comply with the rules and instructions and to take responsibility for themselves compared to their normal peers. However, this study shows that creative drama activities are helpful for individuals with moderate intellectual disabilities to fulfil their daily personal homework and responsibilities. During the implementation phase of the activities within the scope of the study, it was determined that some participant students were more willing to acquire the skills within the scope of adapting skills, while others exhibited a more uninterested or careless attitude. The important point here is that the individual differences of these individuals should also be taken into account during the planning and implementation of creative drama activities. Different and repetitive activities, including creative drama, were carried out with intellectually disabled students who were unwilling or uninterested in following the rules, sharing belongings, doing homework, and fulfilling responsibilities, and positive results were obtained. It was determined that creative drama activities had positive effects on attitude and behaviour acquisitions (Demir Acar & Bayat, 2019). Malley and Silverstein (2014) found that the use of creative drama method

in the education of children with special needs had positive effects on academic and social development as well as peer acceptance.

In Table 7, it is seen that a total of seven codes were created according to the findings of the pre- and post-tests of the participant students on the theme of assertiveness skills, and the pre- and post-test results of the participants were evaluated according to the determined codes. There was a difference between the pre-test and post-test in the codes of attempting to talk to others, inviting friends to the game, saying nice things for oneself, asking unfamiliar rules, introducing oneself, expressing feelings, and participating in group work. Studies have shown that individuals with intellectual disabilities have more deficiencies in self-confidence, self-expression, and communication when compared to their normal peers in terms of the acquisition of social skills. The point reached is that individuals with mental disabilities have less developed social skills. In other words, the ability of these individuals to maintain their daily lives and establish a healthier relationship with others is directly proportional to the level of social skills they have. Therefore, individuals with different levels of intellectual disability should receive education, and different approaches should be included in the content of this education. According to the results obtained in the study, it is thought that creative drama activities applied to moderately mentally disabled participants contribute positively to their self-confidence, self-expression, and communication. Creative drama, which creates an active and experiential psychotherapy environment, has been found to have a positive effect on individuals with special needs (Feniger-Schaal & Orkibi, 2020). In the study conducted by Önemli et al. (2015), they found that creative drama education was effective in the speaking and relationship-building skills of children with special needs. Taylor (2011) found that such children's self-worth, self-confidence, communication, problem-solving, and speaking skills improved with the creative drama program. These findings are in line with our study findings.

In addition to these results, according to the researcher's field notes presented in Table 8, when the characteristics of individuals with mental disabilities are taken into consideration, headings such as developmental characteristics, learning characteristics, motor-physical development, language development, and social development also gain importance. Although all of the participating students in the study were in the category of moderate mental disability, they may differ on some issues. It can be claimed that the reason for this was that although the participants were diagnosed with mental disability, they had fundamentally different developmental characteristics. Çelebi Şeker and Aytıs (2023) stated that characteristics or abilities may differ or be superior to each other in individuals with mental disabilities. The researcher's notes obtained as a result of the observations made during the activities also confirm this finding.

As a result of the findings, the social skill behaviours that were found to differ between the pretest and post-test were revealed, alongside in behaviours that do not show differences. In the behaviours of “talking to friends, participating in discussions, defending the rights of friends” included under the peer-related skills theme, no difference was found between the pre-test and post-test in some participating students. The lack of speech skills that exists in some participants, and the fact that communication skills are already good in some participants can be said to be the reason for this. Önalan Akfırat (2006) emphasized that it is necessary to investigate whether the child has knowledge about behaviour and whether he has used this behaviour before in order to determine social skill deficiency. The size of the mentioned speech skill deficiency constitutes an obstacle to the acquisition of expected social skill behaviour within the scope and process of the planned creative drama activity. In the “following the rules” behaviour, which is included under the theme of self-control skills, the expected social skill behaviour could not be acquired as a result of the participant student having problems focusing and following directives. Therefore, a difference was not able to determine between the pretest and the post-test in this student. As the reason why no difference can be detected in the behaviour of “following the instructions” included under the theme of compliance skills; it is believed that the current situation of the participating students in this type of behaviour is already at a good level. Finally, it can be stated that the lack of speech skills that must be possessed is effective for the behaviour of “inviting friends to the game and making attempts to talk to others", which is included under the theme assertiveness skills. To put it briefly, it can be said that the absence of differences in some skills in the

findings related to the pre-test and post-test results is due to the fact that the participating students have different levels of mental disability.

Conclusion

As a result, the basis of the study was to reveal the existing deficiencies in terms of social skills in individuals with moderate intellectual disabilities and to develop social skills in this direction. In the scope of the study, it was determined that the social skill levels of the students with moderate intellectual disability before starting the creative drama activities were low. In spite of that, it was determined that the creative drama technique contributed positively to the development of social skills in students with moderate intellectual disability.

Recommendations

Based on the results of this study.

- It is recommended that creative drama be included in the curriculum in order to increase the social skill levels of individuals with mild and moderate intellectual disabilities and to ensure their integration with society.
- Interdisciplinary collaborations, especially in educational institutions such as universities, are recommended to ensure the social development of mentally disabled students in accordance with special needs and taking into account their individual differences.
- After the creative drama activities, it is recommended that more comprehensive studies be carried out so that individuals can generalize the skills they have learned to different environments and make them permanent and to ensure the acquisition of especially social skills and competencies by these individuals.
- The number of research in which monitoring and generalization studies are carried out in the acquisition in the skills provided should be increased. It should be ensured that the development areas of mentally disabled individuals are supported by including the creative drama method.
- It should also be ensured that special education teachers are competent in the field of creative drama as well.
- Necessary social, academic, and political arrangements should be made to include creative drama in the education of mentally disabled individuals.
- This study was conducted with individuals with intellectual disabilities and within the scope of social skill acquisition. Creative drama applications, which are thought to support the development of other individuals with special needs, are also recommended to be used in different areas.
- With the provision of social skill development, it can be mentioned in the possibility that these individuals will be able to provide employment and exist in society in the future. Based on this, it is thought that there is a need for new areas of study that will make a positive difference in the lives of these individuals.
- It is proposed to use the method applied in the study in the teaching of behaviour and concepts of individuals with special needs.

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Original Article

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Examining the reading and writing performance of students with learning disabilities and students with low and high reading achievement *

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Abstract

In this study, the reading and writing performance of students with learning disabilities were compared to those of students with low and high reading achievement, and the distribution of achievement levels was examined. The study employed a correlational survey design, one of the quantitative research methods. Participants included 24 third- and fourth-grade students diagnosed with learning disabilities, along with 23 students demonstrating low reading achievement and 24 students demonstrating high reading achievement from the same classrooms as the students with learning disabilities. Measurements were conducted for variables including reading fluency, reading accuracy, reading comprehension, spelling, writing productivity, and content quality. The assessments utilized four tests from the Literacy Assessment Battery (Passage Reading Fluency Test, Passage Comprehension Test, Spelling Test, and Written Expression Test). The analysis revealed significant differences among the groups for all examined variables. Post-hoc test results indicated significant differences among all groups for reading fluency. For other variables, the learning disabilities and low reading achievement groups scored significantly lower than the high reading achievement group. However, no significant differences were found between the learning disabilities and low reading achievement groups. When group differences were analyzed based on z-scores, the gap between the learning disabilities group and the high reading achievement group ranged from 1 to 2 standard deviations across all variables. An analysis of the distribution of achievement levels showed that students in the learning disabilities and low reading achievement groups typically fell within very low and low levels for reading fluency and reading comprehension, while those in the high reading achievement group were mostly at moderate and high levels. For reading accuracy, the learning disabilities and low reading achievement groups were

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predominantly at the frustration level, whereas the high reading achievement group was at the independent level. Although the distribution patterns for spelling were less distinct than those for reading skills, students in the learning disabilities and low reading achievement groups tended to cluster at low and very low levels for writing productivity and content quality. In contrast, students in the high reading achievement group was predominantly at high levels. The findings were discussed in relation to previous research, and several recommendations were provided for future studies and practice.

Introduction

Reading and writing skills are among the most frequently used tools for accessing and sharing information in today's society. These skills not only enable individuals to be active and productive members of their communities but also form the foundation of academic success (Joshi, 2019). To achieve success across all subjects throughout their school lives, students must possess grade-level reading and writing skills (Rasinski et al., 2005). Research shows that students who fail to adequately develop these skills often experience academic failure (Boakye, 2017; Erbeli et al., 2020; Fatiloro et al., 2017; Jordan & Plakans, 2004; Miao et al., 2002). Academic failure, in turn, is frequently associated with low self-perception (Metsäpelto et al., 2020; Pullmann & Allik, 2008), social exclusion (Nowicki, 2003; Wentzel et al., 2021), problem behaviours (Bonifacci et al., 2008; Bub et al., 2007; Lugt, 2007; Metsäpelto et al., 2015) and school dropout (Beatriz Saraiva et al., 2011; Glennie et al., 2012). In addition, students with low academic achievement are more likely to secure low-status jobs in the future (Rothon et al., 2009). Given these potential negative outcomes, it is crucial to examine students' achievement levels in reading and writing skills to better understand and address these challenges.

Despite their critical importance for academic and social life, many students struggle with reading and writing skills due to their complex nature (Demirtaş & Ergül, 2019; Ergül, 2012; Ergül et al., 2022; Gao et al., 2018; Hooper et al., 1993; Jenkins et al., 2003; Lovett et al., 2000; Nascimento et al., 2011). According to a national assessment report published in the United States, one in three fourth-grade students performs significantly below grade level in reading and writing skills (National Assessment of Education Progress [NAEP], 2017). Similarly, a study conducted in Türkiye (Ergül et al., 2022) revealed that 34% of first-grade students exhibited low reading achievement by the end of the school year, and 66.9% of these students continued to exhibit low performance in the second grade. For some students, these difficulties may stem from various environmental disadvantages, such as limited learning opportunities, insufficient or unqualified teaching, and low socioeconomic status. However, in a significant number of students, these problems may be attributed to learning disabilities (Bear et al., 1998; Nazer & Hamid, 2017; Sanders et al., 2018; Semrud-Clikeman & Glass, 2008).

Learning disabilities (LD) are characterized by difficulties in acquiring or developing skills such as listening, speaking, reading, writing, mathematics, and reasoning (National Joint Committee on Learning Disabilities [NJCLD], 2016). These difficulties are not caused by intellectual disabilities but arise from impairments in cognitive processes critical to children's learning (Swanson, 2010). Therefore, reading and writing difficulties arising from LD are not caused by conditions such as insufficient learning opportunities, general intelligence level, physical disabilities and emotional/behavioural disorders (Swanson, 2010). It is estimated that 5-15% of school-age children have LD (American Psychiatric Association [APA], 2013). Moreover, students with LD represent the largest subgroup among students with disabilities (National Centre for Education Statistics, 2023). Although the prevalence of LD in Türkiye remains significantly lower than the figures reported in developed countries, a rapid increase in the number of diagnosed LD cases has been observed, driven by growing social awareness and advancements in educational practices (Melekoğlu et al., 2009).

Students with LD generally experience difficulties in language development and literacy skills, with the most pronounced challenges occurring during the acquisition of reading skills. Indeed, 80-90% of these students are referred to special education services due to problems with reading (Bender, 2007; Kavale & Reese, 1992; Lyon et al., 2001). A closer examination of their reading difficulties reveals that a significant proportion struggle with decoding and word recognition skills (Karageorgos et al., 2020; Martínez-García et al., 2019) and fail to learn letter-sound correspondences (Shaywitz & Shaywitz, 2005; Vellutino et al., 2004), leading to frequent errors during reading (Lyon et al., 2003). Many of these students not only fail to develop decoding but also do not develop reading fluency. Even among those who learn to decode, some do not achieve fluency, and these students typically read at a slower pace than their grade-level peers (Arabacı, 2022; Aracı & Melekoğlu, 2023; Carpenter & Miller, 1982; Nascimento et al., 2011; Torppa et al., 2020). Research shows that students with LD are often 2-3 years or 1-2 standard deviations behind their typically developing peers in reading skills (Ferrer et al., 2015; Ferrer et al., 2023). Consequently, reading difficulties in students with LD can manifest at varying levels and types, presenting a heterogeneous profile. These variations in reading difficulties are addressed in theoretical approaches such as the double-deficit hypothesis and phonological processing (Norton & Wolf, 2012; Wolf & Bowers, 1999). These theoretical frameworks emphasize that the diverse manifestations of LD correspond to the variety of underlying causes.

Another key skill that students with LD often struggle with is reading comprehension (Hulme & Snowling, 2016). Reading comprehension is considered the ultimate goal of reading (Paris & Hamilton, 2009), and academic success is largely achieved through it (García-Madruga et al., 2014; Meneghetti et al., 2006). However, due to the complexity of the reading comprehension process and the multitude of skills it involves, students with LD face various challenges in this area (Sulaimon & Schaefer, 2023). These students encounter difficulties in understanding words/sentences, grasping the message conveyed by a sentence or paragraph, connecting with prior knowledge, and making inferences about information or messages not explicitly stated in the text (Borella et al., 2010; Watson et al., 2012). Such challenges intensify as students progress through grades and are required to read more difficult and complex texts and apply the knowledge gained from them (Richmond et al., 2023; Vaughn, Klingner vd., 2011). According to the Simple View of Reading model, reading comprehension primarily relies on decoding and language comprehension skills (Gough & Tunmer, 1986). The relative importance of these skills varies by grade level; during the early years of elementary school, decoding has a greater impact on reading comprehension, while in later years, language comprehension becomes more significant (Castles et al., 2018; Gentaz et al., 2015; Oslund et al., 2018). Accordingly, differences in reading comprehension performance among students in early elementary grades can often be attributed to their decoding performance, whereas in later years, differences are more strongly linked to their language comprehension skills (Catts et al., 2012; Oakhill et al., 2019). Students with LD face difficulties in one or both of these areas (Hulme & Snowling, 2016; Kida et al., 2016; Snowling et al., 2019), which leads to increasingly severe reading comprehension challenges as they progress through school. A longitudinal study by Snowling et al. (2020) found that students with reading difficulties lagged behind their typically developing peers in vocabulary knowledge, decoding, and reading comprehension in both second and third grade. Similar findings have been reported in studies involving middle school students with reading difficulties, showing deficits in decoding, oral language, and reading comprehension skills compared to their peers (Cirino et al., 2013; Kalindi & Chung, 2018; Richmond et al., 2023). In fact, a report from the United States indicated that 88% of students with LD perform below average in reading comprehension (Cortiella & Horowitz, 2014). Additionally, research has identified that reading comprehension problems in students with LD may stem from deficits in working memory, strategy use, and prior knowledge (Brandenburg et al., 2015; Cain & Oakhill, 2007; De Weerdt et al., 2013). Collectively, these findings indicate that reading comprehension problems in students with LD are both widespread and severe.

Students with LD also experience difficulties in writing, similar to their challenges in reading (Graham et al., 2021). Writing is one of the most frequently used skills in students' academic lives. As such, instruction in both reading and writing begins in the first year of elementary school, with the aim of developing students' handwriting and spelling skills. The ultimate goal of writing instruction is to enable students to effectively express their knowledge, emotions, thoughts, and experiences in written form and to communicate through writing (Tan & Miller, 2007). However, due to the reliance of reading and writing on similar cognitive resources (Graham, 2020), students with LD face significant difficulties in writing, just as they do in reading and reading comprehension (Afonso et al., 2020; Dickerson Mayes & Calhoun, 2007; Hebert et al., 2018; Suárez-Coalla et al., 2020). These students often struggle with acquiring handwriting skills, forming letters correctly, and spelling words accurately. Such challenges result in the production of illegible texts that are short in word count and poorly organized (Liberty & Conderman, 2018; Santangelo & Quint, 2008; Troia, 2006). Similar to reading skills, the difficulties experienced by these students increase as they progress to higher grade levels and face more complex writing tasks. Goldstand et al. (2018) reported that students with writing difficulties experience more handwriting challenges than their typically developing peers. Kalindi and Chung (2018) found that the spelling performance of typically developing students was twice as high as that of students with LD. García and Fidalgo (2008) observed that texts written by students with LD were inferior in content quality, organization, and structure compared to those of their typically developing peers.

The reading and writing difficulties experienced by students with LD typically emerge in first grade and intensify as they progress through elementary school. However, diagnostic and support processes often begin much later than the onset of these difficulties, further widening the gap between these students and their peers. Therefore, identifying the extent of reading and writing problems faced by students with LD in third and fourth grades, understanding the differences between them and their peers, determining intervention needs, and raising awareness about the importance of earlier interventions are deemed crucial. This information could serve as a guide for teachers, families, and policymakers in preventing these problems from escalating. Additionally, understanding the extent of differentiation in reading and writing skills at grades where these skills become tools for learning (such as third and fourth grade) can provide valuable insights into the effectiveness of special education services and inclusive practices offered to these students. Despite the frequent reporting of such findings in international literature, studies examining the extent of reading and writing difficulties faced by students with LD in Türkiye and the performance differences between them and their peers remain limited. Considering these aspects, there is a need to identify the specific difficulties and levels of challenges faced by students with LD and to examine the extent and areas of differentiation compared to their typically developing peers. Accordingly, this study aims to determine and comparatively examine the reading and writing skill levels of students with LD, as well as those with low reading achievement (LRA) and high reading achievement (HRA). To achieve this, the study seeks to address the following research questions:

1. Are there significant differences in reading fluency, reading accuracy, reading comprehension, spelling, and written expression performances among third- and fourth-grade students with LD, LRA, and HRA?
2. What are the distributions of performance levels in reading fluency, reading accuracy, reading comprehension, spelling, and written expression among third- and fourth-grade students with LD, LRA, and HRA?

Method

This study employed the correlational survey model, one of the quantitative research methods. Correlational survey studies examine the relationships between two or more variables without any intervention (Frankel et al., 2022).

Participants

The participants included 71 third- and fourth-grade students attending nine primary schools in Kırıkkale, comprising 24 students diagnosed with LD, 23 students with LRA, and 24 with HRA. The students with LD were selected from those registered with medical and educational diagnosis reports at the Kırıkkale Guidance and Research Center, and those with an IQ score below 85 or comorbid diagnoses were excluded. A total of 25 students with LD were initially identified, with one student selected from each class. Face-to-face meetings were held with the teachers of these students, who were asked to nominate one student with LRA and one with HRA from their classes, provided these students had no formal diagnoses. To confirm the suitability of the nominated students' reading levels for the study and to validate the diagnoses of the LD group, the Passage Reading Fluency Test from the Literacy Assessment Battery (LAB) was administered. Based on these evaluations, one student with moderate reading achievement from the LD group, two students with moderate reading achievement from the LRA group, and one student with low reading achievement from the HRA group were excluded. The final sample consisted of students aged between 101-124 months, with a mean age of 112 months for the LD group, 114 months for the LRA group, and 112 months for the HRA group. The LD group included 9 girls and 15 boys, the LRA group included 9 girls and 14 boys, and the HRA group included 14 girls and 10 boys. The distribution of the groups by grade level and reading levels is shown in Table 1.

Table 1. Distribution of Groups by Grade Level and Reading Levels

	Groups					
	LD		**LRA**		**HRA**	
	n	**%**	**n**	**%**	**n**	**%**
Grade Level						
Grade 3	11	45.8	10	43.5	12	50.0
Grade 4	13	54.2	13	56.5	12	50.0
Reading Level						
Very Low	21	87.5	15	65.2	0	0
Low	3	12.5	8	34.8	0	0
Moderate	0	0	0	0	11	45.8
High	0	0	0	0	11	45.8
Very High	0	0	0	0	2	8.3

Data Collection Instruments

Literacy Assessment Battery

LAB is a test battery developed to evaluate the reading, reading comprehension, and writing skills of students from first to fourth grade (Ergül et al., 2021). The battery includes four tests for assessing reading (Word Recognition Test, Word Decoding Test, Phonetic Analysis Test, and Passage Reading Fluency Test), three tests for reading comprehension (Passage Comprehension Test, Semantic Processing Test, and Cloze Test), and three tests for writing (Spelling Test, Copying Test, and Written Expression Test). Most tests are time-based, measuring the number of words read/written or items answered correctly within a specified time frame (e.g., 60-90 seconds). Each test has two forms, A and B. Based on the assessment results, student performance can be classified as very low, low, moderate, high, or very high, according to the cut-off scores and intervals defined by LAB. The battery is administered only by specialists trained in its application.

The validity and reliability of LAB have been thoroughly tested. For discriminative validity, significant differences were found between upper and lower groups (η2=.53-.71). Criterion validity demonstrated significant correlations (r=.10-.44) between LAB scores and skills such as phonological awareness, working memory, rapid naming, letter knowledge, oral language, and vocabulary. Cronbach's alpha coefficients for internal consistency ranged from .67 to .85, test-retest correlation coefficients ranged from .86 to .96, and equivalence correlation coefficients between A and B forms ranged from .82 to .96.

Within the scope of this study, four tests of the LAB, namely the Passage Reading Fluency Test, Passage Comprehension Test, Spelling Test, and Written Expression Test, were used. The tests used are briefly explained in the following section.

Passage Reading Fluency Test. This test measures students' reading fluency, evaluating the number of correctly read words in one minute. Student performance is assessed using two passages—one narrative and one informational. In this study, students read passages prepared in 14-point font size, aligned with their grade level, aloud, and the number of correct words read within one minute was recorded.

Passage Comprehension Test. Developed to assess students' reading comprehension, this test uses the same passages as the Passage Reading Fluency Test. After reading the passages aloud, students are asked to silently re-read them and then answer six factual and three inferential questions verbally. Correct answers to these questions are recorded as the performance score.

Spelling Test. Designed to evaluate writing accuracy and fluency, this test requires students to write the dictated words correctly and quickly within 90 seconds. Each word is dictated twice in a clear and sequential manner. The number of correctly written words within the 90-second limit constitutes the performance score.

Written Expression Test. This test assesses written expression skills. Students are asked to write a story based on images depicting an event, including the setup, conflict, and resolution. They are given 30 seconds to plan by observing the images before starting to write. The images remain visible throughout the writing process, which has no time limit. The written stories are evaluated separately for the total number of correct words and for readability and content quality using rubrics. In this study, the students' stories were assessed based on the total number of correct words (writing productivity) and content quality using the respective rubric.

Data Collection Process

The data of this study were collected within the scope of the approval obtained from the Ethics Committee of Kırıkkale University with the decision dated 18/06/2022 and numbered 06 and the permissions obtained from the provincial directorate of national education. Consent forms were collected from the parents of all participating students. Assessments were conducted in a quiet environment within the schools, free from distractions. Prior to the assessments, students were engaged in brief conversations to help them feel comfortable and adapt to the evaluator, and they were provided with information about the assessment process. Each assessment was conducted in a single session lasting 25-30 minutes. The data collection process was completed over a period of one and a half months, during May and June.

Inter-Rater Reliability

Inter-rater reliability was calculated for the assessments conducted with the participants. To this end, the evaluation forms of 22 students (30% of the sample), randomly selected from the 71 participants, were re-scored by a doctoral student specializing in Turkish Education. Inter-rater reliability was determined to be 90% for the Passage Reading Fluency Test, 95% for the Passage Comprehension Test, 90% for the Spelling Test, 95% for the Written Expression Test, and 86% for the Content Quality Rubric. Inter-rater reliability was calculated using the formula "Agreement / (Agreement + Disagreement) x 100" (Tekin-İftar & Kırcaali-İftar, 2013).

Data Analysis

Descriptive statistics were initially examined for participants' scores in reading fluency, reading accuracy, reading comprehension, spelling, writing productivity, and content quality. Outliers were checked, and normality tests were conducted. For the first research question, group comparisons were performed using one-way analysis of variance (ANOVA). Since normal distribution could not be achieved for the Spelling Test scores of students with HRA (Skewness: -1.420; Kurtosis: 3.48) (George & Mallery, 2010), ANOVA with bootstrapping was employed. Post-hoc analysis was conducted to identify which groups differed significantly. Effect sizes were interpreted based on thresholds of .01, .06, and .14 for small, medium, and large effects, respectively (Büyüköztürk, 2018).

For the second research question, the distribution of students' performance levels on the relevant variables was examined across five levels (very low, low, moderate, high, very high) based on LAB cut-off scores and evaluation intervals. Reading accuracy performance was calculated as the ratio of the number of correct words read per minute to the total number of words read, and distributions were determined across three levels (below 89% as "frustration," 90-94% as "instruction," and 95% and above as "independent"; Rasinski & Hoffman, 2003).

Findings

In this study, which aimed to compare the performance of students with LD, LRA, and HRA in terms of reading fluency, reading accuracy, reading comprehension, spelling, writing productivity, and content quality, the analyses began with an examination of the descriptive statistics for the groups. Subsequently, to address the first research question, ANOVA was used to test whether there were significant differences between the groups' performance on the relevant variables and, if significant differences were found, post-hoc tests were conducted and the effect sizes were calculated. The mean scores, standard deviations, and ANOVA results are summarized in Table 2.

Table 2. Mean Scores, Standard Deviations, and ANOVA Results of Groups in Target Variables

Variable	Group	n	$\bar{X}$	SD	F	p	Post-Hoc	η2
Reading Fluency	LD	24	52.58	17.93	104.86	.000	LD-HRA	.75
	LRA	23	63.63	12.82			LD-LRA	
	HRA	24	110.83	12.91			LRA-HRA	
Reading	LD	24	81.79	5.31	65.71	.000	LD-HRA	.65
Accuracy	LRA	23	83.87	6.14			LRA-HRA	
	HRA	24	96.41	1.71				
Reading	LD	24	4.52	1.25	20.16	.000	LD-HRA	.37
Comprehension	LRA	23	5.06	1.81			LRA-HRA	
	HRA	24	7.06	1.24				
Spelling	LD	24	18.54	6.22	12.81	.000	LD-HRA	.27
	LRA	23	20.74	3.30			LRA-HRA	
	HRA	24	24.96	3.09				
Writing	LD	24	25.25	11.36	26.95	.000	LD-HRA	.44
Productivity	LRA	23	31.57	11.23			LRA-HRA	
	HRA	24	53.96	18.64				
Content Quality	LD	24	9.67	2.31	31.92	.000	LD-HRA	.48
	LRA	23	10.48	2.29			LRA-HRA	
	HRA	24	15.13	2.96				

As seen in Table 2, the LD group had the lowest mean scores across all variables, followed by the LRA group with slightly higher scores, while the HRA group had the highest mean scores. Significant differences ($p < .05$) were found among the groups for all variables related to reading and writing. These differences demonstrated a very large effect size in all cases ($\eta 2 > .14$). Post-hoc test results (Tukey) indicated that, for reading fluency, significant differences were present among all three groups. For the remaining variables, the LD and LRA groups scored significantly lower than the HRA group, but no significant differences were found between the LD and LRA groups. For a visual analysis of group differences, the group means were standardized as z-scores and presented in Figure 1.

Figure 1. Visual Analysis of Groups' Performance in Target Variables Based on Z-Scores

Figure 1, which clearly illustrates the differences among the groups, shows that the performance scores of the groups differ significantly from one another. Specifically, students with LD demonstrated differences exceeding 1 standard deviation compared to students with HRA across all variables. Among these variables, reading fluency showed the most pronounced difference, with LD students scoring up to two standard deviations lower than HRA students. A similarly notable difference, approximately two standard deviations, was observed in reading accuracy. For variables such as reading comprehension, spelling, writing productivity, and content quality, differences of up to 1.5 standard deviations were observed. Among these, spelling exhibited the smallest difference relative to the other variables. When comparing LRA and HRA students, the differences exceeded 1 standard deviation across all variables except spelling. For reading fluency and accuracy, the differences were approximately 1.5 standard deviations, while the difference in spelling was close to 1 standard deviation.

For the second research question, the analysis descriptively examined the distribution of the groups' performance levels across the relevant variables. The LAB tests were categorized into five levels: very low, low, moderate, high, and very high, while reading accuracy was analyzed at three levels: frustration, instructional, and independent. The results are presented in Tables 3 and 4.

Table 3. Distribution of Groups' Performances in Target Variables Across Achievement Levels

Reading Level	Group	Reading Fluency		Reading Comprehension		Spelling		Writing Productivity		Content Quality	
		n	%	n	%	n	%	n	%	n	%
Very Low	LD	21	87.5	22	91.6	12	50	1	4.1	10	41.6
	LRA	15	65.2	16	69.5	5	21.7	0	0	7	30.4
	HRA	0	0	6	25	1	4.1	0	0	1	4.1
Low	LD	3	12.5	2	8.3	1	4.1	13	54.1	12	50
	LRA	8	34.7	4	17.3	6	26	10	43.4	11	47.8
	HRA	0	0	1	4.1	0	0	1	4.1	5	20.8
Moderate	LD	0	0	0	0	10	41.6	10	41.6	2	8.3
	LRA	0	0	0	0	9	39.1	12	52.1	5	21.7
	HRA	11	45.8	15	62.5	16	66.6	5	20.8	8	33.3
High	LD	0	0	0	0	0	0	0	0	0	0
	LRA	0	0	1	4.3	0	0	1	4.3	0	0
	HRA	11	45.8	2	8.3	6	25	13	54.1	10	41.6
Very High	LD	0	0	0	0	1	4.16	0	0	0	0
	LRA	0	0	0	0	3	13.0	0	0	0	0
	HRA	2	8.3	0	0	1	4.1	5	20.8	0	0

As shown in Table 3, it is evident that the intended distribution in reading fluency was achieved, as the students' reading levels were used as the basis for forming the research groups. Accordingly, students with LD and those with LRA were exclusively categorized at the very low and low levels for reading fluency, while students with HRA were concentrated at the moderate and high levels. For other variables, similar distributions to reading fluency were observed in reading comprehension and content quality. Students with LD and those with LRA were predominantly concentrated at the very low and low levels in both variables, while students with HRA were mostly concentrated at the moderate level for reading comprehension and at the moderate and high levels for content quality. In writing productivity, students with LD and LRA were mostly concentrated at the low and moderate levels, whereas students with HRA were concentrated at the moderate and high levels. Lastly, the distribution for spelling showed a broader spread. Students with LD were predominantly concentrated at the very low and moderate levels, students with LRA were spread across the very low, low, and moderate levels, and students with HRA were more concentrated at the moderate and high levels.

Table 4. Distribution of Groups' Reading Accuracy Performances by Accuracy Levels

Level	Group	Reading Accuracy	
		n	%
Frustration	LD	23	95.8
	LRA	18	78.2
	HRA	0	0
Instruction	LD	1	4.1
	LRA	4	17.3
	HRA	3	12.5
Independent	LD	0	0
	LRA	1	4.3
	HRA	21	87.5

As presented in Table 4, it was observed that 23 of the students with LD, except for one, were at the frustration level in terms of reading accuracy. Among the students with LRA, 18 were at the frustration level, while 4 were at the instruction level. On the other hand, among the students with HRA, 21 were at the independent level, while 3 were at the instruction level.

Conclusion and Discussion

This study compared the performance of students with LD, LRA, and HRA in reading fluency, reading accuracy, reading comprehension, spelling, and written expression skills, and examined the distribution of their achievement levels. The results of the group comparisons for the first research question indicated significant differences among the groups across all variables. According to the post-hoc test results, the LD and LRA groups scored significantly lower than the HRA group, while no significant differences were found between the LD and LRA groups in skills other than reading fluency. For the second research question, the analysis of achievement level distributions revealed that in reading fluency and reading comprehension, the LD and LRA groups were primarily at very low and low levels, whereas the HRA group was concentrated at moderate and high levels. In reading accuracy, the LD and LRA groups were predominantly at the "frustration" level, while the HRA group was at the "independent" level. Although the distributions in spelling were less pronounced compared to reading, the LD and LRA groups were concentrated at low and very low levels in word production and content quality, while the HRA group was concentrated at high levels. The findings were discussed in detail with a focus on group performances.

The results of the analyses aligned with previous research findings on students with LD. These findings indicate that students with LD demonstrated the lowest performance among the groups in reading and writing. In terms of achievement levels, they were concentrated at very low and low levels in reading fluency, reading comprehension, and content quality; very low and moderate levels in spelling; low and moderate levels in writing productivity; and at the "frustration" level in reading accuracy. These findings are consistent with prior studies investigating the reading and writing skills of students with LD (Alves et al., 2014; Arabacı, 2022; Aracı & Melekoğlu, 2023; Chung et al., 2011; Cirino et al., 2013; Graham et al., 2017; Kalindi & Chung, 2018; Lin et al., 2020; Mather et al., 1991; Richmond et al., 2023; Snowling et al., 2020; Toledo Piza et al., 2014; Torppa et al., 2020). For example, a study by Lin et al. (2020) found that students with LD performed significantly lower in reading fluency and reading comprehension compared to their typically developing peers. Similarly, Graham et al. (2017) reported that students with LD scored one standard deviation lower in content quality compared to their peers. These findings, consistent with previous research, clearly highlight the low performance of students with LD in reading and writing and the significant differences in their abilities compared to grade-level expectations.

The findings regarding group differences revealed significant differences across all skills between students with LD and those with HRA. Specifically, in reading, HRA students read an average of 110 words per minute, while LD students read only 52 words, demonstrating that LD students achieved less than half the reading fluency of the HRA group. Furthermore, the reading fluency of LD students in third and fourth grades corresponds to the performance level of students in the second semester of first grade, according to the LAB standards. Similarly, in writing, HRA students produced an average of 53 words while writing a narrative text, compared to only 25 words produced by LD students. This performance indicates that LD students achieved less than half the writing output of the HRA group, corresponding to the performance level of students in the second semester of second grade, based on LAB standards. These results suggest that LD students are 2-3 years behind in reading fluency and 1-2 years behind in writing productivity for written expression relative to their grade level. When the test scores were standardized as z-scores, the differences were approximately 2 standard deviations for reading fluency and reading accuracy, 1.5-1.6 standard deviations for written expression skills, and 1-1.5 standard deviations for reading comprehension and spelling. Similarly, numerous studies in the literature have found that students with LD are 1-3 years behind their peers or demonstrate performance that is 1-2 standard deviations lower in reading and writing (Ferrer et al., 2015; Ferrer et al., 2023; Graham et al., 2017).

These findings, consistent with previous research, warrant careful consideration from multiple perspectives regarding students with LD. First, the significant performance gap observed between students with LD and those with HRA highlights the urgent need for interventions and preventive measures. Prior studies indicate that such performance gaps are likely to widen over time (Ergül et al., 2023; Prochnow et al., 2015), potentially leading to broader academic failure and more complex challenges. For instance, one study identified low reading performance in third grade as a strong predictor of high school dropout (Alexander et al., 2001), while another study reported that approximately 75% of high school dropouts had reading difficulties (Sweet, 2004). Based on these findings, it is highly likely that the low performance levels observed in LD students in third and fourth grades will persist and intensify, potentially evolving into different problems if not addressed with timely and appropriate interventions. In the Turkish education system, students identified with LD are educated in general education classrooms but can receive up to 40% of their weekly instruction time in resource rooms (Özel Eğitim Hizmetleri Yönetmeliği, 2018) or up to three hours of support per week in private special education and rehabilitation centers (Milli Eğitim Bakanlığı Özel Eğitim Kurumları Yönetmeliği, 2012). While the extent of additional support received by the students in this study was not determined, the findings clearly indicate that the current support services are insufficient for bringing students to grade-level performance. Based on these results, it is evident that support services for LD students in Türkiye need to be expanded, and schools must plan more intensive, long-term interventions for these students. Research shows that high-quality interventions targeting reading and writing skills are highly effective in preventing these difficulties and improving the reading and writing abilities of LD students (Chard et al., 2002; Datchuk et al., 2020; Donegan & Wanzek, 2021; Graham & Kelly, 2018; Horne, 2017; Jeffes, 2016; Johnston, 2002; Roberts et al., 2015; Rosário et al., 2019; Vaughn, Wexler vd., 2011; Vellutino et al., 2004). Therefore, selecting and implementing appropriate methods and techniques in intervention programs is likely to be effective in mitigating the challenges faced by these students.

Secondly, the findings regarding the low performance of students with LD provide valuable insights for planning interventions targeting these students. Primarily, the significantly lower performance of LD students in reading fluency and reading accuracy compared to their peers highlights a critical need for intensive support in these areas. Although reading difficulties are more prominent in LD, the study's findings also demonstrate that these students lag significantly behind their peers in writing skills, such as spelling and written expression. Therefore, interventions for students with LD should adopt a multidimensional approach, focusing not only on reading skills but also on other competencies, such as spelling and written expression. Such a comprehensive intervention plan could contribute significantly to mitigating the challenges these students face. Moreover, considering the potential differences in individual needs among students, it is evident that tailoring intervention content to address these specific needs will be crucial in enhancing their effectiveness.

Another noteworthy finding from the analyses conducted for the research questions relates to the performance of students with LRA. The results indicate that the differences between LRA students and those with LD were not significant in skills other than reading fluency. Similarly, in terms of achievement levels, LRA students were predominantly concentrated at very low and low levels in reading fluency, reading comprehension, and content quality; at low and moderate levels in spelling and writing productivity for written expression; and at the "frustration" level in reading accuracy. These findings suggest that there are many students who, despite not having a formal diagnosis, demonstrate performance as low as that of students with LD in reading and writing. Similar findings have been reported in previous studies (e.g., Ergül, 2012; Ergül et al., 2022; Hooper et al., 1993; Jenkins et al., 2003; Lovett et al., 2000; Nascimento et al., 2011; Seçkin Yılmaz & Baydık, 2017). These results highlight the need for careful evaluation of Türkiye's diagnostic system. Students without a formal diagnosis but with low reading and writing performance may be experiencing undiagnosed learning disabilities. However, the lack of recognition of these difficulties points to certain issues within the diagnostic system in Türkiye. Studies on the diagnostic process in Türkiye reveal several challenges. For instance, experts and teachers involved in the initial identification process often lack sufficient knowledge (Çakmak,

2017; Fırat & Koçak, 2020; Öğülmüş et al., 2021), while very short durations were allocated for the evaluation process (Çağlayan, 2022). The tools used for assessment are also found to be limited and inadequate (Çağlayan, 2022; Yanık & Gürgür, 2017), and there is a shortage of trained professionals involved in the diagnostic process (Doğan & Türkkal, 2019; Ekim, 2015). Furthermore, effective collaboration among specialists and institutions involved in the diagnostic process is often lacking (Çakmak, 2017; Doğan & Türkkal, 2019; Dayı et al., 2022; Öğülmüş, 2021; Yılmaz & Doğan, 2023), and families are not sufficiently included in the process (Avcıoğlu, 2012; Dayı et al., 2022; Yanık & Gürgür, 2017). Considering all these findings and results, it is evident that problems within Türkiye's diagnostic system play a significant role in the failure to recognize reading and writing difficulties, accurately assess the severity of these challenges, and properly diagnose students with LD.

In conclusion, the findings of this study demonstrate that the performance of students with LD is significantly lower not only compared to their peers with HRA but also relative to their grade level. To prevent this pronounced performance gap from widening further, it is suggested that expanding support education services and developing intensive, long-term intervention programs targeting reading and writing skills would be beneficial. Additionally, the observation that students with LRA exhibited similar performance levels to those with LD is a notable finding, raising concerns that some students with LD may remain undiagnosed. Therefore, these results underline the critical importance of implementing high-quality interventions and improving diagnostic processes to enhance the performance of both LD and LRA students.

Limitations and Recommendations

When interpreting the results of this study, it is essential to consider its limitations. First, the study was conducted with 24 students diagnosed with LD, 23 students with LRA, and 24 students with HRA, all of whom were enrolled in schools in Kırıkkale. To strengthen the generalizability of the findings, future research is recommended to involve larger student groups from different regions. Second, the data analysis was limited to between-group comparisons. Future studies could employ different statistical methods to identify the variables that explain the reading and writing performance of these groups. Additionally, longitudinal studies could be conducted to explore questions such as how differences in reading and writing skills between LD, LRA, and HRA students evolve over time, whether LRA students eventually receive an LD diagnosis, or how many continue their education without being diagnosed. Third, this study focused on reading and writing skills, specifically reading fluency, reading accuracy, reading comprehension, spelling, and written expression. Future research could include other skills, such as word decoding, word identification, or copying, to investigate differences across a broader range of reading and writing abilities. Lastly, this study was limited to third- and fourth-grade students. Future research could extend these comparisons to students in earlier elementary grades or later grades, such as middle school, to provide valuable insights into how the reading and writing skills of LD students differ from their typically developing peers across various educational stages.

Based on the results of this study, several practical recommendations can be made. First, efforts should be undertaken to improve the quality of special education services, and teachers working with students with LD should receive training on reading and writing interventions. This is considered crucial for enhancing the low performance of LD students and narrowing the gap between them and their peers. Second, to effectively identify students who have not been formally diagnosed but exhibit similar challenges to those with LD, it is recommended to improve the effectiveness of the diagnostic system and adopt evidence-based approaches such as response-to-intervention models. Implementing more effective diagnostic approaches could significantly contribute to reducing the potential long-term negative outcomes for all students experiencing reading and writing difficulties.

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Original Article

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The efficiency of teaching with simultaneous prompting? To children with Autism Spectrum Disorder to acquire the skill of describing people

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Abstract

This study aimed to examine the effectiveness of simultaneous prompting teaching method on children with ASD to acquire the skills of describing people, the level of preserving the skills of the participants to describe the people they gained after the implementation ended, and the level of generalization to different people and different environments. In this study, a multiple probe model with probe phase between participants, which is one of the single-subject research models, was used. Four children with ASD, aged 5-10 years, participated in the study. Inter-observer reliability and application reliability data were collected at each stage of the study. Social validity data were collected from the parents and teachers of the four participants who participated in the study to determine their views on the research. While the inter-observer reliability coefficient of the study was calculated as 97.75%, the coefficient of the application reliability data was obtained as 96.65%. The effect size of the study was calculated with the Tau-U method, which is one of the methods based on non-overlapping data. Accordingly, the effect size Tau-U value of the application was calculated as 0.8131 which indicates a medium effect size. At the end of the research, it was seen that the application performed with simultaneous prompting of the participants was effective in developing the skills of children with ASD to describe people and that they were able to generalize these skills to different environments and to different people, and they were able to maintain these skills 7, 14 and 21 days after the implementation ended.

Keywords

Autism Spectrum Disorder

Describing people

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Introduction

Autism spectrum disorder (ASD) is defined as a neurodevelopmental disorder that occurs in the first three years of early childhood and is characterized by inadequacies in social interaction and interests, as well as obsessive and repetitive behaviors (American Psychiatric Association [APA], 2013). Although there are many characteristics (e.g., lack of eye contact, echolalia, mutism) that distinguish children with ASD from their typically developing peers and other disability groups, children with ASD also perceive dangerous situations in the environment as a result of perceiving stimuli at the same time or being overly sensitive to some stimuli and experience limitations in recognizing (APA, 2013). When

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children with ASD look at any individual, they have limitations in answering questions about these people and reading clues about their physical characteristics (Bradshaw et al., 2010; Chawarska & Shic, 2009; Özer & Özdemir, 2015; Schultz, 2005). These limitations can compromise their safety in social environments by reducing their ability to identify unfamiliar or threatening individuals.

Safety skills are defined as behavior sets developed to help individuals protect themselves from harmful situations such as abduction, harassment, or accidents (Jang et al., 2016; Miltenberger, 2008). While typically developing children acquire these skills naturally through observation and experience, children with ASD often require systematic instruction to develop and generalize these behaviors (Ergenekon & Çolak, 2019; Scheuermann & Webber, 2002; Tekin-İftar et al., 2018). Numerous studies emphasize that individuals with ASD are more likely to encounter life-threatening situations and are often less equipped to respond effectively due to challenges in stimulus discrimination, communication, and generalization (Baruni & Miltenberger, 2022; Celik & Olcay, 2025). Despite these risks, safety skills are often under-prioritized by educators and families (Sirin & Tekin-Iftar, 2016), and many children receive no structured training in this domain (Değirmenci et al., 2022).

Studies indicate that children with ASD can learn safety behaviors through behavioral teaching methods; however, interventions that focus specifically on person identification and description remain sparse. While various strategies such as behavioral skills training, video modeling, and prompting procedures have been used to teach abduction prevention or poison safety (Miltenberger et al., 2020; Morosohk & Miltenberger, 2022), targeted teaching of person description—especially as a verbal reporting safety skill—has not been systematically addressed. Furthermore, it is emphasized in the literature that generalization and maintenance are often overlooked, despite being critical for the effectiveness of safety interventions (Baruni & Miltenberger, 2022).

The person description skill —referring to articulating physical features such as age, height, clothing, and facial characteristics—is critically important in ensuring children can report harmful encounters to caregivers or authorities (MoNE ,2009). The inability to describe a person involved in a harmful incident (e.g., abuse, threat, insult) may prevent timely intervention, and in some cases, expose the child to repeated harm. This concern becomes especially significant for children with ASD, who may face barriers in both perceiving and verbally expressing such descriptions (Miltenberger, 2008). Considering the national and international statistical data, it is stated that although the rate of child abduction has increased, education programs aimed at protecting and avoiding strangers have not been developed sufficiently (Johnson et al., 2005; Kutlu, 2016). Studies reveal that children with ASD can learn safety skills through systematic practices, however, it is seen that the teaching of vital safety skills for children is limited, and this teaching is usually done with individuals during adolescence and adulthood (Değirmenci, 2018; Saiano et al., 2015; Summers et al., 2011; Tekin-İftar et al., 2018; Wiseman et al., 2017).

The ability to describe people, which forms the basis of the research, is defined as the description of a person's physical appearance through characteristics such as age, height, body, hair, eyes, face or clothing (MoNE, 2009). It is thought that it is vitally important for children with ASD to report this situation to their relatives by giving a description of the person concerned, when they encounter any harm (violence, insult, abuse, etc.) from any peers or adults in any social environment. If children with ASD do not report this to their adult relatives and cannot describe the physical appearance of the person concerned, there may be a high probability of encountering a similar danger situation with the same person later on. It is thought that if the child with ASD reports this attempt to an adult by describing the perpetrator with its external appearance characteristics, in the danger situations of which examples are given, it is thought that the people who harm or are likely to harm themselves will also be taken under control (Miltenberger, 2008).

As far as our research on the subject, we did not come across any study that teaches the ability to describe people within the scope of security skills in the national and international literature. Considering this gap, the present study investigates the effectiveness of simultaneous prompting in teaching person description skills to children with ASD as a critical component of safety instruction. In addition to addressing a neglected area of applied research, this study also explores the generalization and maintenance of the acquired skill and includes the perspectives of families and teachers to ensure social validity. It is thought that teaching the skills of describing people to children with ASD in the early period will also form the basis for the teaching of safety skills. In this context, the aim of this research is to determine the effectiveness of simultaneous prompting in the teaching of the ability to describe people in order to protect children with ASD from strangers.

Simultaneous prompting is an evidence-based instructional method proven effective in teaching various academic, self-help, and safety skills to individuals with developmental disabilities, including ASD (Tekin-İftar & Kircaali-İftar, 2006). Despite its documented utility in areas like abduction prevention or street safety, research applying simultaneous prompting specifically to teach person description as a verbal safety skill remains minimal. Moreover, while general education literature includes interventions targeting descriptive language and threat identification, these methods are rarely adapted or validated for use with children on the autism spectrum. Given these gaps, this study aims to contribute evidence regarding the applicability and efficacy of simultaneous prompting in promoting this critical safety behavior. In this context, the following questions were sought to be answered in the research:

1. Is simultaneous prompting effective in teaching the skills of describing people to children with ASD?
2. Do children maintain this skill at follow-up points (7th, 14th, and 21st days post-intervention)?
3. Can the learned skill be generalized across different people and environments?
4. What are the opinions of participant teachers regarding the effectiveness of this instruction?
5. What are the families' views on teaching person description skills through simultaneous prompting?

Method

Research Model

In the study, a multiple probe model with probe phase between participants, one of the single-subject research models, was used in teaching the skills of describing people to children with ASD. The multiple probe model with probe phase between participants is a model that is carried out with at least three participants and examines the effect of the independent variable on the dependent variable (Gast, 2009; Tekin-İftar, 2018).

Variables of the Study

The dependent variable, person description skill, was operationalized as the ability to correctly describe at least three physical features of a target individual within 5 seconds after being presented with the instruction. The expected features included height (tall/short), weight (thin/fat), and gender (male/female). A response was recorded as correct (+) only if it matched the predetermined acceptable expressions outlined during the pilot (e.g., “tall” or “bigger than me” for height). Inappropriate or no responses within the allotted time were marked as incorrect (-). The total correct responses were divided by the total number of prompts to calculate accuracy percentages.

Working Group

During the process of recruiting child participants, the officials, teachers and parents of a special education school providing education to children with ASD were interviewed. Institutional and parental permissions were obtained for the research. The prerequisite skills required for the participants to be included in this study are listed in Table 1.

Table 1. Prerequisite Skills Required in Participants.

- Being diagnosed with ASD
- Have no previous training in person describing skills
- Determining the ability to describe people in IEP as a goal
- Be able to imitate three- or four-word sentences
- To be able to distinguish/name the concepts of short and long
- To be able to distinguish/name the concepts of thin and fat
- Be engaged in an activity for at least five minutes
- Not having problem behaviors
- Fulfilling 2-3 word instructions

Four boys with ASD aged between four and 10 participated in the study. Gilliam Autistic Disorder Rating Scale-2-Turkish Version (GADRS-2-TV; Diken et al., 2011) and Adapted Autism Behavior Checklist (A-ABC; Diken et al., 2018) were used to evaluate the ASD levels of the participants. In the study, the average OBI scores were obtained by applying A-ABC in line with the information received from the families of the participants. According to the GADRS-2-TV results, the probability of ASD was found in four of the participants (Ege, Alper, Poyraz and Ozan). Accordingly, the Autistic Disorder Index (ADI) scores of the children included in the GADRS-2-TV results ranged from 70 to 81, and the average ADI score of the children was 75.5. This shows us that there is a possibility of ASD in the participants. The general characteristics of the participants participating in the research are shown in Table 2.

Table 2. General Characteristics of Participants

Name	Gender	Age	Year of Special Education	GADRS Score	A-ABC Score	Education Level
Ege	Boy	5	3 Years	70	5	Kindergarten-Inclusion
Poyraz	Boy	8	5 Years	74	7	2nd Class-Inclusion
Alper	Boy	9	5 Years	81	14	2nd Class- Special Education Class
Ozan	Boy	11	7 Years	77	13	3rd Class-Special Education Class

Ege is a five-year-old boy diagnosed with ASD. According to the evaluation made with GADRS-TV-2, Ege's ASD rating was 70 and there was a possibility of autistic disorder. According to the A-ABC evaluation, his score was five, and the level of support need for ASD level was determined as mild support need. Poyraz is a seven-year-old boy diagnosed with ASD. According to the evaluation made with GADRS-TV-2, Poyraz's OSD rating was determined as 74 and there is a possibility of ASD. At the same time, the score obtained in the evaluation with A-ABC was 7 and was determined at the level of mild support need. Alper is an eight-year-old boy diagnosed with ASD. According to the evaluation made with GADRS-TV-2, the ASD rating was 81 and the possibility of ASD was determined as present, but the score obtained according to the evaluation made with A-ABC was 14 and the need for support was determined as mild. Ozan is a 10-year-old boy diagnosed with ASD. According to the evaluation made with GADRS-TV-2, Ozan's ASD rating was 77 and there was a possibility of ASD. At the same time, the score obtained in the evaluation with A-ABC was 13 and was determined at the level of mild support need.

Environment

The daily probe, entire probe and follow-up sessions of the research were carried out at a foundation's autism school in Şişli, Istanbul, in four sessions per week in the classrooms where the participants received individual education. Generalization sessions, on the other hand, are the school corridor and the playground in the backyard of the school, which are available when you enter through the door.

Materials

In order to teach the skills of describing people, people with different physical characteristics were determined among the school staff. In the generalization sessions, planning was made so that they would be in the designated location in the corridor and garden of the school at the predetermined time and day. In addition, smart phones, detected reinforcers and data forms were used for the videos to be used in the research. It is a visual clue that includes examples of gender, height and weight on the training material to be used in the teaching of the skill of describing the person with simultaneous prompt and covered with lamination. Visual cues were used to enable participants to more concretely notice the features they would describe.

Experiment Process

Pilot Practice

A pilot application was organized in order to identify and prevent possible problems that may arise during the implementation and to better support the internal validity of the research. In the pilot application, another child with the prerequisites who was not a participant in the research was studied in two sessions a day, five days a week. As a result of the pilot application, it was determined that the participant gained the ability to describe people. After the pilot application, the correct response intervals of the participating children were increased. For example, “female, male” answers for the gender variable; It was arranged to cover the reactions of "male, female, guy, girl". For the weight variable, “fat and thin” answers; Definitions such as “large, small, strong, wide” were also accepted as the correct response. In addition, the main directive "describe that person" was expanded and changed to "look at his face, body, feet and describe that person".

Baseline Sessions

The baseline data collection process was collected for at least five consecutive sessions until stable data were obtained for all four participating children separately from each other. Visual materials were not used in the introductory level sessions, and the sessions were held in the classrooms of the participants. Before starting the session, the researcher and the participant first had a short conversation (eg, “Hello!”, “How are you today?”). Afterwards, the researcher said, "We will do a study with you and there will be some rules you have to follow" and explained the rules and the prize he would win if he followed the rules (for Ege, trampoline and/or train toy; for Ege, Poyraz Alper and Ozan, tablet). The researcher pointed to the person entering the classroom and presented the target stimulus by saying "Look at that person's face, body, feet and describe them". Five seconds after the instruction is given responds correctly about the person's gender (male/female, male/female, girl/boy or man), weight (underweight/fat, smaller/bigger than me, stronger/weaker than me) and height (taller/shorter than me) the researcher recorded correctly (+) in the relevant box in the data form. Five seconds after the instruction is given. If the participant did not give any response but simply repeated the instruction or gave an incorrect response, the researcher recorded it as (-) in the data form.

Teaching Sessions

After obtaining stable data at the baseline level, teaching the skills of describing people with simultaneous prompting was started with the first participant. In the teaching sessions, the stages performed at the introductory level are applied before starting the teaching (short conversation, explaining the rules and reward, presenting a remarkable stimulus). After the person to be described entered the classroom, the researcher presented the control prompt (verbal cue) after presenting the target stimulus. If the participant describes according to the steps in the describing skill, he reinforces the participant's correct responses by describing them with the reward determined before the session. The rules, the purpose of the study, the introduction of the materials, the award and the presentation of the simultaneous prompt were applied in the same way for all participants in the teaching session. Teaching sessions continued until the 100% criterion was met for five consecutive sessions in participants' daily probe sessions. It is acknowledged that some participants reached the mastery criterion in fewer sessions than expected. However, this was anticipated based on pilot testing and the

participants' prerequisite skills, such as verbal labeling and basic concept differentiation (e.g., height, weight). The rapid acquisition is also interpreted as a sign of the efficiency of simultaneous prompting, as it eliminates trial-and-error learning. To control for this, a minimum of five baseline sessions was ensured and generalization/follow-up data were collected to confirm maintenance and transfer, thereby strengthening the internal validity of the instructional impact.

Entire and daily probe sessions

In the entire probe sessions, data were collected by following the process in the baseline sessions. The teaching of the person description skill was organized for all participants after it ended with the first participant. The fourth and last entire probe session was held after the last participant's teaching was terminated and again for all participants. Entire probe sessions were held simultaneously with each participant. Daily probe sessions were held before each teaching session. Daily probe sessions were carried out similarly to the baseline session. The session was terminated when the participant gave 100% correct response three times in a row in the daily probe sessions.

Generalization and follow-up sessions

In the research, generalization sessions were carried out to demonstrate the skill of describing a person in different environments and with different people. In the generalization sessions, the visual clues that the participants used during the teaching session were not used. Generalization sessions were held in the school hallway and playground in the backyard. While the researcher and the participant were in the corridor or in the garden (with Poyraz in the corridor and in the garden with the other participants), people whom the participant hardly knew came to the environment. The correct reactions of the participant in the generalization sessions were reinforced verbally by saying "well done, how well you described it!", "you are very careful, it is great that you can describe it like that!". Incorrect responses were ignored, and the generalization sessions were terminated without saying anything. Follow-up sessions were held 7th, 14th and 21st days after the end of the last probe sessions, held after the end of the teaching sessions, to examine the level of preservation of the skills of describing people. The participants were given instructions on the person description skill without any hints, and they were expected to describe the people they described in the teaching sessions.

Data Collection and Analysis

Data collected in (a) baseline, (b) daily probe, (c) entire probe, (d) follow-up and (e) generalization sessions for the effectiveness of simultaneous prompt instruction in the teaching of the person description skill performed on participants throughout the research, as effectiveness data evaluated. The analysis of the data in the sessions [(Number of Correct Responses/Total Number of Responses) x100] formula was obtained (Bilmez & Tekin-İftar, 2014). The percentages of data obtained are indicated by transferring to the graph. In the graph, the number of sessions on the horizontal axis and the percentages of correct responses in the skill analysis of describing people are given on the vertical axis. Tau-U, one of the non-overlapping data-based methods, was used for effect size calculation. The Tau-U value is defined as the number of overlapping data pairs obtained by comparing the baseline data points with the data points in the teaching session, subtracting the non-overlapping data pairs, and then the ratio of the value obtained to the total number of data pairs compared (Parker et al., 2011). The formula used to calculate the Tau-U value was stated as (Kendall correlation number (S)/Total number of pairs) x 100]. The Tau-U value obtained as a result of the calculations is between 0 and 1. Effect size of 0-0.65 indicates low impact, 0.66-0.92 moderate impact, and 0.93 and higher mean, high impact (Parker et al., 2011; Rispoli et al., 2013). In this study, the effect size Tau-U value was calculated using the calculation engine at the http://singlecaseresearch.org/calculators/Tau-U web address. As a result of the calculation, the effect size of this study was calculated as Tau-U value of 0.8131 which indicates a moderate impact.

In calculating the inter-observer reliability coefficient of the research, 30% of all teaching session with video recordings were evaluated by two observers, and the correct or incorrect responses recorded jointly were accepted as consensus. If the same reaction of the participant was accepted as right or wrong by one observer and did not agree with the other observer, this situation was recorded as a difference of opinion. Consensus/(consensus + disagreement) x 100 formula was used to calculate the inter-observer reliability data. The interobserver reliability findings obtained in the study were calculated as 97% in the baseline sessions, 98% in the daily probe sessions, 97% in the entire probe sessions, 99% in the generalization sessions and 98% in the follow-up sessions.

In calculating the application reliability coefficient of the research, application reliability data from 30% of the sessions were analyzed. While calculating the application reliability data, the formula "observed practitioner behavior/planned practitioner behavior x 100" was used. The steps of collecting application reliability data "Batch Probe, Daily Probe and Follow-ups" were formed by taking the opinions of three experts and consist of eight steps. These steps are "chatting briefly", "explaining rules", "explaining rewards", "giving attention-grabbing cues", "giving target instruction", "waiting for response interval time", "offering associated praise" and "giving rewards". Teaching sessions consist of 11 steps and these steps are; "chat briefly", "explain the rules", "state the purpose of the lesson", "explain the rewards", "give attention-grabbing hint", "give the target instruction", "present the controlling hint", "wait the response interval", "appropriate responding", "giving praise associated with the behavior" and "giving the reward". Generalization sessions application confidence consist of five steps. These steps are; "chatting briefly", "giving the target instruction", "waiting for the response interval time", "reacting appropriately" and "ending the session". The ability to describe people with simultaneous prompting was found to be 97% in baseline sessions, 99% in daily probe sessions, 95% in entire probe sessions, and 97.5% in generalization sessions.

The data were visually graphed using Microsoft Excel with clear vertical phase-change lines to indicate transitions between baseline, instruction, generalization, and follow-up phases. Data points were aligned on the horizontal axis representing sessions, and the vertical axis showed the percentage of correct responses. Care was taken to ensure consistent scaling and spacing to improve readability and phase interpretation accuracy.

Results

Efficacy and Persistence Findings

In this section, the data collected in the baseline, entire probe, teaching, generalization and follow-up sessions regarding the skill levels of Poyraz, Alper, Ege and Ozan are given in Figure 1. The number of sessions are indicated on the horizontal axis of the graph, and the response percentages for the dependent variable (the ability to describe people) are indicated on the vertical axis of the graph. Figure 1 illustrates the session-by-session progress of each participant from baseline through teaching and follow-up phases. It clearly demonstrates the rapid performance increase following the introduction of simultaneous prompting and the maintenance of skills over time. Entire probe data is from the responses of the participants in the entire probe sessions; daily probe data were obtained from their responses in daily probe sessions held before the teaching sessions.

Five baseline data collected before starting the application with Poyraz is at the level of 25%. In the teaching session, 33% in the first teaching session; gave 100% correct response in the second, third, fourth, fifth and sixth teaching session. At the end of the implementation process, it was observed that Poyraz met the 100% criterion for five consecutive sessions. It was measured that Poyraz performed his ability to describe people correctly at the 100% level in a total of four polling phases held after the teaching session. Poyraz also gave a 100% correct response in the follow-up sessions 7, 14 and 21 days after the end of the teaching. These data suggest that Poyraz acquired the person description skill with a high level of accuracy after only two teaching sessions. Maintaining 100% performance throughout follow-up indicates that the acquired skill was both internalized and retained over time, reflecting the effectiveness and permanence of the simultaneous prompting method.

The baseline data in Alper's ability to describe people is at the level of 25%. In five of the first probe sessions held before the teaching session, 25% responded correctly, and then the teaching session was passed. Alper in the teaching session, 67% in the first, second and third teaching sessions; In the fourth, fifth, sixth, seventh and eighth teaching session, five consecutive sessions performed 100% correctly. In the collective polling phase held after the end of the teaching session, Alper performed the skill steps of the person description skill correctly at the 100% level. He gave 100% correct response in the first Follow-up, 88% in the second Follow-up, and 100% in the third Follow-up for Alper. These findings demonstrate that Alper benefited significantly from the simultaneous prompting instruction. Although his performance was stable but low during baseline and probe phases (25% accuracy), he achieved a consistent 100% correct response across five consecutive sessions following instruction. Furthermore, his high performance during generalization and follow-up sessions suggests that the skill was not only learned effectively but also retained over time and applied in novel contexts. This highlights the functional impact of the intervention in supporting real-life communication and safety behaviors.

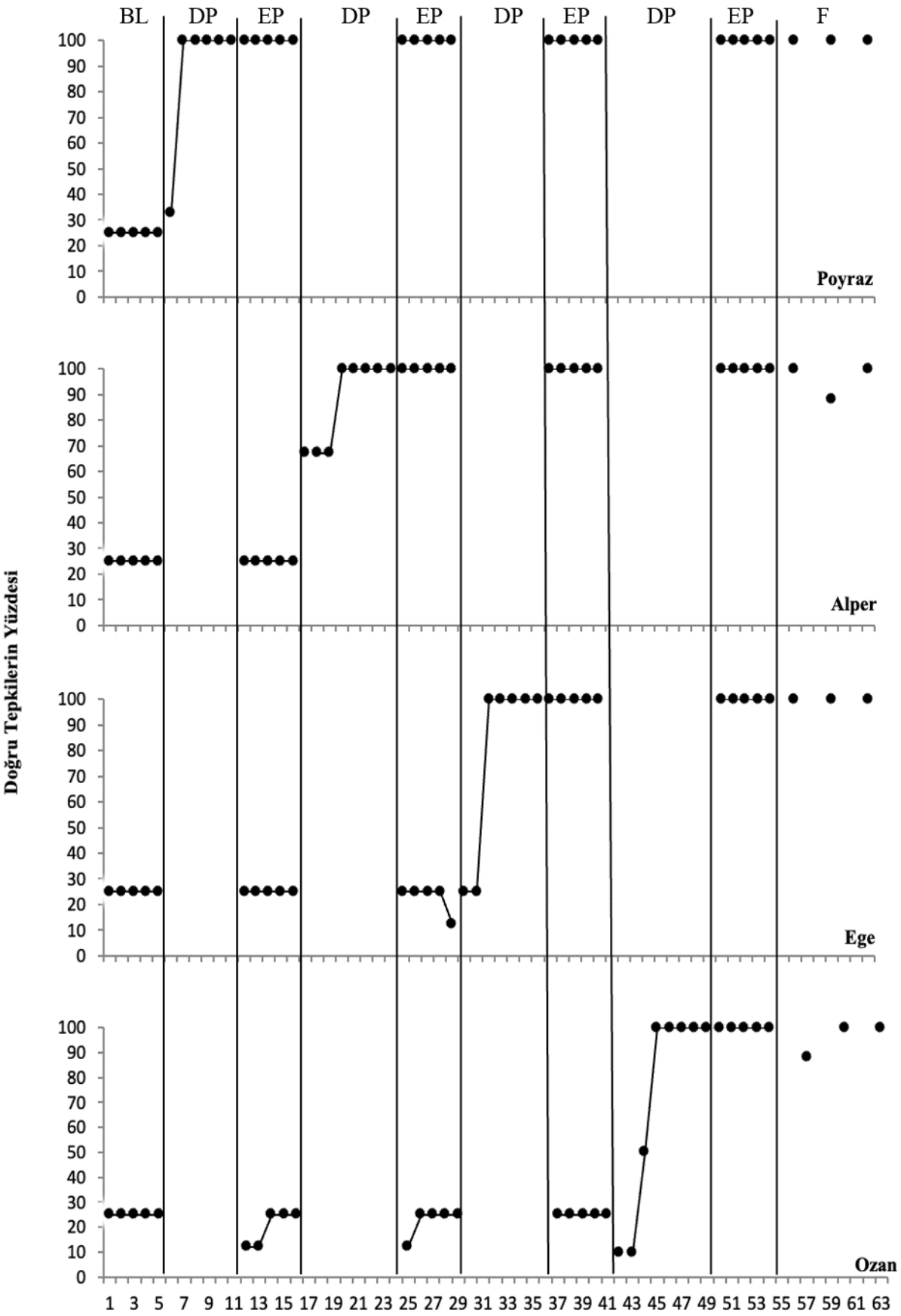

Figure 1. Percentage of Correct Response to Poyraz, Alper, Ege, and Alper in Describing Persons Baseline (BL), Daily Probe (DP), Entire Probe (EP) and Follow-up (F) Sessions

It was noted that Ege's correct response at the level of 25% in the person description skill by responding correctly in the section of the skill steps, only looks at the person to be described, in the baseline session. Ege's performance was the same as at the baseline level in the first entire probe session and five sessions, which was carried out before the teaching session, and a correct response percentage of 25% was recorded. In the second entire probe session, 25% correct response percentage in the first four sessions and 10% correct response percentage in the last session was recorded and the teaching session was started. In the teaching sessions, Ege initially scored 25% but achieved 100% accuracy in the second through sixth sessions. Although Ege's performance level was 100% in five sessions in a row, in the two entire probe sessions held after the teaching session, the performance in the skill steps of describing people was recorded as 100%. Ege's correct response percentage in the first, second and third follow-up sessions was also measured as 100%. Although Ege demonstrated slower progress during baseline and probe phases, he reached 100% accuracy within a short teaching span and maintained this performance during all post-instruction sessions. This outcome highlights the efficiency of individualized instruction tailored to prerequisite skills.

Ozan responded correctly at the level of 25% in the skill level of describing people by responding correctly in the section of the skill steps, he only looks at the person he will describe. Considering Ozan's performance in three entire probe sessions held before the teaching session, it is listed as follows. In the first entire probe session held after the baseline level, 10% correct response percentage in the first two sessions and 25% in the next three sessions was determined. In the second entire probe phase, it performed 10% correctly in the first session and 25% in the four sessions. It showed the same performance as at the baseline level in the five sessions of the follow-up probe phase, which was held before the teaching session, and a 25% correct response percentage was recorded. Ozan in the teaching session, 10% in the first and second teaching sessions; 50% in third teaching session; 100% accurate performance level was measured in the fourth, fifth, sixth, seventh and eighth teaching session. It was noted that Ozan achieved 100% correct response percentage in a row in the last five sessions of the teaching. In a entire probe session held after the end of the teaching session, it was measured that Ozan's ability to describe people correctly performed the skill steps at the 100% level. It was determined that Ozan responded correctly at the level of 100% in the first follow-up session, 88% in the second follow-up session, and 100% in the third follow-up session. It was determined that Ozan maintained his ability to describe people in the follow-up sessions held 7, 14 and 21 days after the teaching sessions ended. Ozan's data illustrate a more gradual acquisition pattern compared to the other participants. His low and inconsistent baseline performance (10-25%) and slower progress in the early teaching sessions indicate that more instructional exposure was initially required. However, he reached 100% correct responses in the final five teaching sessions and maintained this accuracy throughout follow-up and generalization phases. This suggests that once the instructional content was internalized, Ozan was able to generalize and retain the skill effectively. His improvement exemplifies the adaptability of simultaneous prompting to different learning paces and profiles within the ASD population.

Generalization Findings

It was tested with the pre-test, post-test model whether the effect of simultaneous prompting instruction on different interpersonal and inter-environmental generalizations was realized in teaching the person description skill. Generalization data were collected after starting the teaching session and reaching the target criteria in the teaching session. Generalization sessions were planned with people whom the participants hardly knew. While Poyraz was chatting with his educator from the corridor of the school, an educator he barely knew came to the environment. Then, the researcher presented the target instruction (describe that person) to Poyraz for describing the person. It was noted that Poyraz performed 25% in the pre-test generalization session regarding his ability to describe people. In the post-test generalization session, it was noted that Poyraz was able to generalize his skills to different people and different environments at 100% performance level. While Alper was chatting with the researcher in the garden of the school, an educator he did not know well, came to the garden at the planned time. Then, the researcher presented the target instruction (describe that person) to Alper to describe the person. The pre-test generalization performance level of Alper's ability to describe people was determined as 25%. The performance in the post-test generalization session was measured as 100% and it was noted that the acquired skill was generalized to different people and different environments.

While Ege and the researcher were chatting with the educator in the garden of the school, an educator he knew little came close by the researcher and Ege. Afterwards, the researcher gave the target instruction (describe that person) to Ege to receive discription from Ege. While Ege's correct response percentage was 25% in the pre-test generalization session, his performance level in the post-test generalization session was measured as 100%. This situation reveals that Ege generalizes his describing skills to different people and different environments. While Ozan was chatting with his educator in the garden of the school, an educator he barely knew came to the environment. Then, the researcher presented the target instruction (describe that person) from Ozan to describe the person. Ozan's performance level in the pre-test generalization performance was recorded as 0%. The data obtained in the post-test generalization session was determined as 100% and it was noted that Ozan's ability to describe the people he gained generalized to different people and different environments. These findings indicate that the person description skill, once taught through structured prompting, can be effectively transferred to naturalistic settings. The ability to apply the skill outside the training environment suggests that the instruction was functionally meaningful and contextually relevant. As shown in Figure 2, each participant successfully generalized the acquired skill to different individuals and settings, confirming the instructional method's effectiveness beyond the original learning context. The generalization data of Poyraz, Alper, Ege and Ozan's ability to describe people are presented in Figure 2.

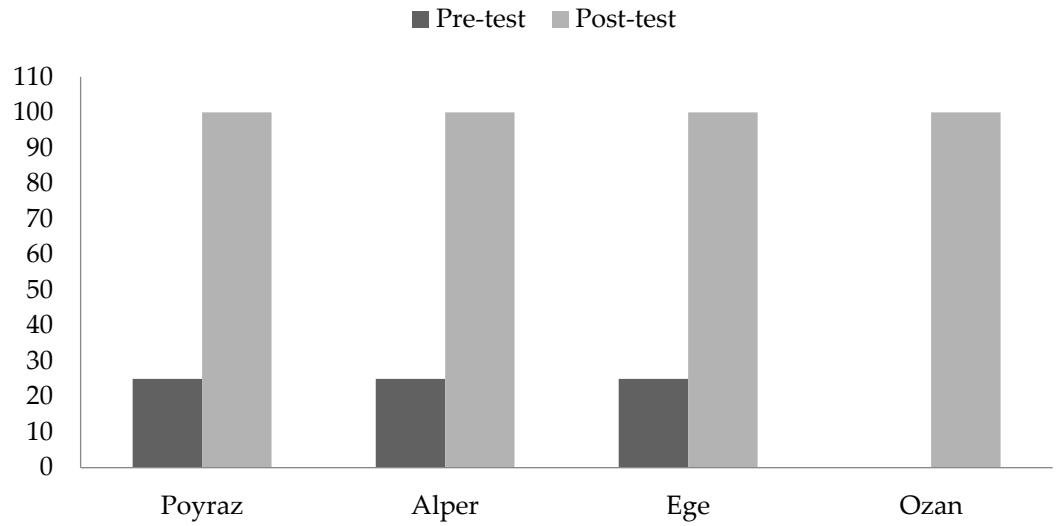

Figure 2. Percentage of Correct Response to Poyraz, Alper, Ege and Alper in the Generalization Sessions of Describing People

Social Validity Findings

In this research, social validity data were collected from families and teachers of the participants in order to get their opinions about the research. All of the teachers of the participants included in the study answered "Yes" to all questions in the social validity form. The teachers stated their positive opinions about the suitability of the students for teaching life, the applicability of the teaching method used, the support for safety skills, and the significance of the research findings, which was conducted with children with ASD. The parents of the participants in the study also answered "Yes" to all questions in the social validity form. Parents stated that this study, which was conducted with children with ASD, was positive about their children's suitable for their social life, supporting their safety skills for the risks they might experience in daily life, the applicability of the teaching method used, supporting safety skills, and the significance of the research findings. The positive evaluations from both teachers and families further reinforce the social importance of this intervention. Participants' ability to describe unfamiliar individuals is not only academically relevant but also a critical safety behavior with real-world implications, especially for children with ASD who are more vulnerable in public spaces.

Discussion and Conclusion

When the national literature is examined, no previous study has been found on the ability to describe people with children with ASD. This skill is one of the most important skills for children with ASD to ensure their own safety and protect themselves from abuse. These outcomes are especially significant when considering the real-world importance of enabling children with ASD to verbally describe potentially dangerous individuals. As emphasized in the introduction, this skill may help children report unsafe encounters, thus potentially preventing recurring risks. For this reason, the results of this study demonstrates the importance of acquiring these skills for children with ASD. In this context, the results of the research will make significant contributions to the national and international literature and will lead to further research on these issues.

Although there is no research on the skills of describing people, there is only one research conducted in Turkey within the scope of security skills with simultaneous prompting. In this study carried out by Tekin-İftar et al. (2003), the effectiveness of teaching with simultaneous prompting in teaching the ability to say the names of first aid tools, one of the safety skills, was examined. At the end of the research, they concluded that simultaneous prompting is effective in the ability to say the names of first aid materials. In addition, the results of this research are similar to the results of other studies conducted with the simultaneous prompt processing process (Akmanoglu & Batu, 2002; Akmanoglu & Tekin-Iftar, 2011; Altunel, 2007; Genc-Tosun & Kurt, 2017; Kanpolat, 2008; Karşıyakalı, 2011; Kılıç, 2019; Özer, 2018; Pennington, 2010; Ramirez et al., 2014; Williams et al., 2000).

The results of the research show that the children with ASD who participated in the study retained the ability to describe the person taught with the simultaneous prompting teaching method 7th, 14th and 21st days after the end of the teaching. The current findings directly address gaps highlighted in the literature regarding the insufficient focus on generalization and maintenance in safety skill interventions (Baruni & Miltenberger, 2022). By including structured follow-up and generalization sessions, this study demonstrates that person description skills can not only be acquired but also sustained and transferred to different people and settings when taught through systematic instruction. The follow-up findings of the study revealed that Poyraz, Alper, Ege and Ozan maintained their skills of describing people taught by simultaneous prompting teaching method at an average rate of 100%, 96%, 100%, and 96%, respectively, 7, 14 and 21 days after the end of the instruction. These results coincide with the findings of different studies conducted with the simultaneous prompting method of teaching children with special needs (Akmanoglu & Batu, 2002; Akmanoglu & Tekin-Iftar, 2011; Altunel, 2007; Genc-Tosun & Kurt, 2017; Kanpolat, 2008; Karşıyakalı, 2011; Kılıç, 2019; Özer, 2018; Pennington, 2010; Ramirez et al., 2014; Williams et al., 2000).

It is seen that after the end of the education, children with ASD can generalize their skills of describing the people gained by the simultaneous prompting teaching method to different environments and people. The data obtained in the generalization sessions show that Poyraz, Alper, Ege and Ozan were able to generalize their personal describing skills to 100%. When the literature is examined, there is no research that tests the generalization of the skills of describing people with the simultaneous prompting teaching method. Considering the generalization results of this study, it is similar to the generalization data results of studies conducted with simultaneous prompting teaching method (Akmanoglu & Tekin-Iftar, 2011; Collins et al., 1992; Gunby et al., 2010; Gunby & Rapp, 2014).

The findings revealed that the parents and teachers of the children with ASD who participated in the study had positive views on the importance of the aims of the research, the suitability of the method used in the research, the applicability of the method used in the research, and the functionality of the research findings. The opinions of all parents and teachers on whether the ability to describe people within the scope of safety skills is a priority skill is that it is a priority skill. This result is in line with the studies in the literature on the importance of teaching safety skills (Değirmenci, 2018; Saiano et al., 2015; Summers et al., 2011; Tekin-İftar et al., 2018; Wiseman et al., 2017).

The efficiency and consistency of participant learning outcomes further reinforce the value of simultaneous prompting as a structured, errorless teaching method. Its capacity to reduce confusion and facilitate quick acquisition of complex skills has been echoed in previous studies and is once again supported here through high follow-up retention. As a result, it is seen that the practice carried out with the simultaneous prompting method of gaining the skills of describing people to children with ASD is effective, permanent and generalizable. In order to determine this effectiveness, the graphs of the data collected systematically throughout the research were created and analyzed by visual analysis. As a result of these analyzes, it has been concluded that the simultaneous prompting method is effective in teaching person describing skills. In addition, in order to support the results obtained and to reveal the effect size, the effect size value of the intervention was calculated with the Tau-U calculation method, which is one of the techniques based on non-overlapping data. As a result of the Tau-U calculations, the application was found to be effective. In the study, it was also concluded that as a result of the social validity data collected from the teachers and parents of the children, the views on the effectiveness of teaching with simultaneous prompting, the applicability of teaching with simultaneous prompts and the importance of research in teaching the skills of describing people were positive. Another result that emerged from the answers of parents and teachers is that teaching the skills to describe people can inform their relatives in detail about the risk situations that may arise in daily life. From a practical standpoint, these findings highlight the potential of integrating structured person description instruction into individualized education plans (IEPs) for children with ASD. Future research may expand on these findings by exploring more diverse attributes, including emotional expressions or contextual details. In addition to its contributions, the study has two limitations. The first of these is that the research was carried out with four male students with ASD who received individual education in a special education school in Istanbul, and the second was that only the dependent variables of "gender, weight and height" were studied from person describing skills.

Suggestions

. In the light of the findings of the study, some suggestions can be made for both practice and future research. Suggestions for practice can be listed as follows: (a) using simultaneous prompting to parents of children with ASD and teachers working with children with ASD in teaching challenging skills such as describing people, (b) Teachers, administrators in all educational institutions interacting with children with ASD. In-service trainings can be organized to inform people about describing skills within the scope of security skills, (c) parent training programs for teaching safety and avoidance of abuse to parents with children with special needs, and vocational training programs for teaching security and protection from abuse skills to teachers with special needs students development programs can be arranged. Suggestions for future research can be listed as follows: (a) when we look at the literature, we could not find any research that aimed to teach the skills of describing people to children with ASD. Therefore, in order to generalize the findings obtained in the study, similar studies were repeated with different participants, (b) all stages of this study were carried out by the researcher. In further research, studies in which different practitioners (e.g., siblings, mothers, teachers, peers) teach teach skills within the scope of security skills. Further research can examine the effectiveness of other practices (e.g., basic response teaching, embedded teaching) in teaching these behaviors, (c) more research can be conducted on teaching safety and protection from abuse skills in children with ASD, (d) physical education, which is included in the skills of describing people, can be investigated. Applications in which characteristics are taught (eg, eye color, hair color and clothing attributes) can be performed.

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Original Article

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The effect of variety-support in physical education on participation: the serial mediation role of enjoyment and motivation *

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Abstract

Although adolescents' Physical Activity (PA) levels are associated with various benefits, PA participation rates remain low. Previous studies have revealed that one of the psychological factors that may have a significant impact on adolescents' PA and participation in Physical Education and Sport (PES) is perceived variety-support. The aim of this study is to examine the serial mediation role of enjoyment and motivation in the relationship between variety-support and participation in PES. For this purpose, firstly, the "The Perceived Variety-Support in Physical Education Scale (PVSPES)" developed by Eather et al. (2022) adapted to Turkish and applied to middle school (n=561) and high school (n=457) samples. CFA results showed that the Turkish version of the PVSPES was measurement invariant across gender and educational level. The study, which examined the serial mediation role of enjoyment and motivation in the relationship between variety-support and participation, was conducted using structural equation modeling with a sample of 1018 (532 female, 486 male) middle school (n=561) and high school (n=457) students. The findings of the study revealed that students' perceptions of variety-support in the PES had a significant positive direct effect on course participation. It was found that enjoyment (b = .086, BootSE = .014, 95% CI [.059, .115]) and motivation (b = .061, BootSE = .012, 95% CI [.039, .087]) mediated the relationship between variety-support and participation. The serial mediation model revealed that the serial mediation effect of enjoyment and motivation was significant in the effect of students' perception of variety-support on participation

Keywords

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(b= .087, BootSE= .011, 95% CI [.067, .109]). As a result, it was found that students' perception of variety-support in PES increases enjoyment and motivation towards the courses, and as a result, both factors positively affect course participation through serial mediation. Offering a variety of activities to students in PES will increase their enjoyment and motivation towards the course and contribute positively to their course participation.

Introduction

Physical Education and Sports (PES) covers all healthy life activities that develop the mental, affective and psychomotor abilities of the individual, remove them from inactivity, and enable them to socialize (Demir & Cicioğlu, 2018). The PES lesson plays an important role in providing the necessary knowledge, skills and motivation to sustain lifelong mobility (Eather et al., 2022; Kliziene et al., 2021; Kohl & Cook, 2013). In this context, it is very important to understand the factors affecting participation in the PES course in order to intervene in the increasing rates of inactivity in adolescents especially with the introduction of technology into our lives and to provide them with lifelong movement habits. When the rates of participation in PES are analyzed; Global Student Health Survey data show that 55.2% of adolescents attend PES classes 1-2 days a week, while 20% of adolescents almost never attend PES classes (Martins et al., 2020). There may be many different reasons for this situation, but one of the most important reasons is the lack of variety and monotony in PES classes. This situation negatively affects students' attitudes towards the course and reduces interest and participation (Silverman & Scrabis, 2004). Studies have shown that when PES courses are enriched with variety, students are more enthusiastic about the course and this increases participation (Dismore & Bailey, 2010; MacPhail, 2011; Smith & Parr, 2007).

Variety is one of the important factors that enrich the PES course and increase students' interest in the course. While the concept of variety is defined as the experience of various activities and opportunities in one's social environment (Kahn & Ratner, 2005; Sheldon & Lyubomirsky, 2012), variety-support is defined as the way in which an individual structures activities and opportunities to facilitate the experience of available opportunities (Sylvester, Standage et al., 2016). Variety in PES classes includes diversity in effort, opportunities, and tasks (Lyubomirsky & Layous, 2013; Sylvester, Standage, Dowd et al., 2014), as well as diversity in pedagogy, equipment, lesson topics, assignments, venues such as fields or gyms, activities, and teaching methods (Eather et al., 2022). There are studies showing that students like the course more, show interest, and participate more when the curriculum content of the PES course is appropriate to their own experiences and variety-support is provided (Dismore & Bailey, 2010; MacPhail, 2011; Smith & Parr, 2007). In this context, it can be said that providing variety in the PES course has the potential to greatly affect activity behavior and increase participation (Juvancic-Heltzel et al., 2013). While participation increases at the same rate when variety-support increases (Agans & Geldhof, 2012; Koorts et al., 2011), a lack of variety in the PES course may cause negativity in students' interest and attitudes (Hazar et al., 2021). Research on variety in the literature shows that variety is directly related to increased participation, as variety-support increases, participation and efficiency of the course increases, and as variety-support decreases, interest, attitude and participation in the course decreases (Agans & Geldhof, 2012; Hazar et al., 2021; Koorts et al., 2011, Michael et al., 2016; Yetim et al., 2014). For example, a study examining the impact of school physical education on exercise habits (Wang et al., 2024) found that the variety of sports offered in class encouraged children to participate in out-of-school exercise. In addition, it was found that when one extra type of exercise was added to the PES program, the likelihood of students exercising increased by 5.6%.

Variety-support is an important element that increases the enjoyment of the lesson, thus making the lesson more fun and attractive (Hazar et al., 2021; Michael et al., 2016). Enjoyment is conceptually defined as an individual's intrinsic motivation towards an activity and the enjoyment of the activity is

directly proportional to variety-support (Michael et al., 2016). PES is a field in which an individual can only participate if he/she likes, wants and enjoys it. One of the important factors that can increase enjoyment in PES is variety-support. Providing variety in PES and the chance to choose among different alternatives can increase the enjoyment of participation in the activity. Studies indicate that enjoying the PES is one of the important reasons affecting participation in the course (Frederick & Ryan, 1993) and that especially children and young people participate in the PES course for physical improvement, fun and enjoyment (Gill et al., 1983; Kolt et al., 1999; White & Duda, 1994). In this direction, it can be said that if the individual cannot experience enjoyment in PES, he/she may move away from the activities. Michael et al. (2016) emphasized the necessity of providing adolescents with a variety of activities, methods, and tools to increase their participation in the PES and stated that the variety provided in the PES increases participation through enjoyment. Similarly, Dimmock et al. (2013) found that variety increases the enjoyment of the activity, and increased enjoyment increases interest in the activity. Based on the researches, it can be said that providing variety-support in PES increases the enjoyment of the PES course.

Providing variety-support is one of the most important intrinsic motivation reasons (Wann, 1997; Ryan & Deci, 2000). Instead of using a single teaching strategy in lessons, diversifying the teaching strategy encourages students' motivation to learn (Halawah, 2011). While monotonous lessons with traditional methods in PES reduce attention span, trying new methods and providing variety in lessons can greatly increase students' interest and motivation levels (Öztürk & Eren, 2020). Failure to provide a variety of materials, activities, environments, and methods in PES is cited among the reasons that lead to decreased lesson efficiency, decreased motivation, reluctance, and student disengagement from the lesson (Güven, 2021; Sylvester, Standage, Ark et al., 2014). In a study examining the effect of diversified instructional strategies, the course motivation of the student group in which different instructional strategies were used increased throughout the semester, while the motivation of the other group remained at the same level or decreased throughout the semester (Tremblay-Wragg et al., 2021). Therefore, based on the related studies, the key factor in the formation of motivation and willingness to participate is the provision of variety in the PES. When variety is not provided, individuals may develop feelings of inadequacy, lack of control and reluctance (Pelletier et al., 1995). This may reduce students' motivation for the lesson and negatively affect their participation in the lesson.

One of the challenges in learning environments is the decline in students' motivation due to the lack of enjoyment (Dismore & Bailey, 2011; Ntoumanis, 2001). An individual's intrinsic motivation is directly proportional to the enjoyment derived from an activity (Aydın et al., 2024; Deci et al., 2001). Enjoyment in PES is identified as a key factor influencing lesson motivation (Frederick & Ryan, 1993). When examining factors that increase participation in PES, psychological reasons such as the need for socialization and having a good time, along with physical goals like improving fitness, stand out. Among these, the fundamental requirement is the enjoyment and motivation developed toward PES (Demir & Cicioğlu, 2018; Gill et al., 1983; Rickel, Park, & Morales, 2012; Sit & Lindner, 2007). If individuals do not experience the enjoyment gained from participation, they are unlikely to maintain motivation for the activity and may eventually distance themselves from it.

Research has shown that a lack of excitement and enthusiasm for PES classes, disinterest in in-class activities (De Corby et al., 2005; Morgan & Bourke, 2005), difficulty in adapting to lessons, absence of enjoyment, and lack of motivation negatively impact class participation (Boyle et al., 2008; Dagkas & Stathi, 2007). At this point, it can be stated that providing adequate variety-support could enhance the enjoyment and motivation derived from activities, thereby influencing participation (Dimmock et al., 2013; Glaros & Janelle, 2001; Juvancic-Heltzel et al., 2013). When students' motivation and interest in classes decrease, participation in PES declines, leading to a sedentary lifestyle (Silverman & Scrabis, 2004). Participation in PES classes is essential for individuals to take a step toward a healthy life, and for participation, enjoyment and motivation play a critical role (Demir & Cicioğlu, 2018). This study emerged from the need to examine the factors affecting participation in PES classes. The conceptual framework of the study involves designing a mediation model to test the role of perceived enjoyment

and motivation in the relationship between variety-support and participation in PES. The research problem is centered on the question: Does variety-support influence participation in PES classes? Within this scope, the study aims to examine the serial mediation role of enjoyment and motivation in the relationship between variety-support and participation in PES classes.

Method

Before initiating the research, ethical approval was obtained from the Research Ethics Committee of Kırıkkale University, along with the necessary permissions from the Governorship and the Ministry of National Education. Prior to data collection, permission and appointments were secured from school principals. Additionally, consent forms were collected from students, and data were gathered only from those who voluntarily agreed to participate in the study. Students were also verbally informed about the study.

Participants

The research data were collected during the 2022-2023 academic year from a sample of 1018 middle school and high school students (ages 11-18; 532 girls, 486 boys) across eight schools in Kırıkkale. The sample size was determined using the method of selecting 15 participants per variable (Pituch & Stevens, 2015). Additionally, data from a subsample of 70 students (6th grade = 32, 9th grade = 38; 39 boys) were used for test-retest reliability analysis (Bonett & Wright, 2015). All data were collected by researchers under exam-like conditions in schools, and it took approximately five minutes for students to complete the scale. The demographic information and mean values of the participants are presented in Table 1.

Table 1. Demographic information and mean values of participants

Grade	Gender	n	Age ($\bar{X}$)	Variety-Support ($\bar{X}$)	Enjoyment ($\bar{X}$)	Motivation ($\bar{X}$)	Participation ($\bar{X}$)
5th	Male	78	10.551	2.978	4.197	3.958	4.560
Grade	Female	59	10.525	3.095	3.842	3.815	4.350
6th	Male	78	11.487	2.941	3.917	3.712	4.447
Grade	Female	67	11.433	2.938	3.945	3.692	4.318
7th	Male	98	12.480	2.767	4.092	3.663	4.408
Grade	Female	71	12.465	2.805	3.819	3.464	4.246
8th	Male	52	13.423	2.700	3.949	3.577	4.577
Grade	Female	58	13.569	2.416	3.489	3.260	3.966
9th	Male	51	14.529	2.873	3.990	3.618	4.464
Grade	Female	80	14.613	2.814	3.660	3.429	4.229
10th	Male	55	15.582	2.648	3.882	3.524	4.303
Grade	Female	72	15.458	2.597	3.810	3.374	4.225
11th	Male	47	16.574	2.630	3.890	3.514	4.301
Grade	Female	68	16.515	2.623	3.757	3.370	4.054
12th	Male	27	17.556	2.958	3.914	4.026	4.407
Grade	Female	57	17.474	2.765	3.895	3.659	4.295
Total		1018	13.7	2.786	3.883	4.321	3.593

Measures

Perceived Variety-Support in Physical Education (PVSPE) Scale: Developed by Eather et al. (2022) and analyzed for reliability and validity in this study, was used to measure students' perceptions of variety-support in PES. Example items: "In PES classes, I can try different activities/events within a lesson" and "In PES classes, my teacher provides a range of different sports equipment for me to use throughout the term (e.g., balls, hoops, rackets, nets)."

In order to adapt the PVSPE to Turkish, the translation steps suggested by De Vaus (2002) were followed. It is recommended to have at least two independent translators in the translation process

(Coster & Mancini, 2015). Therefore, in the translation process, the scale items were translated from English, the source language, into Turkish, the target language, by two PES field experts and two non-PES translators. After the translations, each item of the scale was evaluated by 4 researchers who are experts in the field of PES in terms of semantic, conceptual, and suitability for the target audience (Çapık et al., 2018). Minor corrections were made that did not make a difference in the meaning of the items and were appropriate for the field and culture (e.g., using the term "grass field" instead of "oval", which is not common in Turkey). In addition, the meaning of each translated item was explained in detail and the original scale authors were consulted. After the Turkish language expert confirmed that the scale items were appropriate for Turkish, the scale was administered to a middle school class as a pilot study (n= 26). In the pilot study, the responses of students who marked the "I understood the questions/I did not understand the questions" option were evaluated by four PES experts, who concluded that the items were understandable. Based on these findings, the scale was deemed suitable for use in the study.

In this study, data were collected during the 2022-2023 academic year from a sample of 561 middle school students (255 girls, 306 boys) in Kırıkkale to adapt the PVSPE scale for middle school students. Additionally, to evaluate the generalizability of the PVSPE scale to the high school population, data were collected from a sample of 457 high school students (257 girls, 180 boys). All data were gathered by the research team under exam-like conditions in schools, and it took approximately five minutes for students to complete the scale. Participants' ages ranged from 11 to 18. Test-retest reliability data were collected and analyzed from a sample of 32 middle school and 38 high school students (Bonett & Wright, 2015).

The single-factor, eight-item structure of the scale was tested using Maximum Likelihood rotation Confirmatory Factor Analysis (CFA) on the middle school sample. The results indicated that the scale demonstrated good model fit indices (χ^2= 44.849, p<.05, χ^2/df= 2.242, CFI= .987, SRMR= .0235, and RMSEA= .047). Factor loadings for the scale items ranged between .65 and .81. The AVE and CR values indicated high reliability across all factors (AVE = .50, CR = .89). Cronbach's Alpha was calculated as .89, skewness as .318, kurtosis as .356, and the test-retest reliability coefficient as .899.

The confirmatory factor analysis results for the high school sample of the PVSPE scale were analyzed. The scale demonstrated high model fit indices (χ^2= 43.356, p<.05, χ^2/df= 2.168, CFI= .985, SRMR= .0254, and RMSEA= .051). Factor loadings for the scale items ranged from .67 to .82. To assess the validity and reliability levels of the scale for the high school sample, AVE (.50), CR (.89), and Cronbach's Alpha (.89) values were examined. These results indicate that the scale is reliable (Field, 2009). The test-retest reliability coefficient (.899) further confirms that the scale remains consistent over time.

The measurement invariance of the single-factor PVSPE scale was compared across gender (male-female) and educational stage (middle school-high school). A multiple group analysis was conducted using the Maximum Likelihood estimation method, as the data demonstrated a normal distribution. The results of the measurement invariance analysis are presented in Table 2.

Table 2. Measurement invariance results for gender and educational stage

Models	χ^2 *(df)*	χ^2/df	**CFI**	**SRMR**	**RMSEA**	**Model Comparison**		
							Δχ² (Δ*df*)	**ΔCFI**
Gender (Male-Female)								
1. Configural	81.18 (40)	2.03	.988	.0272	.032	—	—	—
2. Metric	85.22 (48)	1.17	.989	.0279	.028	2 vs. 1	4.04 (8)	.001
3. Scalar	112.72 (32)	2.01	.983	.0280	.032	3 vs. 2	27.5* (8)	.006
4. Strict	121.41 (24)	1.9	.983	.0291	.030	4 vs. 3	8.69 (8)	.000

Table 2. Continued

Models	χ^2 (*df*)	χ^2/df	CFI	SRMR	RMSEA	Model Comparison		
							$\Delta\chi^2$ (Δdf)	ΔCFI
Educational Stage (Secondary School-High School)								
1. Configural	88.27* (40)	2.21	.986	.0235	.034	—	—	—
2. Metric	104.98* (48)	2.19	.984	.0261	.034	2 vs. 1	16.70* (8)	.002
3A. Scalar[a]	249.58* (56)	4.46	.945	.0271	.058	3A vs. 2	144.6* (8)	.039
3B. Scalar[b]	189.32 (33)	3.44	.962	.0264	.049	3B vs. 2	84.34* (7)	.022
3C. Scalar[c]	146.98 (54)	2.72	.973	.0266	.034	3C vs. 2	42* (6)	.011
3D. Scalar[d]	129.01 (53)	2.43	.978	.0263	.038	3D vs. 2	24.03* (5)	.006
4. Strict	285 (64)	4.453	.937	.0281	.058	4 vs. 3D	155.99* (11)	.041

Note: *p<.05; n= 1018 (Male= 532, Female= 486 / Secondary school= 561, High school = 457); a= Measurement intercepts; the constants (intercepts) of b= item named Ç8, c= item named Ç5, and d= item named Ç4 are released; CFI= Comparative fit index; SRMR= Standardized Root Mean Square Residual; RMSEA= Root mean square error of approximation.

In the measurement invariance analysis conducted by gender, configural equivalence was first tested using the baseline model without constraining any parameter values. The results indicated good model fit, suggesting that configural equivalence was achieved (χ^2 [40, n=1018] = 81.18, $p < .05$, χ^2/df = 2.03, CFI = .988, SRMR = .0272, and RMSEA = .032). After establishing configural equivalence, metric equivalence was tested by constraining the scale items, and the results from the multi-group CFA were compared with the configural model. In measurement invariance analyses, it is recommended to use differences in CFI (ΔCFI) instead of χ^2 for model comparisons, with ΔCFI values of < .01 indicating invariance across models (Byrne, 2010). Since the ΔCFI values between the structural model and the metric model, the metric model and the scalar model, and the scalar model and the strict model were all < .01, the results indicate that the scale is equivalent across groups.

In the measurement invariance analysis conducted across educational levels, configural equivalence was first tested using the baseline model without constraining any parameter values. The model fit indices indicated that configural equivalence was achieved (χ^2 [40, n=1018] = 88.27, $p < .05$, χ^2/df = 2.21, CFI = .986, SRMR = .0235, and RMSEA = .034). Metric equivalence was then tested by constraining the scale items, and the multi-group CFA results were compared with the configural model. Since ΔCFI < .01, metric equivalence was established. To test scalar equivalence, the intercepts of the scale items were constrained across groups, and the resulting CFA results were compared with the metric model. The comparison showed that ΔCFI > .01, indicating that scalar equivalence was not achieved. When examining the intercept differences across groups, the greatest discrepancy was observed in item Ç8. The parameter constraints for item Ç8 were relaxed, and the analysis was repeated. However, the comparison still showed ΔCFI > .01, indicating that scalar equivalence was not achieved again. Next, the parameter constraints for item Ç5, which also had a high intercept difference, were relaxed, and the analysis was repeated. The comparison with the metric model revealed a ΔCFI value of .011, which was borderline. Finally, the parameter constraints for item Ç4, another item with a high intercept difference, were relaxed, and the analysis was repeated. The comparison with the metric model showed ΔCFI < .01, establishing scalar equivalence. To test strict equivalence, the error variances of the scale items were constrained across groups, and the multi-group CFA results were compared with the scalar model. Since ΔCFI > .01, strict equivalence was not achieved.

Classroom Engagement Inventory (CEI): Developed by Wang et al. (2014) and adapted into Turkish by Sever (2014), this scale was used to measure students' engagement in PES classes. The scale consists of three subdimensions and 23 items (e.g., "I actively participate in classroom discussions during PES classes"; "I participate seriously in activities conducted during PES classes"). In this study, the subdimensions of emotional engagement, behavioral engagement-compliance, and behavioral engagement-effortful classroom participation were used, as these items better reflect the context of PES. The subdimensions of cognitive engagement and disengagement were excluded from the study because they contain items that do not fully align with the PES context (e.g., "When we have a quiz, I think more deeply about the topics"). The scale is evaluated using a 5-point Likert scale (1 = Never, 3 = Sometimes, 5 = Always). To enable the use of relevant subdimensions, bifactor analysis, a superior and more recent method compared to second-order CFA (Bonifay et al., 2017), was applied. The model fit indices for this study were calculated as $\chi^2/df = 7.17$, RMSEA = .078, SRMR = .050, CFI = .947, and NFI = .940. Cronbach's Alpha coefficient was calculated as .89, skewness as .546, and kurtosis as .202.

Enjoyment of Participation in Physical Education Classes (EPPEC): To measure the enjoyment derived from participation in PES classes, the "Satisfaction Interest Scale" developed by Duda and Nicholls (1992) and adapted into Turkish by Erturan-İlker et al. (2018) was used. The scale, named "Enjoyment of Participation in Physical Education Classes (EPPEC)" in Turkish, consists of a single factor and six items (e.g., "I usually have fun in PES classes"; "I usually enjoy being in PES classes"). The scale is evaluated using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The model fit indices for this study were calculated as $\chi^2/df = 9.890$, RMSEA = .093, SRMR = .0307, CFI = .957, and NFI = .953. The Cronbach's Alpha coefficient was calculated as .68, skewness as .697, and kurtosis as .221.

Physical Education Motivation Scale (PEMS): Developed by Sulz et al. (2016) and adapted into Turkish by Akbulut (2021), this scale was used to measure students' motivation toward PES. The scale consists of three subdimensions (Intrinsic Motivation, Extrinsic Motivation, and Amotivation), with three items under each subdimension, making a total of nine items (e.g., "I participate in PES because it is interesting"; "PES is a waste of time"). The scale is assessed using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). In this study, only the subdimensions of Intrinsic Motivation and Amotivation were used. Amotivation is considered the opposite of intrinsic motivation, occurring when an individual is neither intrinsically nor extrinsically motivated (Ntoumanis, 2001; Wang, 2017), and has been coded as a reverse item (Deci & Ryan, 1985). The subdimension of Extrinsic Motivation and its regulatory styles, which are commonly used in studies to measure motivation (Standage et al., 2006; Vallerand et al., 2008; Wang et al., 2002), were excluded from this study. This decision was influenced by the abstract nature of distinctions among regulatory styles, the difficulty of applying these distinctions to younger age groups (Sebire et al., 2013), the lack of relevance of integrated regulation (the regulatory style closest to intrinsic motivation) as a reason for participation in sports contexts (Deci & Ryan, 1985), and the cognitive and developmental limitations of adolescents in adopting this regulatory style (Vallerand, 1997). To evaluate motivation using a single subdimension, a bifactor model analysis was conducted. The analysis results indicated good model fit indices for this study (χ^2/df = 4.381; RMSEA = .058; SRMR = .020; CFI = .993; NFI = .990). The Cronbach's Alpha coefficient was calculated as .82, skewness as .1057, and kurtosis as .262.

Statistical Analysis

A multiple serial mediation analysis was conducted to determine the effect of variety-support in PES on participation in PES through the mediating roles of enjoyment and motivation. Multiple serial mediation analysis is a method used to test the direct and indirect effects of X on Y through the mediators M_1 and M_2 using Ordinary Least Squares (OLS) regression analysis (Hayes, 2022). The analyses were performed using Process Macro 4.2 developed by Hayes (2022). Model 6, which tests serial mediation effects, was selected in Process Macro (Figure 1). The bootstrap method, considered to provide more reliable results compared to the traditional method of Baron and Kenny (1986) and the

Sobel test (1982) (Gürbüz, 2021; Hayes, 2022), was applied with 5000 resamples. In mediation analyses using the bootstrap method, the 95% confidence interval values must not include zero (MacKinnon et al., 2004). Additionally, prior to the analysis, CFA was conducted using AMOS 22 to check the model fit indices.

Results

In the study, a CFA was first conducted to validate the serial mediation model. For this purpose, a measurement model was created, including 8 items from the PVSPE, 13 items from the CEI, 6 items from the EPPEC, and 6 items from the PEMS. The CFA results showed that all model fit indices were within the desired ranges except for the CFI value, which was .872. To improve the CFI value to the acceptable threshold (.90), covariance corrections were examined, and the highest modification indices were found under the CEI. Considering the two highest modification indices among the CEI items, two covariances were drawn between the related items. The final CFA results indicated that the measurement model was validated (χ^2[487, n=1018] = 2039.248, p < .001, χ^2/df = 4.187, CFI = .902, SRMR = .0523, and RMSEA = .056).

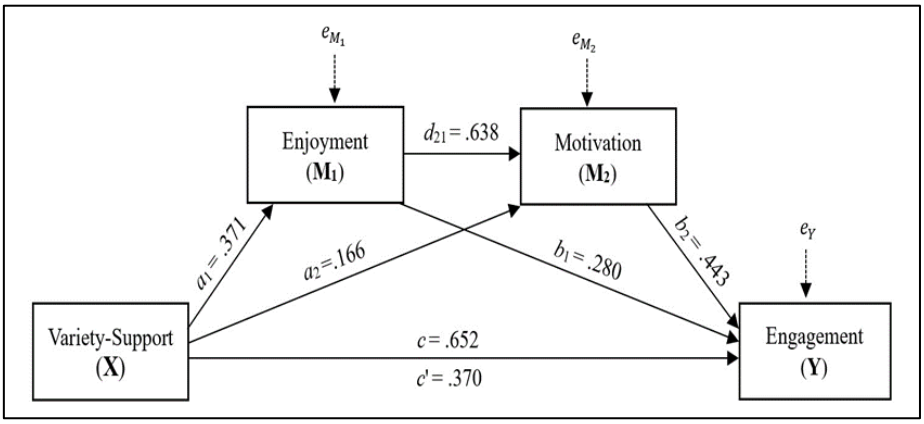

Figure 1. The serial mediation model

In the study, the mediating effects of enjoyment derived from PES and motivation toward PES, acting serially, were analyzed in the relationship between perceived variety-support in PES and participation in PES. The results of the multiple serial mediation analysis are presented in Table 3 and Figure 1.

Table 3. Regression coefficients, standard errors, and model summary information of the serial multiple mediation model

		Consequent									
		Enjoyment (M_1)			**Motivation (M_2)**				**Engagement (Y)**		
Antecedent	**Path**	***Coeff.***	***SE***	***p***	**Path**	***Coeff.***	***SE***	***p***	**Path**	***Coeff.***	***SE***	***p***
Variety-Support (X)	a_1	.371	.029	.000	a_2	.166	.025	.000	c	.652	.032	.000
									c'	.370	.028	.000
Enjoyment (M_1)		—	—	—	d_{21}	.638	.025	.000	b_1	.280	.035	.000
Motivation (M_2)		—	—	—		—	—	—	b_2	.443	.034	.000
Constant	i_{M_1}	2.852	.083	.000	i_{M_2}	1.380	.098	.000	i_Y	.439	.117	.000
			R^2=.14				R^2=.48				R^2=.55	
		F(1, 1016)= 164.803, *p*<.000			F(2, 1015)= 468.446, *p*<.000				F(3, 1014)= 419.645, *p*<.000			

Table 3. Continued

Indirect Effects of X on Y	Path	Effect	BootSE	Boot 95% CI	
				LL	UL
Total indirect effect		.282	.024	.238	.331
Ind1 (Variety S. →Enjoyment→Engagement)	a_1b_1	.104	.017	.071	.139
Ind2 (Variety S. →Motivation→Engagement)	a_2b_2	.074	.015	.046	.105
Ind3 (Variety S. →Enjoy. →Motiv. →Engagement)	$a_1d_{21}\ b_2$	.105	.014	.079	.133
Completely Standardized Indirect Effects of X on Y	**Path**	**Effect**	**BootSE**	**Boot 95% CI**	
				LL	**UL**
Total indirect effect		.235	.18	.200	.269
Ind1 (Variety S. →Enjoyment→Engagement)	a_1b_1	.086	.014	.059	.115
Ind2 (Variety S. →Motivation→Engagement)	a_2b_2	.061	.012	.039	.087
Ind3 (Variety S. →Enjoy. →Motiv. →Engagement)	$a_1d_{21}\ b_2$	.087	.011	.067	.109

Note: n= 1018; SE: Standard Error; CI: Confidence Intervals; LL: Lower Limit; UL: Upper Limit

As shown in Table 3, the results of the multiple serial mediation analysis indicate that the total effect of variety-support in PES on participation in PES (path c) is positive and significant (b = .652, SE = .032, p < .000). Variety-support positively predicts the mediating variable of enjoyment derived from PES (path a1; b = .371, SE = .029, p < .000). Additionally, variety-support positively predicts the other mediating variable, motivation toward PES (path a2; b = .166, SE = .025, p < .000). The effect of the mediating variable enjoyment on the other mediating variable, motivation (path d21), is also positive and significant (b = .638, SE = .025, p < .000). According to the results of the multiple regression analysis, where variety-support, enjoyment, and motivation were considered predictor variables for participation in PES, both enjoyment (path b1; b = .280, SE = .035, p < .000) and motivation (path b2; b = .443, SE = .034, p < .000) significantly and positively predict participation in PES. Furthermore, the direct effect of variety-support on the dependent variable, participation in PES (path c'), is positive and significant (b = .370, SE = .028, p < .000).

In the two-variable serial mediation analysis, the indirect effect of variety-support in PES on participation in PES was tested using the bootstrap method (see Table 3). The results indicated that enjoyment and motivation mediated the relationship between variety-support and participation. Specifically, the serial mediation effect of enjoyment (Ind1: b = .086, BootSE = .014, 95% CI [.059, .115]) and motivation (Ind2: b = .061, BootSE = .012, 95% CI [.039, .087]) on the effect of variety-support on participation was found to be significant. Additionally, the combined serial mediation effect of both enjoyment and motivation (Ind3: b = .087, BootSE = .011, 95% CI [.067, .109]) was also significant. The fully standardized effect sizes of the indirect effects were calculated as .086 for Ind1, .061 for Ind2, and .087 for Ind3, indicating medium effect sizes (Preacher & Kelley, 2011).

Discussion

The purpose of this study is to determine the serial mediation role of enjoyment and motivation in the relationship between variety-support provided in the PES and participation in the PES. Our findings support that the scale adapted by the authors is suitable for use with Turkish middle and high school students. The study tested a serial mediation model that includes three mediation pathways: enjoyment, motivation, and enjoyment-motivation in assessing the link between variety-support and participation. Our findings support the direct positive effect of variet-support in the PES on participation in the PES as well as the serial mediation effects of enjoyment and motivation in the link between variety-support and participation.

Given that PES is mandatory in teaching curricula and delivered by trained professional educators (PE teachers), it should provide unique and important opportunities to develop the necessary skills for PA among all students (Eather et al., 2022). Given that the experience of variety in PES is a

psychological factor that supports optimal motivation and well-being (Lubans et al., 2016), it is important to assess variety-support and examine its impact on students' participation in PES. In a cross-country study examining the level of participation in PES, it was reported that most adolescents worldwide (in a review covering 54 countries) participate in PES 1-2 days a week (55.2%), while almost 20% do not participate in PES at all (Martins et al., 2020). In another study comparing adolescents' PA levels at school across 52 countries, data show that Turkish students engage in PES 1-2 days a week, compared to Hungary, where students are offered PES 3-4 days a week (Bann et al., 2019). Considering the importance of PES classes for students, the findings of the studies show that participation in PES is not at an adequate level. Therefore, understanding the factors influencing students' participation in PES can contribute to the development of effective strategies to increase interest in these classes.

The Mediating Role of Enjoyment

The purpose of this section is to confirm the effect of variety-support provided in PES on class participation, as well as the mediating role of enjoyment in the relationship between perceived variety-support and participation. The results of our study confirmed a medium-sized positive effect among the variables and the mediating role of enjoyment. When standardized path coefficients were evaluated, a one-standard-deviation change in the predictor variable (variety-support) resulted in a 9-unit increase in participation mediated by enjoyment (Table 3). The findings indicate that variety-support in PES positively influences students' perceived enjoyment and, consequently, their level of participation in the class. Similarly, a previous study demonstrated that individuals exposed to messages emphasizing variety in an exercise class reported higher levels of enjoyment and interest compared to those exposed to messages highlighting monotony (Dimmock et al., 2013). A study conducted by Juvancic-Heltzel et al. (2013) found that equipment variety enhanced enjoyment and increased participation among children, adolescents, and older individuals. Considering the impact of enjoyment derived from PES classes on participation, the desire to have fun and enjoy oneself emerges as a critical factor to address (Dismore & Bailey, 2010; Sylvester, Lubans et al., 2016). Teachers can develop strategies to enhance enjoyment by offering a variety of activities that appeal to both boys and girls (Brooke et al., 2013). Additionally, designing and implementing age-appropriate activities can foster gains in enhancing enjoyment through variety (Callcott et al., 2015). Training teachers in this regard is crucial for providing an optimal learning environment for students.

The Mediating Role of Motivation

The purpose of this section is to confirm the effect of variety-support in PES on participation, as well as the mediating role of motivation in the relationship between perceived variety-support and participation. Our findings confirm a medium-sized positive effect among the variables and the mediating role of motivation. The standardized path coefficients indicate that a one-standard-deviation change in the predictor variable (variety-support) results in a 6-unit increase in participation mediated by motivation (Table 3). The results suggest that perceived variety-support in PES positively influences students' interest, thereby enhancing their motivation, which in turn increases the participation levels of highly motivated individuals. Previous studies have shown that perceived variety in exercise settings positively contributes to fulfilling the needs of autonomy, competence, and relatedness as explained by self-determination theory (SDT), playing a significant role in predicting motivation and, indirectly, exercise behavior (Miao et al., 2024). This suggests that it may serve as an important factor in predicting autonomous motivation and behavior in exercise settings (Sylvester, Standage, Dowd et al., 2014). Similarly, Sylvester et al. (2018) found a positive link between perceived variety in exercise and self-reported exercise participation. Moreover, this positive link between perceived exercise variety and self-reported exercise participation was mediated by autonomous motivation to exercise. Considering that various reasons affect individuals' activity motivation and that factors such as activity type, duration and preferred location may vary from person to person (Akbulut, 2021), the importance of motivation in the effect of variety-support on participation emerges. The variety created in the use of equipment, activities, and learning environment in PES can increase students' engagement by creating a motivational factor that each student discovers for himself/herself (Vansteenkiste et al., 2020). Students' mental, emotional, and physical motivation can help improve the learning environment through active

engagement (Scott Rigby et al., 1992). Therefore, teachers should utilize factors that can influence perceptions of motivation, such as exercise history and skill level, to increase engagement by using variety in PES (Sylvester et al., 2018).

The Serial Mediating Role of Enjoyment and Motivation

The research findings confirm that enjoyment and motivation mediate the direct positive effect of variety-support in PES on participation. Analyzing the standardized path coefficients of the serial mediation analysis reveals that a one-standard-deviation change in the predictor variable (variety-support) results in a 9-unit increase in participation mediated by enjoyment and motivation (Table 3). Our results indicate that perceived variety-support in PES enhances individuals' enjoyment and motivation, thereby increasing their engagement in classes. The variety of methods, equipment, tasks, and activities provided in PES classrooms can naturally make the experience more engaging and rewarding (Pronin & Jacobs, 2008), as diverse cognitive stimuli have been found to produce more enjoyment compared to uniform stimuli (Cabanac, 1979). This heightened engagement fosters interest (Silvia, 2006) and creates positive emotions such as enjoyment, which are directly linked to well-being (Sheldon & Lyubomirsky, 2012). Considering that people tend to voluntarily participate in activities they find personally interesting and enjoyable (Ryan & Deci, 2002) and are more motivated toward them (Juvancic-Heltzel et al., 2013), it can be concluded that variety-support in PES helps students derive greater enjoyment from classes, which in turn increases their motivation toward activities and ultimately enhances their participation. Sylvester, Lubans et al. (2016) found that participants who received variety-support during a six-week exercise program reported higher perceived variety compared to those following a standard program, which was associated with better exercise adaptation and well-being. Furthermore, it is suggested that variety-support could enhance students' enjoyment of PA and exercise settings, thereby increasing their motivation for PES classes, which is linked to higher participation (Juvancic-Heltzel et al., 2013; Sylvester, Lubans et al., 2016).

Strengths and Limitations

In this study, it was possible to examine the links between variety-support and three important and meaningful variables (Participation, Motivation, and Enjoyment) related to PES as suggested by Eather et al. (2022). Moreover, the data were collected from a substantial population-based sample of Turkish students, including high school and middle school students, which increases the external validity of the findings. However, generalizing these results should be approached cautiously, as the demographic characteristics of Kırıkkale may not fully reflect those of the broader Turkish population. Additionally, self-report questionnaires, while widely used, have limitations in accurately assessing variables such as participation, motivation, and enjoyment (Ekelund et al., 2011). Instruments like accelerometers, however, can offer valuable insights into PES-related activities that may not be easily captured through self-reported measures.

Implications and Recommendations

Our findings contribute to the field of PA research by investigating and expanding the foundations of Self-Determination Theory (SDT) as established by Ryan and Deci (2002), aligning with significant studies conducted by Sylvester, Lubans et al. (2016), Sylvester, Standage, Ark et al. (2014), Sylvester, Standage, Dowd et al. (2014). These findings support the notion that variety may represent a fourth psychological need (in addition to autonomy, competence, and relatedness) influencing PA behaviors. Considering the high levels of physical inactivity among adolescents, our results are particularly relevant for PA researchers, teacher training institutions, and PES teachers. They provide valuable insights for developing strategies to enhance adolescents' participation in and engagement with PES classes. PES teachers can target variety to increase students' enjoyment and motivation in PES, which in turn may contribute to improved academic performance and success. Thus, employing diverse teaching methods (e.g., direct instruction, stations, exploratory activities, small-sided games), creating learning tasks with various equipment (e.g., balls of different sizes, station tools, ropes), and utilizing different venues and facilities (e.g., schoolyards, gymnasiums, outdoor spaces) are essential for developing new teaching strategies that enhance variety (Eather et al., 2022). Administrators and

policymakers should allocate funding, create regulations to ensure access to equipment, and develop national education policies to improve the quality of PES classes by increasing variety. Providing durable materials, equipment for different mobility needs, and legal frameworks for sports equipment standards is crucial for sustaining variety-support in PES. Moreover, the scope of our study could be expanded by addressing new factors influencing variety and participation in PES. Research conducted across different age groups and subpopulations in PA settings could foster broader participation and success by developing strategies tailored to individuals' physical capabilities, interests, and needs.

Conclusion

This study evaluated the validity and reliability of the PVSPE, adapted for use with Turkish adolescents in a school context. The findings revealed a positive relationship between perceived variety-support and participation in PES among middle and high school students, as well as the serial mediation role of enjoyment and motivation. Our research is the first to investigate the relationships among these variables within the context of PES for this population, supporting the idea that providing variety in PES practices can be an effective strategy for teachers aiming to enhance adolescents' PA levels through increased enjoyment and motivation. Further research in diverse school settings is needed to support our novel findings on the benefits of variety-support.

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Appendix 1

Beden Eğitimi Çeşitlilik Desteği Ölçeği (BE-ÇDÖ)

Lütfen aşağıdaki soruları dikkatlice okuyunuz ve sağdaki seçeneklerden en yakın hissettiğinizi X ile işaretleyiniz.		**Asla**	**Bazen**	**Sık Sık**	**Genellikle**
1	Beden eğitimi dersinde, öğretmenim dönem boyunca kullanmam için bir dizi farklı spor ekipmanı sağlar (örneğin toplar, çemberler, raketler, file).				
2	Beden eğitimi dersinde, öğretmenimiz farklı türde branşları öğretmek için bizi okulumuzun farklı yerlerine götürür (örneğin spor salonu, çim saha, basketbol sahası).				
3	Beden eğitimi dersinde, bir ders süresince farklı aktiviteler/etkinlikler deneyebiliyorum.				
4	Beden eğitimi dersinde yaptığımız aktiviteler bir dersten diğerine değişiklik gösterir.				
5	Beden eğitimi dersinde, yaptığımız aktivitelerin amaçları çeşitlilik gösterir. (örneğin becerileri veya zindeliği geliştirmek, takım olarak çalışmak, puan toplamak, karar verme kabiliyetini geliştirmek).				
6	Beden eğitimi dersinde, bir konuyu anlamazsam öğretmenim bana onu öğretmek için farklı yollar kullanır (örneğin öğretmenim bana bir beceriyi nasıl yapacağımı söyler veya gösterir).				
7	Beden eğitimi dersinde, farklı beceri düzeylerine sahip öğrencilerle çalışabiliyorum (örneğin başlangıç düzeyi, ileri düzeyi).				
8	Beden eğitimi dersinde, aktiviteler farklı şekillerde öğretilir (örneğin takım oyunları, eşli oyunlar, değişmeli tur oyunları).				

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Original Article

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A model for the effect of organizational justice on negative attitudes of teachers

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Abstract

This study aims to determine the relationships between organizational justice perception and teachers' organizational cynicism, work alienation, and burnout levels. Scale-based relational model was used in the design of the study. The population of this study consists of teachers working in primary schools in Adana province. 284 teachers in 47 schools randomly selected from the primary schools in this population with the disproportionate cluster sampling method constitute the sample of the study. It was determined that the scales used in the study were valid and reliable. The data were analyzed with descriptive statistics, correlation, and structural equation modeling analyses. The existence of statistically significant relationships between the variables examined was proven with the correlation and then the measurement model. According to the structural model with the best-fit values, teachers' organizational justice perceptions negatively affect organizational cynicism and burnout levels. In addition, organizational justice perception has a negative effect on teachers' burnout levels with the partial mediation effect of organizational cynicism and work alienation. It has been seen that school principals who want to reduce teachers' organizational cynicism, work alienation, and burnout levels should be sensitive and delicate in their practices and in the processes in which these practices are implemented, to strengthen teachers' organizational justice perceptions.

Keywords

Organizational justice
Organizational cynicism
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Introduction

The need for people to live together to achieve their own goals creates the need for legal regulations regarding interpersonal relationships and the sharing of resources among individuals. This essential need is also taken into account in organizations (Atalay, 2015). Because members in an organization make comparisons regarding situations such as the distribution of rewards, decisions taken and their implementation, and the management's approach to them in their work environments. As a result of these experiences, they develop perceptions of equality or inequality in the organization (Lunenburg & Ornstein, 2012). Unless the management corrects and balances the behaviors and practices of the managers that are considered unfair by the organization members, members' criticism,

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complaints, and accusations increase (Şimşek et al., 2011). In this case, members of the organization first try to change their work habits and then the system. Koçel (2018) emphasizes that members' feelings about whether the management's decisions and practices are fair also affect their motivation and performance. It is also known that achieving organizational goals is related to meeting the psycho-social needs of organization members rather than their material interests (Eren, 2015). For such reasons, it is important to focus on the concept of organizational justice and its outcomes, thus providing a broader conceptual framework for this structure.

It is conceivable that the perception of injustice in practices carried out in educational organizations causes teachers to show negative attitudinal and behavioral reactions, which may lead to a decrease in peace and happiness in schools and a decrease in the quality of education provided. In this regard, Eren (2015) emphasized the importance of managers acting honestly, equally, and fairly in making and implementing decisions to ensure organizational peace and happiness. Otherwise, teachers feel that their work is meaningless and they are worthless in their institutions and eventually experience burnout syndrome. Shukla and Trivedi (2008) emphasize that burnout causes teachers to exhibit negative attitudes and behaviors towards their students, feel emotional exhaustion and insensitivity, and experience exhaustion, depression, and failure in their professions. Burnout syndrome can be a source of very serious problems, especially in educational organizations (Kyriacou, 2000). For quality education, full utilization of human resources, a healthy environment, and the development of students, this issue requires special attention and emphasis (Shukla & Trivedi, 2008). For such reasons, it is important to prevent burnout in organizations and to reduce its effects if it is experienced. It was stated that the occupational group that experiences burnout most intensely is the teaching profession (Çokluk, 2014). In addition, reducing cynicism, work alienation, and burnout in educational organizations is seen as essential in terms of increasing teachers' productivity, and thus institutional performance. Considering the fact that emotions are contagious among people (Robbins & Judge, 2015), it comes to mind that negative emotions can seriously harm the quality of education and training. Indeed, it is known that the most important criterion determining the quality of education systems is the quality of teachers (Mourshed et al., 2010). It is clear that teachers' creativity increases even more in school environments where they feel peaceful, happy, and safe.

Organizational justice

The concept of organizational justice is based on J. Stacy Adams's Equity Theory (Atalay, 2015; Eren, 2015). This theory explains the effect of employees' perceptions of injustice and inequality in their organizations on their motivation and how they behave (Kreitner & Kinichi, 2009). Employees compare the results they get in return for their efforts with the efforts and results of their colleagues in the same status (Huseman et al., 1987; Özkalp & Kırel, 2010; Schermerhorn et al., 2011). If employees perceive equality as a result of the comparison, they become happy and their efforts continue to increase. On the contrary, if they perceive inequality, they feel unhappy, become resentful towards the institution and their manager, their motivation decreases, and they want to leave the organization (Güney, 2012; Kulik & Ambrose, 1992).

Organizational justice is a concept that predicts that the principles on which practices in an organization are based should be clear, should not change from person to person, and the reasons for these practices should be expressed transparently, even if they differ from person to person (Koçel, 2018). Lunenburg and Ornstein (2012) define organizational justice as the perceptions of individuals regarding the extent to which they are treated fairly in their organizations. Cohen-Charash and Spectator (2001) suggested that the factors that constitute the perception of organizational justice are organizational outputs (value of outputs), practices in the organization (compliance with the rules of justice, communication with employees, and the quality of behavior) and perceived characteristics (personal and personality). The concept of organizational justice consists of three elements: distributive justice (justice in distributions), procedural justice (process justice or transactional justice), and interactional justice (Eren, 2015). *Distributive justice* is the perception of how fair the distribution of rewards is (Lunenburg & Ornstein, 2012). *Procedural justice* is about whether there is fairness in decision-

making, planning, and management (Eren, 2015). In addition, this type of justice is the degree to which the methods, procedures, and policies used in determining and measuring situations such as wages, promotions, financial opportunities, working conditions, and performance evaluation are seen as fair (Doğan, 2002). *Interactional justice* is how fair employees perceive the treatment they encounter when distributing rewards and implementing procedures (Lunenburg & Ornstein, 2012). Therefore, school administrators should convince teachers that they are applying equal practices and that no one is treated preferentially.

The open and honest explanation of the decisions made in the organization, together with the reasons, for those affected by the decisions, makes it easier for employees to adopt the process and strengthens the perception of justice (Greenberg, 1990). When the members of the organization see that the decisions made and the practices of the management are prejudiced and unfair, their anger and rage increase, and their feelings of commitment, trust, and loyalty towards their jobs, managers, colleagues, and the organization as a whole decrease (Eren, 2015). Based on this, as a result of these erroneous and unfair practices of the organization managers, it is inevitable for the members to generalize their negative attitudes and behaviors to the entire organization, make pessimistic comments about their organizations, make complaints, and display destructive critical attitudes. As a natural result of these situations, the organizational climate is negatively affected (Mumcu & Özyer, 2020).

Organizational cynicism

Cynicism refers to the belief that individuals always work for their interests, are not virtuous, look out for their interests in the good deeds they do, and their words and intentions are not consistent (Koçel, 2018). Brandes et al. (1999) defined organizational cynicism as a negative attitude that an individual exhibits towards his/her organization, which has cognitive, affective, and behavioral dimensions. This three-dimensional structure of organizational cynicism is also supported in later studies (Brandes, 1997). The cognitive dimension is the belief that the organization lacks integrity, the affective dimension is a strong negative attitude towards the organization, and the behavioral dimension is a tendency towards critical and condescending behavior (Brandes et al., 1999). Organizational cynicism refers to a situation where management practices are inappropriate, misleading, and wrong, and therefore, a behavior that should be ridiculed and belittled (Koçel, 2018).

An organization where cynicism is experienced has an appearance that lacks organizational integrity, lacks organizational justice, is not treated fairly in promotions, has serious criticisms regarding organizational policies and practices, organizational commitment and sense of belonging decrease, and young retirees increase (Saruhan & Yıldız, 2014). In such an organization, members experience negative emotions such as anger, frustration, disappointment, hopelessness, contempt, and distrust directed towards work organizations and managers (Andersson, 1996). As a result of the unfulfilled expectations in their organizations and the accumulation of such negative experiences, members exhibit cynical behaviors in their organizations as a reaction (Reichers et al., 1997); in other words, they constantly complain, think pessimistically about their organizations, and exhibit derogatory and destructive critical attitudes towards the organization and their colleagues (Abraham, 2000).

Teachers who experience cynicism do not trust their managers and colleagues. In addition, these individuals think that they are not given the opportunity for career development and that their ideas and work are not valued (Mirvis & Kanter, 1989). It seems possible that all these negative thoughts they have may lead them to despair that their expectations will be met in this organization, and thus, to isolate themselves from their organizations. Indeed, studies (Abraham, 2000; Dağyar & Kasalak, 2018; Demir et al., 2018) revealed that one of the consequences of organizational cynicism is alienation.

Work alienation

Pappenheim (2000) defined alienation as an introverted attitude resulting from the absence of values and a social-psychological disorder caused by the inability of the modern individual to participate in processes. Şimşek et al. (2011) explained alienation as the decrease in individuals' adaptation to their social, cultural, and natural environments, especially the ineffectiveness of their control over their environment, and the decrease in this control and adaptation causing feelings of helplessness and loneliness in the individual. Attitudes and behaviors such as not feeling a sincere commitment to something, not being integrated with the environment or process, disconnections in relationships, isolation, indifference, and disaffection constitute the symptoms of work alienation (Sidorkin, 2000). Work alienation is observed in employees due to reasons such as management style, past events and experiences, working conditions, and group characteristics in organizations (Şimşek et al., 2011). Work alienation is an important concept related to many individual and organizational variables. It decreases the positive attitudes of teachers and increases their negative attitudes. In this regard, Chiaburu et al. (2014) found in their meta-analysis study that work alienation has negative relationships with job satisfaction, organizational commitment, job involvement, and organizational citizenship variables, and positive relationships with the intention to quit and burnout variables.

Burnout

Stress is a part of the work environment in the teaching profession (Hock, 1988). Teachers may experience stress due to reasons such as student discipline problems, excessive workload, inadequate administrative support, and parents who are not supportive but make excessive demands (Russell et al., 1987). Teachers experience burnout as a result of prolonged stress related to their work and their inability to cope with this stress (Kyriacou, 2000). Those who experience burnout exhibit hostile attitudes towards their institutions and exhibit behaviors that include boredom, pessimism, dissatisfaction, and feelings of inadequacy (Şimşek et al., 2011).

Russell et al. (1987) found that teachers who had supportive administrators and who received positive feedback from others (friends and relatives) about their abilities and skills were less prone to burnout. Sarros and Sarros (1987) revealed that excessive workloads related to bureaucratic practices in their institutions, status and recognition, participation in decision-making, dissatisfaction with promotions and advancements, and wages constituted the sources of teachers' feelings of burnout. Schwab et al. (1986) found that unmet expectations, inconsistent reward and punishment practices, work conditions with low levels of participation in decision-making, role conflicts, lack of freedom and autonomy, and lack of social support systems led to burnout. The feeling of burnout that occurs for such reasons causes teachers to reduce their effort, not to show the necessary sensitivity to their work, and a decrease in the quality of their personal lives (Russell et al., 1987; Schwab et al., 1986).

The Relationship between Organizational Justice and Negative Teacher Attitudes

Perception of organizational justice facilitates the development of positive attitudes and behaviors and the reduction of negative attitudes and behaviors in organizations (Cohen-Charash & Spectator, 2001; Kulik & Ambrose, 1992). In the meta-analysis study of Cohen-Charash and Spectator (2001), it was revealed that perception of organizational justice is related to performance, extra-role behaviors (organizational citizenship behavior), counterproductive behaviors, attitudes, and emotions (job satisfaction, organizational commitment, trust, and intention to leave). In previous studies, it has been found that the perception of organizational justice is negatively related to negative attitudes such as cynicism (Biswas & Kapil, 2017; Çetin, Özgan, & Bozbayındır, 2013; Yazıcıoğlu & Gençer, 2017), work alienation (Kurtulmuş & Karabıyık, 2016), and burnout (Demir & Eser, 2019; Dishon-Berkovits, 2017; Gürboyoğlu, 2009; Korkmaz & Bozkurt, 2018). In addition, studies have clarified that there is a positive relationship between organizational cynicism and work alienation (Abraham, 2000; Dağyar & Kasalak, 2018; Demir et al., 2018), between organizational cynicism and burnout (Duman et al., 2020; Gün & Baskan, 2017; Johnson & O'Leary-Kelly, 2003; Mahmood & Sak, 2019), and between work alienation and burnout (Chiaburu et al., 2014; Demir & Eser, 2019).

Purpose of the Study

It is widely known that the perception of organizational justice has positive effects on employees (Cohen-Charash & Spectator, 2001; Koçel, 2018). This study provides important information on preventing or reducing negative attitudes of teachers. It reveals the extent to which the perception of organizational justice is effective in combating negative attitudes and behaviors that can lead to very serious problems in educational organizations. In addition, in this study, all of the variables of organizational justice, organizational cynicism, work alienation, and burnout were examined together, and the information on these variables examined together was expanded, and a structural model was proposed and tested to develop a better understanding of the complex relationships between these variables by considering the relevant literature and to form a basis for future studies. In this context, the study aimed to determine the relationship between the perception of organizational justice and the variables of organizational cynicism, work alienation, and burnout. In line with the purpose of the study, the following hypotheses were tried to be tested.

H1: Perception of organizational justice has a negative effect on burnout.

H2: Perception of organizational justice has a negative effect on burnout through the partial mediation effect of organizational cynicism and work alienation.

Method

Design

In this study, scale-based correlational design was used. Teachers' organizational justice, organizational cynicism, work alienation, and burnout levels were determined by scales. In addition, the existence and level of relationships between these variables were revealed. In order to provide stronger evidence for the research findings, a structural model was proposed based on the theoretical framework.

Population and Sampling

The population of the study consists of 8697 teachers working in 499 primary schools in Adana province in the 2022-2023 academic year. 46 primary schools were selected completely randomly using the cluster sampling method. A list of all primary schools in Adana was created and a sufficient number of primary schools were included in the sample by drawing lots. In this way, each primary school had an equal chance of being selected for the sample. The forms containing the scales were applied to the teachers in these schools. The results obtained were generalized to the entire population. Therefore, in this study, data were collected using the disproportionate cluster sampling method (Karasar, 2012). 302 of the distributed forms were returned, but it was seen that 18 of them were scored incompletely, carelessly, and negligently. 284 forms were found to be valid and these data were analyzed. Çokluk et al. (2014) emphasized that the number of samples in multivariate studies should be 200 and above, which is sufficient for performing analyses. In addition, this sample size has the power to represent the universe at a level of 95% (Field, 2009). Kline (2011) emphasized that the number of participants between 5 and 10 times the total number of items in the scales would be sufficient for representing the population and performing multivariate analyses. In this study, the total number of items in the scales is 54, and 5 times is 270. Therefore, the number of participants is sufficient in terms of representing the population and analyzing the data.

Data Collection Tools and Procedure

Information on the five-point Likert-type scales used in collecting research data is presented below in summary.

Organizational justice scale. The "Organizational Justice Scale" developed by Niehoff and Moorman (1993) and adapted to Turkish by Şahin (2014) was used to measure teachers' perceptions of organizational justice. The scale has three subscales: distributive justice, procedural justice, and interactional justice. It consists of a total of 20 items, including 5 items in the distributive justice, 6 items in the procedural justice, and 9 items in the interactional justice. The factor structure of this scale is

compatible with the data set of the study (χ^2 = 242.51, df = 101, χ^2/df = 2.40, P value = 0.00, RMSEA = 0.07, IFI = 0.96, TLI = 0.96, CFI = 0.96). x^2/df ratio is greater than 2 and the RMSEA value is greater than .05. These fit values are at an acceptable level. IFI, TLI, and CFI fit values are above .95. Therefore, these values show a good level of fit. Within the scope of this research, Cronbach's Alpha coefficient of the entire scale is 0.97. Cronbach's Alpha coefficients for three subscales are; Distributive justice: 0.85, Procedural justice: 0.95, and Interactional justice: 0.96. Büyüköztürk (2012) suggested that the reliability values of the scales being .70 and above are sufficient. Therefore, in the context of this research, it was determined that the scale and its subscales were reliable.

The "*Organizational Cynicism Scale*" developed by Brandes et al. (1999) and adapted to Turkish Culture by Karacaoğlu and İnce (2012) was used to measure organizational cynicism. The scale has three subscales: cognitive, affective, and behavioral. It consists of a total of 13 items, 5 items in the cognitive subscale and 4 items each in the affective and behavioral subscales. It was seen that this scale, which has 13 items and a 3-factor structure, is compatible with the data of the study (χ^2 = 83.91, df = 32, χ^2/df = 2.62, P value = 0.00, RMSEA = 0.07, IFI = 0.98, TLI = 0.97, CFI = 0.98). The x^2/df ratio is greater than 2 and the RMSEA value is greater than .05. These values indicate an acceptable fit. The IFI, TLI, and CFI fit indexes are greater than .95, so these fit values are at a good level. As a result of the reliability analysis, Cronbach's Alpha coefficients were calculated as .94 in the cognitive subscale of the scale, .97 in the affective subscale, .87 in the behavioral subscale, and .95 in the whole scale.

Work alienation sclale. The "*Work Alienation Scale*" developed by Hirschfeld and Feild (2000) and adapted to Turkish Culture by Kanten and Ülker (2014) was used to measure teachers' work alienation levels. As a result of the CFA, it was seen that this scale is compatible with the research data (χ^2 = 45.95, df = 20, χ^2/df = 2.29, P value = 0.01, RMSEA = 0.06, IFI = 0.95, TLI = 0.93, CFI = 0.95). The x^2 /df ratio is greater than 2, the RMSEA value is greater than .05 and the TLI index is greater than .90. These values are at an acceptable level. The IFI and CFI fit values are greater than .95, so these values show a good level of fit. As a result of the reliability analysis, Cronbach's Alpha value was determined as .83.

Burnout scale. In this study, the burnout scale developed by Pines (2005) and adapted to Turkish by Tümkaya et al. (2009) was used to reveal the burnout levels of teachers. It was observed that the single dimension with 10 items explained 64.985% of the total variance in the measurement tool. As a result of the confirmatory factor analysis applied to the data set of this study, it was seen that this single-dimensional factor structure produced a good level of fit values (x^2 = 3.83, df = 5, x^2/df =.76, P value = 0.57, RMSEA = 0.00, IFI = 1.00, TLI = 1.00, CFI = 1.00). In this study, Cronbach's Alpha Reliability value is .93.

Analysis

The skewness and kurtosis coefficients for the variables examined were calculated. The skewness values were determined to be -.60 for organizational justice, .63 for cynicism, .39 for burnout, and .46 for alienation. The kurtosis coefficients were determined to be -.07 for organizational justice, .47 for cynicism, -.24 for burnout, and -.25 for alienation. The fact that the values obtained varied between -1.96 and +1.96 provides evidence that the normality assumption was met (Field, 2009). The fact that the relationships between the independent variables were not at high levels provides evidence that the multicollinearity problem would not occur. A CFA was performed for each variable. Afterwards, a measurement model was created that included measurement errors to provide strong evidence for the existence of relationships between the variables in the study. After the relationships between the variables were determined in this model, a structural model was proposed.

Findings

Descriptive Statistics and Correlation Findings

The values obtained as a result of descriptive statistics and correlation analyses are presented in Table 1.

Table 1. Descriptive statistical values and correlation

Variables	$\bar{x}$	Sd.	Std error	1	2	3	4
1. Justice	3.57	.88	.05	1			
2. Cynicism	2.44	.80	.04	-.63**	1		
3. Alienation	1.85	.57	.03	-.25**	.34**	1	
4. Burnout	2.27	.78	.04	-.33**	.34**	.41**	1

*p<.05, **p<.01; Notes: Justice: Organizational justice, Cynicism: Organizational cynicism, Alienation: Work alienation

According to the mean scores, teachers' organizational justice perceptions are above the average (4: Agree). In addition, teachers' organizational cynicism, burnout, and work alienation levels are below the average (2: Disagree). According to the correlation matrix, there is a moderate, negative, and significant correlation between organizational justice perception and organizational cynicism perception (r = -.63, p < .01). While organizational justice and burnout variables are moderately, negatively, and significantly correlated (r = -.33, p < .01), organizational justice and work alienation variables are weakly, negatively, and significantly correlated (r = -.25, p < .01). There are moderate, positive, and statistically significant correlations between organizational cynicism and work alienation (r = .34, p < .01) and burnout (r = .34, p < .01) variables. Work alienation and burnout variables are moderately, positively, and significantly correlated with each other (r = .41, p < .01).

Measurement model

The measurement model for the relationships between the latent variables in this study is presented in Figure 1.

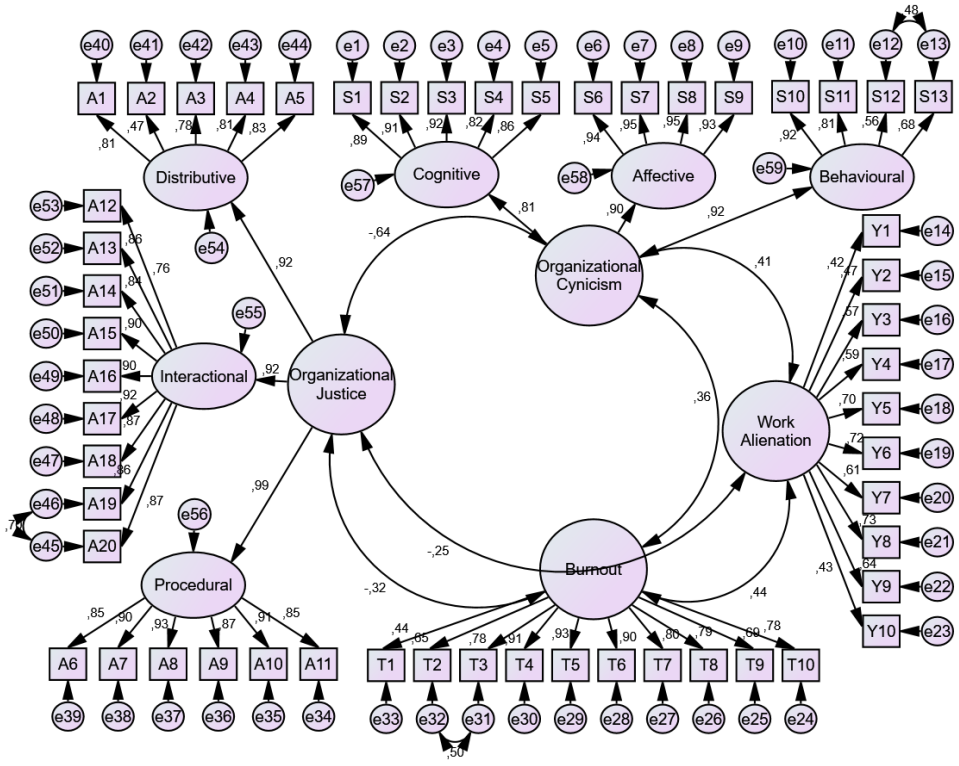

Figure 1. Measurement model

In the measurement model, it was observed that the errors of items A19 and A20, T2 and T3, and S12 and S13 were related to each other. Therefore, error covariances were added between the specified items in the model. The fact that the items in the scale are related leads to an increase in the chi-square value. This problem can be solved by adding covariance between the items whose errors are related (Byrne, 2010). The measurement model clarifies that the scales used in the study exhibit an acceptable fit with the data (x^2 = 2635.31, df = 1310, x^2/df = 2.01, p = .00, IFI = .90, CFI = .90, TLI = .90, RMSEA = .06). The x^2/df ratio is greater than 2; the RMSEA value is greater than .05; and the IFI, TLI, and CFI fit values are greater than .90. Therefore, these values are at an acceptable level. When Figure 1 is examined, it is seen that all latent variables in this model have significant relationships with each other.

Structural model

After obtaining the measurement model that produces the best-fit values, a structural model was proposed to provide stronger evidence for the relationships between latent variables. In this context, the covariances between the latent variables in the model were deleted and one-way paths were drawn to the latent variables based on the tested hypotheses. As a result of the analysis, the path coefficients were found to be insignificant, so the paths Organizational justice → Work alienation (B = .01, p = .77, ß = .02) and Organizational cynicism → Burnout (B = .11, p = .18, ß = .11) were deleted from the model, respectively.

Table 2 provides information regarding the deletion of meaningless paths from the structural model.

Table 2. Removing statistically insignificant paths from the structural model

	x^2	df	x^2/df	Δx^2	IFI	TLI	CFI	RMSEA
1. Saturated model	2635.31	1310	2.01	-	.90	.90	.90	.06
2. Justice → Alien.	2635.40	1311	2.01	0.00	.90	.90	.90	.06
3. Cynicism → Burn.	2637.13	1312	2.01	0.00	.90	.90	.90	.06

Notes: Justice: Organizational justice, Cynicism: Organizational cynicism, Alien: Work alienation, Burn: Burnout.

After the insignificant path coefficients were deleted from the model, the final structural model was obtained. It was seen that the structural model produced acceptable fit values with the research data (x^2 = 2637.13, df = 1312, x^2/df = 2.01, p = .00, IFI = .90, CFI = .90, TLI = .90, RMSEA = .06). The final structural model obtained is presented in Figure 2.

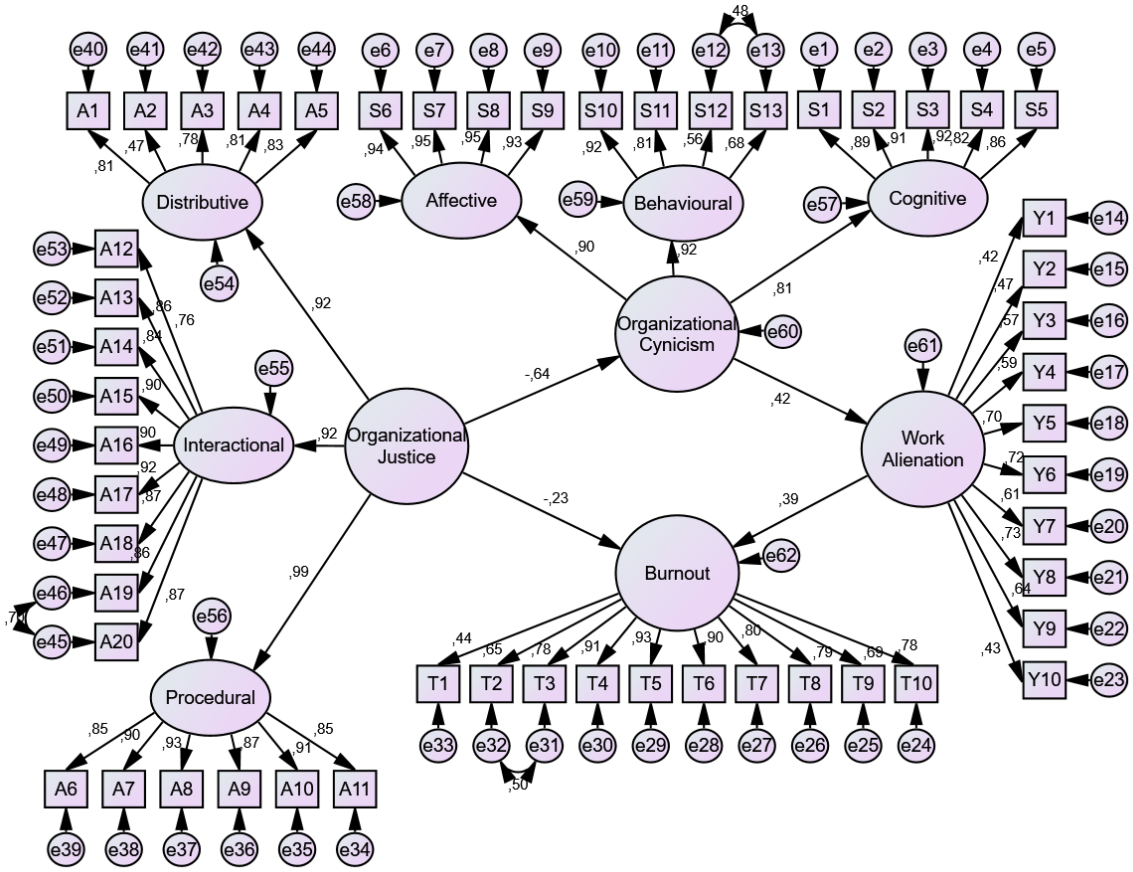

Figure 2. Structural model

According to the structural equation model that presents the best-fit indices, organizational justice perception negatively affects teachers' organizational cynicism (ß = -.64, p < .01) and burnout (ß = -.23, p < .01) levels. In addition, organizational justice has a negative effect on teachers' burnout (ß = -.10, p < .01) levels with the partial mediation effect of organizational cynicism and work alienation. It is seen that organizational justice perception has a direct and indirect effect on teacher burnout.

Discussion

This study determined the complex relationships between organizational justice, organizational cynicism, work alienation, and burnout. The effects of the variables examined within the scope of this research, which was shaped by the relational model, on teachers' burnout feelings were revealed. In this study, it was determined that teachers' organizational justice perceptions reduced their organizational cynicism levels. It was revealed that organizational justice perception reduced teachers' burnout levels with the partial mediation effect of organizational cynicism and work alienation. Therefore, it was determined that organizational justice perception reduced teachers' burnout levels both directly and indirectly.

In previous studies (Biswas & Kapil, 2017; Çetin et al., 2013; Yazıcıoğlu & Gençer, 2017), it was found that perceived organizational justice reduces organizational cynicism. When school administrators act in accordance with rules and procedures in their practices, in other words, when they do not act arbitrarily in their practices and the processes in which the practices are carried out, teachers' perceptions of organizational justice are strengthened. In a school that is managed fairly and equitably, teachers trust the practices and the processes of these practices. Therefore, teachers do not complain and do not make destructive criticisms while fulfilling their duties and responsibilities. Eren (2015) emphasized that perceiving the decisions taken and the practices of the management as fair and equitable will reduce people's anger and increase teachers' feelings of commitment, trust, and loyalty

towards their work, managers, colleagues, and the organization as a whole. Similarly, Cohen-Charash and Spectator (2001) found that organizational justice perception has a positive effect on attitudes and behaviors such as performance, organizational citizenship behavior, job satisfaction, organizational commitment, and trust in employees. It is understood that teachers who have such positive feelings and exhibit positive behaviors in their organizations are not expected to show cynical attitudinal reactions. Kılıç and Toker (2020) found that organizational justice perception is negatively related to organizational cynicism attitude. They also revealed in their studies that organizational justice and the subscales of organizational cynicism attitude are also negatively related. It was seen that the finding of the current study that organizational justice perception reduces the level of organizational cynicism is supported by the findings of previous studies. Therefore, it is evaluated that in an institution where organizational justice is perceived, teachers will not complain or become pessimistic while performing their jobs, and will not make destructive and degrading criticisms towards the institution. Based on this, it is seen that the justice perceived in the institution shapes the behaviors of teachers. In other words, the perception of justice positively affects the attitudes and behaviors of teachers.

Studies (Dishon-Berkovits, 2017; Eroğluer & Erselcan, 2017; Gürboyoğlu, 2009; Korkmaz & Bozkurt, 2018) revealed that the perception of organizational justice is negatively related to burnout. Similarly, this study also shows that the perception of organizational justice has a direct effect on burnout. Cohen-Charash and Spectator (2001) found that the perception of injustice in the organization causes negative reactions in the form of anger and moodiness and increases counterproductive behaviors. These negative emotions feed other negative emotions. It is conceivable that a teacher who experiences weariness and hopelessness in his/her school decreases his/her contribution to organizational performance as his/her counterproductive work behaviors increase. Therefore, it is thought that teachers experiencing a sense of burnout decrease the quality of education and training they provide to their students. It is doubtless that reducing the burnout of teachers, who are considered the most important element of the education system, increases their productivity and efficiency. It is evaluated that teachers have the opportunity to channel their energy more intensively to their work by reducing their burnout.

There are studies in the literature that reveal the existence of bilateral relationships between the variables of organizational justice, organizational cynicism, work alienation, and burnout. It is seen that the perception of organizational justice is negatively correlated with organizational cynicism (Biswas & Kapil, 2017; Çetin et al., 2013; Yazıcıoğlu & Gençer, 2017). One of the results of organizational cynicism is work alienation (Abraham, 2000; Dağyar & Kasalak, 2018). Demir et al. (2018) found a positive and significant relationship between organizational cynicism and work alienation in their research. In addition, there are studies in the literature that clarify the direct relationship of organizational cynicism with burnout (Duman et al., 2020; Mahmood & Sak, 2019). Work alienation is positively correlated with burnout (Chiaburu et al., 2014). Demir and Eser (2019) found that the attitude of organizational cynicism has a partial mediating effect on the relationship between organizational justice and burnout. The findings of this study revealed that the perception of organizational justice reduces the burnout levels of teachers through the partial mediating effect of organizational cynicism and work alienation. Therefore, in the current study, it was revealed that in addition to organizational cynicism, work alienation also has a partial mediating effect on the effect of organizational justice on burnout. It is seen that this research finding is also supported by other research findings. Indeed, the fact that teachers think that there is fairness in their institutions contributes to them having fewer negative experiences while providing service. Therefore, burnout is considered to be a preventable or reduceable attitude.

Conclusion and Recommendations

Teachers with high levels of organizational justice perceptions have critical expectations such as equality and trust from the school environment and administrators. Indeed, it is known that feelings of equality and trust are among the most important attitudes. Teachers believe that school administrators treat each teacher fairly in all kinds of work and transactions (preparing a curriculum, distributing lessons, sharing tasks, giving authority, etc.). Therefore, teachers feel peaceful and safe. As a natural result of these situations, they reduce their negative attitudes in their work and enable them to be more tolerant of the negativities they experience. These teachers, who have a positive perspective on their work, see their work as more meaningful and believe that they are useful in their work. It is thought that teachers' feeling that their work is meaningful increases their dedication to their work and therefore their desire to continue their work. This increases their job satisfaction. It is thought that teachers with these positive feelings experience less burnout due to their work.

It is evaluated that the phenomenon of burnout, which poses a threat to teachers' working lives, can be reduced or prevented with organizational interventions. First of all, it is considered important for school administrators to create a more democratic environment in schools. In this way, a school environment is created where all teachers have the opportunity to express their thoughts easily and their participation in decisions is ensured. In rewards, teachers' input and output ratios should be balanced. Administrators should respect personal rights, implement fair practices, inform teachers about the process, and convince them that they are acting fairly. Because even if the practices and the processes are fair, how teachers perceive this situation is important. In this way, teachers' destructive criticisms can be prevented, they can develop suggestions to improve the education and training process and they can focus their potential on their jobs to the fullest. The formation of very serious negative attitudes and behaviors such as organizational alienation and burnout, which can lead teachers to distance themselves from their jobs and institutions, can be reduced. In addition, they can be prevented from displaying these serious negative attitudes and behaviors.

Positive and negative emotions can be experienced together in organizational life. It is considered important to focus on studies aimed at determining and reducing negative emotions experienced in organizations. Because reducing negative attitudes is important for both the individual and the organization's efficiency. This study draws attention to critical negative attitudes. In future studies, examinations can be made with different critical attitudes affecting teachers' burnout. This study includes variables that affect burnout positively and negatively. Future studies can be conducted on the results of burnout. This study can be repeated in different cultures and school levels. In this way, the consistency of the results obtained in this study can be determined. In addition, future studies can be conducted with a mixed design instead of the limitations of a single design. In this way, it can be possible to find explanations for the reasons for the relationships between variables.

In this study, it is seen that attitudes are one of the most important resources of an individual. These attitudes are experienced by teachers in their school life and teachers can be affected by these attitudes. Being aware of these attitudes perceived by teachers and being sensitive to these attitudes yields results that are beneficial for the individual and the organization, such as increased productivity and efficiency. This study helps us to look at the effects of attitudes in organizational life more sensitively. In this respect, it also creates a theoretical infrastructure for future studies.

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Original Article

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Investigating prospective mathematics teachers' use of concrete materials in place value concept in different bases: addition and subtraction with whole numbers

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Abstract

The aim of this study is to examine how prospective mathematics teachers (PMTs) conceptualize the place value concept in different number bases and how they utilize concrete materials in this process. To achieve this aim, a case study design was utilized. The participants of this study consist of 24 PMTs from a public university in Turkey. The participants of this study were asked to answer activity questions that required them to perform addition and subtraction operations on numbers written in base ten, base six and base three using at least two concrete materials. Participants completed this activity as a group, with four weeks to provide written responses and the freedom to use any type of concrete material. The findings revealed that PMTs employed not only proportional and non-proportional models, as stated in related literature, but also a mixed model approach. The use of the mixed model emerged as an effective strategy, allowing PMTs to leverage the strengths of both proportional and non-proportional models. Another finding indicated that PMTs were limited in generating solutions using a second concrete material. This limitation highlights the difficulties PMTs face in maintaining material diversity when working with different base systems, which in turn affects their ability to construct mathematical meaning.

Keywords

Place value

Concrete material

Addition and subtraction operations

Base arithmetic

Middle school mathematics prospective teachers

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Introduction

Children do not come to school knowing nothing about the concept of numbers; in fact, they already have many ideas about it. Natural numbers and operations are fundamental topics in the mathematics curriculum (Ministry of National Education of Turkey (MoNE), 2018; National Council of Teachers of Mathematics (NTCM), 2000). Place value, which is included in these topics, is an important concept that helps students learn arithmetic and algebra (Conference Board of The Mathematical Sciences, 2001). Before the concept of place value, children learn numbers and make sense of them by recognizing patterns when counting sometimes between 10 and 20 (Van de Walle et al., 2018). When representing numbers, perceiving 10 objects as a single entity and representing them in groups according to their place values help make sense of place value. As students advance through their

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schooling, the focus of instruction transitions from counting individual units to counting by grouping items into sets of 10, a process referred to as unitizing. Unitizing sets of 10 marks the formal introduction of place value concepts (Rojo et al., 2021). In a numeral, the size of the group is determined by the position of the digit within the numeral, for instance in 729, the '7' signifies seven hundreds, while in 174, the '7' represents seven tens (Findell et al., 2001). Because place value refers to the idea that a digit's value is determined by its position within a number (Reys et al., 2014).

Basic understanding of the values represented by digits is also important for comprehending different number systems and algorithms (e.g., addition and subtraction) performed in different number systems (Fasteen et al., 2015; Thanheiser, 2009). A rich understanding of the number system is only possible with a solid grasp of the multiplicative structure required for understanding operations on numbers (Nataraj & Thomas, 2009). It is crucial to understand "the marriage of place value" (Hose & Wells, 2013, p. 528) in counting.

Understanding place value concept through the base 10 system begins from the moment students start learning mathematics (MoNE, 2018) and students encounter at the high school or university level under the topic of base arithmetic (Council of Higher Education (CoHE), 2007). As children continue to work on patterns of numbers between 10 and 20, counting up to 100 and discovering patterns between numbers, the construction of a sense of place value also continues. Physical models, grouping numbers, understanding the place value of digits, and comprehending the relationships between them, play a key role in the process of understanding the base 10 system (Rojo et al., 2021; Van de Walle et al., 2018). Games that children play with concrete materials (counting chips, number charts, base ten blocks etc.) support the idea of 10 and beyond becoming widespread (Van de Walle et al., 2018). Van de Walle et al.'s (2018) proportional and non-proportional models for place value represent two distinct approaches to understanding numerical place value. Proportional models visually and physically represent numerical magnitudes in direct proportion to their values; for example, base ten blocks concretely illustrate the magnitude each block represents. In contrast, non-proportional models depict numerical values without a direct correlation to physical size; for instance, tokens or colored rods may represent numbers, but their physical dimensions do not correspond to the numerical value. These two models enable students to grasp the concept of place value in different ways, fostering a deeper understanding of the concept.

Since students work on the base 10 number system in the elementary school curriculum, prospective teachers are also prepared to teach using the base 10 number system. Prospective teachers can have the opportunity to work on other number systems in the specialized area knowledge courses they take (CoHE, 2018). Although the place value is an important part of the elementary school curriculum, it is also one of the topics that prospective teachers have difficulty in conceptual applications (Roy, 2014). Research results show that prospective teachers successfully apply procedures that use the place value, but they fall short in understanding the procedures they apply (Tarım & Artut, 2013). The prior knowledge or readiness of prospective teachers has revealed that they can correctly state the places of numbers, but they cannot transfer this idea to inter-place relationships and operations (McClain, 2009). Therefore, talking about the 10-times relationship between places while working on the base 10 may not actually show that prospective teachers understand this base and the concept of place value conceptually. For example, the results of Thanheiser and Rhoads' (2009) study revealed that only about 30% of prospective teachers came to class with prior knowledge of interpreting the numbers 1 obtained as a carry-over in the tens and hundreds place correctly. According to Thanheiser's (2005) study, only 20% of prospective teachers can interpret the values of digits and the relationships between digits in the base ten system. The researcher believes that the borrowing approach that stands out in exchanging between digits masks their weak understanding of the base ten system. According to him, understanding the grouping represented individually by digits (for example, 300 is 3 groups of 100; 60 is 6 groups of 10, and 7 is 7 groups of 1) is as important as reading the number correctly (367 - three hundred sixty-seven). However, prospective teachers cannot make this grouping idea or effectively use this relationship.

Research studies have also revealed that prospective teachers who work with different bases face some difficulties in the concept of place value. Thanheiser and Rhoads' (2009) study, which worked on a different basis, addressed the processes of understanding the number system of the Mayans, who work in the base 20 number system, and relating it to the base ten system for prospective teachers. One of the results of the study revealed that more than half of the prospective teachers had difficulty understanding the grouping method used by the Mayans working in the base 20 and could not correctly write their three-digit numbers. They interpreted the zero number as filling a gap rather than evaluating it according to the position it is located in. In this process, it has also been revealed that when prospective teachers work with numbers in the base 10 system, the underlying structure of numbers written in base-10 is not deeply understood and remains implicit. Similarly, Yackel et al. (2007), who worked on a different base than the base ten system, implemented a series of mathematical tasks, including the base 8, for primary school prospective teachers in their first field course for developing a deep conceptual understanding of early arithmetic for six weeks. The results of the study showed that the language supporting the place value in the base 8 could be learned through tasks that allow for the application of this language. This process, which started with noticing basic number facts in the base 8 with visual material support, was developed through tasks emphasizing the relation between the digits. In McClain's (2009) study, which aimed to demonstrate the multiplicative relation between place values and the transformations made in addition and subtraction operations, prospective teachers seemed to be reasoning in connecting with the base ten system. However, it was revealed that they could not transfer their base ten thinking to base eight number representations correctly. On the other hand, with a series of sequential mathematical tasks, Roy (2004), who worked in the base 8, asked prospective teachers to perform addition and subtraction operations in the octal system with contextual problems and the support of an empty number line. In this process, it was determined that prospective teachers performed different counting strategies on the number line, made exchanges among the digits of the numbers given to them in the octal system, and they used conceptual problem-solving strategies commonly. This study revealed that prospective teachers made less operational and more in-depth conceptual relations and explanations because of experiencing tasks that support the conceptual value of digits. Prospective teachers were surprised to discover that the algorithm for addition and subtraction operations was the same in different number bases. Fasteen et al. (2015) worked with prospective teachers using the base 5 system to help them explore the underlying structure of different number systems through multiplication. In that study, a lesson was designed to help prospective teachers understand multiplication in the base 5 system using concrete materials. This approach enabled them to grasp the difference between the representation of the number 10 in base 10 and base 5. Understanding 10 in base 5 as a single quantity rather than two digits aided in comprehending multiplication using the area model. Additionally, this method helped prospective teachers develop a conceptual understanding of the positional structure and multiplicative relationships within the base 5 system.

This related literature clearly highlights the difficulties prospective teachers face in understanding the concept of place value in different base systems or what has been done to improve their understanding. While these studies focus on how prospective teachers develop conceptual thinking strategies when working with different bases, they do not deeply investigate how prospective teachers comprehend place value through the use of concrete materials. However, we know that concrete materials provide an opportunity to make the multiplicative relationship between place values tangible, thus offering a discussable context for this relationship (Cady et al., 2008; Rusiman & Him, 2017; Thompson & Lambdin, 1994). Because one of the ways of multiple representation is to learn or teach mathematics through concrete materials. These representations can be symbolic, visual, verbal, or physical, and they play a critical role in the teaching and learning of mathematics. According to Lesh et al. (1987), multiple representations are essential for deep understanding because they allow students to see mathematical ideas from different perspectives and make connections between concepts. For instance, a concept like place value can be represented using base-ten blocks, number lines, or algebraic notation, each offering a unique way to interpret the concept. Goldin and Kaput (1996) also highlight

the significance of multiple representations, suggesting that they support students' ability to communicate mathematical ideas more effectively. By using diverse forms of representation, students can develop a richer and more flexible understanding of mathematical concepts, which is crucial for both learning and teaching mathematics (Duval, 2006).

Ball and Bass (2000) emphasize the importance of intertwining content and pedagogy in teacher education. Prospective teachers need to engage with the same challenges their future students will face, particularly in understanding place value (Yackel et al., 2007). One effective approach to achieving this is by having prospective teachers solve arithmetic tasks in unfamiliar bases, which fosters empathy for their students' struggles and deepens their understanding of place value concepts (Roy, 2014). This understanding is facilitated through the use of concrete materials, as adults also benefit from tangible aids when learning new concepts (Mix, 2010). By incorporating concrete materials as part of multiple representations, this process makes the understanding of place value more accessible for prospective teachers, grounding abstract concepts in concrete experiences. Accordingly, the aim of this study is to examine how prospective mathematics teachers (PMTs) conceptualize the place value concept in different number bases and how they utilize concrete materials in this process. Based on this, the research question of this study is: How do PMTs use concrete materials to conceptualize the place value concept in different number bases, and what strategies do they adopt in this process?

Method

In this study, a case study design, typical of qualitative research, was used (Yin, 2003). In this design, an in-depth investigation of a specific case is conducted. This process requires gathering sufficient data on a specific individual, social environment, occurrence, or collective in order for the researcher to comprehend the mechanics or influence behind it (Berg, 2001, p.225). In the context of this study, PMTs were taken as the case of the research.

Participants and Context of the Study

The participants of this study consist of 24 junior prospective mathematics teachers (4 male, 20 female) who took one of the teaching mathematics courses naming Special Teaching Methods 2, which delve into the fundamentals of elementary and middle school mathematics instruction. It covers teaching methods, materials, strategies, and the latest research in teaching mathematical concepts to students, modern teaching approaches, recent curriculum updates. This course further requires prospective middle school mathematics teachers to create lesson plans and evaluations on a range of subjects. Moreover, in that course, they are guided to learn early number concepts and number sense, meanings for the operations, basic facts, whole-number and place-value concepts, strategies for addition and subtraction, multiplication and division computation, and algebraic thinking. Prior to this course, participants had completed courses in General Mathematics, Abstract Mathematics, Geometry, Linear Algebra I-II, Analysis I-II, Mathematical Misconceptions, and Special Teaching Methods 1 (CoHE, 2007). Notably, these university-level courses did not include specific content related to base arithmetic. However, as base arithmetic is included in the student selection and placement examination, teacher candidates typically enter university with prior exposure to this topic.

The sample of the study was determined within the scope of purposive and accessible sampling (Fraenkel et al., 2012). The criteria for study participation were enrollment in the Special Teaching Methods-2 course and prior experience in using concrete materials in middle school mathematics. In addition, students who took this course were accessible participants for the researchers.

These students were given the opportunity to freely use the materials in the math laboratory within an activity related to the development of the concept of numbers in the early stages, and then they had the experience of using base ten blocks within the scope of the place value topic. In a project aimed at revealing participants' mathematical knowledge and awareness through the use of concrete materials, a set of activity questions, partially presented in Table 1, was provided. Participants were asked to respond to these questions in writing, and reflective thinking reports were used to understand their experiences during this process. PMTs were given four weeks to answer the activity questions and

were free to use any type of concrete material. During this process, they were allowed to use the math laboratory where the course was held in their free time. This laboratory was established as a classroom for using concrete materials individually or in groups, as recommended by the Turkish Ministry of National Education for middle school level. The following materials were currently available in the math laboratory: a student drawing set (compass-protractor-ruler) (50 pieces), ten frames set (15 pieces), geometric shapes (3 boxes), fraction set (round) (5 boxes), pattern blocks (plastic) 256 pieces (2 boxes), unit cubes (2 boxes), connecting unit cubes (2 boxes), geometric strips (2 boxes), base ten blocks (3 boxes), symmetry mirrors (10 pieces), transparent fraction cards (5 boxes), tangram (2 boxes), algebra tiles set (2 boxes), transparent counting chips (3 boxes), and wooden sticks (1000 pieces). If they wanted to use any material that was not available in this classroom, it was stated in classroom announcements that this was possible.

Participants were allowed to complete this activity as a group. The study was conducted with PMTs who voluntarily chose this assignment from among various topics they completed as part of a project. In this scope, a total of 6 groups of PMTs (24 PMTs in total) produced solutions for the activity. In this study, the PMTs who were already divided into groups were assigned group numbers, represented by the letter "G" followed by a number (e.g., G1, G2, ..., G6).

Data collection tool

This study is a part of a research project which consists of four questions and their sub-questions prepared for the operations of addition, subtraction, multiplication and division. In this study, an activity aimed at enabling PMTs to explore the concept of place value through different bases provided to them, was used as a data collection tool which was represented in Table 1. Departing from the relevant literature (e.g: Ev Çimen, 2016; Fasteen et al., 2015; Roy, 2014; Yackel et al., 2007), the PMTs were asked to demonstrate their approach to addition and subtraction operations with numbers given to them in different bases, base 10, base 3, and base 6, through concrete materials.

The questions within this activity served two separate purposes. Firstly, it aimed to enable PMTs to understand the conceptual dimension of the different bases they will encounter, as well as the addition and subtraction operations that will allow them to make this discovery. PMTs will need to understand the exchange operations they perform in numbers written in the base-ten system. to make sense of these operations. In this context, by including numbers written in different bases that they are not familiar with, but that include the same numbers they are familiar with in base 10, PMTs were given the opportunity to make this discovery using their prior knowledge. In addition, since place value models can be modeled in two ways in the literature (proportional models and non-proportional models), PMTs were asked to use at least two different concrete materials. The questions presented to PMTs are shown below:

Table 1. Questions about operations in base 10, base 6 and base 3 presented to PMTs

Each of the following numbers is given in the base 10. If you wanted to show these operations using at least two different concrete materials, how would you do it? (Don't forget to take pictures of your solutions and explain them in detail.)
$\begin{array}{r} 10202 \\ -\ 1121 \\ \hline \end{array}$ $\qquad$ $\begin{array}{r} 4302 \\ +\ \ 505 \\ \hline \end{array}$
The following numbers are given in different number systems. If you wanted to show these operations using at least two different concrete materials, how would you do it? (Don't forget to take pictures of your solutions and explain them in detail.)
$\begin{array}{r} (10202)_3 \\ -\ (1121)_3 \\ \hline \end{array}$ $\qquad$ $\begin{array}{r} (4302)_6 \\ +\ \ (505)_6 \\ \hline \end{array}$

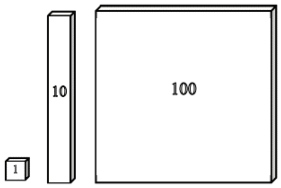
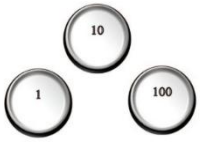
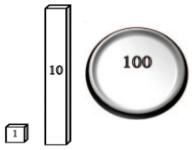
As seen in Table 1, in the measurement tool, two questions for each of addition and subtraction operations were asked. According to Findell et al. (2001), understanding the concept of place value through operations enables the comprehension of the value carried by numbers based on their positions, a concept that becomes particularly evident in arithmetic operations. These operations require students to actively engage with place value by utilizing the positional significance of numbers. For instance, when the value in the hundreds place of one number is added to the value in the hundreds place of another number, the student must focus on the placement order and the value carried by each digit. This process transforms the concept of place value from an abstract idea into a concrete application. Such operations require students to practically test their numerical knowledge in understanding place value. Addition and subtraction provide a less complex and more fundamental foundation for deepening the understanding of place value compared to multiplication and division. Therefore, in this study, the examination of place value is presented through addition and subtraction operations. One of the questions were asked in base 10 and the other was in the same number but represented in a different base. Just as elementary and middle school students may not be familiar with the base 10 number system when developing their understanding of place value, the use of different bases in this activity was a new situation for PMTs.

Data analysis

Content analysis was used to examine the solutions of the PMTs. In the content analysis process, first, the solutions presented by the PMTs were evaluated holistically, and their similarities and differences were noted. Then, parallel to the purpose of the study, they were coded within the scope of "Models for Place Values" mentioned by Van de Walle et al. (2018). "Models for Place Values" approach by Van de Walle et al. (2018) is a well-established widely recognized in the field of mathematics education. This model is grounded in a rich theoretical foundation and has been employed by various researchers (Disney & Eisenreich, 2018; Houdement & Petitfour, 2019; Rojo et al., 2021) to explore students' understanding of place value concepts. Moreover, Hiebert and Carpenter (1992) emphasize the importance of considering the distance between materials and mathematical representation when using concrete manipulatives in the process of understanding place value. According to them, an approach in which grouping is explicitly evident—referred to by Van de Walle et al. (2018) as proportional modeling—allows students to physically experience the relationships between place values. In contrast, an approach that does not provide direct physical cues—termed non-proportional modeling by Van de Walle et al. (2018)—requires students to establish this relationship in a more abstract manner. In this regard, proportional models offer learners greater contextual support, whereas non-proportional models function as more abstract representations (Baroody, 1990). Given the alignment between our research objectives and the strengths of this model, we believe it provides a robust framework for analyzing our data.

Accordingly, if PMTs perform the representations of numbers and the trades, they make during the operations proportionally using place values, it is coded as proportional model usage, and if they perform it non-proportionally, it is coded as non-proportional model usage. Some PMTs, on the other hand, have made sense of place values while performing the representations and operations of numbers without relying on a single model. Data in this form was coded as mixed model usage. An example of each of these models is presented below:

Table 2. Coding definition for the models of representing place value concept through concrete models*

Models for representing place value	Coding definition*	Pictorial representations
Proportional model	Strategies that have number representations and operation descriptions in which the physical relationship between place values is clearly seen.	 (Rojo et al., 2021, p. 37)
Non-proportional model	Strategies in which the physical relationship between place values does not exist in number representations but exists in operation descriptions.	 (Rojo et al., 2021, p. 37)
Mixed model	Strategies in which the physical relationship between place values exists in some digits of number representations, but not in others.	 (the current data of the study produced an additional use getting benefit from Rojo et al. (2021 and Van de Walle et al. (2018))

* Developed from Van de Walle et al. (2018, p.191-193)

The validity and reliability of the study

The content validity was provided by the support of the second author and the related literature. The first researcher initially created the questions, and then the second researcher reviewed them. The questions were developed and refined through input from both authors and their collaborative discussions throughout the process. In this process, the selection of numbers was employed to prompt PMTs to comprehend the multiplicative connections within place value and to devise methods for representing transactions (Ev Çimen, 2016; McClain, 2009; Roy, 2014). Additionally, to contribute to the bases 8, 20 and 5 studied in the literature, the base selection was made differently from these. To gain a more profound insight into the PMTs' conceptual understanding, the researchers decided to demonstrate the concept using at least two different materials, aligning with the guidance in the literature (Van de Walle et al., 2018). After developing the data collection tool, the first author collected the data in the form of a project assignment.

Reliability of the study was ensured through intercoder agreement (Saldaña, 2012). Firstly, two groups were randomly selected, and their activities were analyzed simultaneously by the authors. In this way, coding list was created. Following this, the remaining four activities were independently coded, and the researchers conducted four separate sessions for these four activities. In each session, areas that were coded differently or proposed changes to the coding list were evaluated, and updates to the data analysis were determined and implemented for the next analysis and for the relevant areas in the previous analyses.

Ethics

The procedures performed in studies involving human participants were in accordance with the comparable ethical standards and approved by the Applied Ethics Research Center of the university where the study was conducted.

Findings

Distribution of PMTs' use of concrete materials regarding operations, base numbers and the variety of them

Table 3 shows that G1 and G5 were able to use two types of concrete materials for each of the bases while G2, G3, and G4 were able to use one material for each base. We can say that there may be problems in increasing the variety of materials regardless of the base. Table 3 also revealed that G6 was able to use one material for subtraction in base 10 but was unable to use any material for addition in base 6. Therefore, we can say that increasing the variety of concrete materials can become problematic when the base changes.

The table also clearly shows which materials PMTs used. PMTs used algebra tiles (A.T), wooden sticks (W.S), unit cubes (U.C), connecting cubes (C.C), geometry strips (G.S), or base ten blocks (B.T.B) to represent the operations. Accordingly, it shows that algebra tiles, unit cubes-connected unit cubes, wooden sticks, and geometry strips were the least preferred concrete materials by the groups for representing place value. In contrast, unit cubes, connected unit cubes, and base ten blocks were the most frequently chosen materials. Among these materials, base ten blocks were the only material used across all different bases. Only one group (G4) used unit cubes and connected cubes together in their representations.

Table 3. The distribution of variety of materials* regarding operations and base numbers

Operations	**Addition**		**Subtraction**	
Groups**	**Base 6**	**Base 10**	**Base 3**	**Base 10**
G1	A.T, B.T.B (2 materials)	A.T, B.T.B (2 materials)	U.C, C.C (2 materials)	G.S, B.T.B (2 materials)
G2	B.T.B (1 material)	B.T.B (1 material)	B.T.B (1 material)	B.T.B (1 material)
G3	C.C (1 material)	B.T.B (1 material)	C.C (1 material)	B.T.B (1 material)
G4	U.C – C.C (1 material)	B.T.B (1 material)	U.C – C.C (1 material)	B.T.B (1 material)
G5	U.C, C.C (2 materials)	W.S, B.T.B (2 materials)	U.C, C.C (2 materials)	W.S, B.T.B (2 materials)
G6	N/A***	G.S, B.T.B (2 materials)	U.C, C.C (2 materials)	B.T.B (1 material)

*A.T:Algebra tiles, W.S: wooden sticks, U.C: unit cubes, C.C: connecting cubes, G.S: geometry strips, B.T.B: base ten blocks, U.C – C.C: unit cubes and connecting cubes (which were used together); ** G1-G6: Different groups of participants; ***N/A: Not Applicable which address that group did not offer any representation

Table 4, shows how the prospective teachers modeled place value using different materials. Accordingly, the findings of the study revealed that the participants employed three different modeling strategies to represent place value while using the concrete materials: proportional modeling strategy, non-proportional modeling strategy, and mixed modeling strategy.

Table 4. The distribution of representation approaches regarding the variety of the materials* and base numbers

Representation approaches	**Addition**		**Subtraction**	
	Base 10	**Base 6**	**Base 10**	**Base 3**
Proportional modeling	B.T.B	B.T.B	B.T.B	B.T.B, U.C, C.C
Non-proportional modeling	W.S, G.S	U.C, C.C	W.S, G.S	U.C, C.C
Mixed modeling	A.T	A.T, B.T.B, U.C-CC	-	U.C-CC

**A.T:Algebra tiles, W.S: wooden sticks, U.C: unit cubes, C.C: connecting cubes, G.S: geometry strips, B.T.B: base ten blocks U.C – C.C: unit cubes and connecting cubes (which were used together)

According to this table, proportional modeling involved the use of base-ten blocks, unit cubes, or connecting cubes. It can be stated that base-ten blocks were used consistently across different bases in this modeling approach. In non-proportional modeling, unit cubes, connecting cubes, wooden sticks, or geometry strips were used. Non-proportional modeling was the only representation where the base-ten blocks material was not utilized. In mixed modeling, algebra tiles, base-ten blocks, or a combination of unit cubes and connecting cubes were employed. Algebra tiles were exclusively used in mixed modeling, whereas unit cubes and connecting cubes were applied across all types of modeling strategies. For operations in the base ten, regardless of the specific operation, base-ten blocks, wooden sticks, and geometry strips were preferred. Unit cubes and connected unit cubes were the concrete materials most frequently used in base 3 and base 6.

PMTs' place value representations for the operation of 4302 + 505 in bases 6 and 10

4302 + 505 was presented to PMTs to be solved with at least two concrete materials in both base 10 and base 6. In the following, we closely examine the usage of proportional, non-proportional, and mixed model for this operation.

Representing Approaches in the Base 10

Utilizing proportional model in the base 10. As seen from Table 4, the use of proportional model for addition operation in the base 10 has only been represented through base ten blocks. An example was represented in Figure 1 below. G4 emphasized in their explanations that they started to make addition from the units place and moving to the left. Accordingly, 5 ones plus 2 ones equals 7 ones. As there are no tens in either number, the sum has 0 in the tens place. Following this, they obtained 8 hundreds in the hundreds place and 4 thousand in the thousands place. Therefore, the sum is 4807, consisting of 4 thousand, 8 hundreds, 0 tens, and 7 ones.

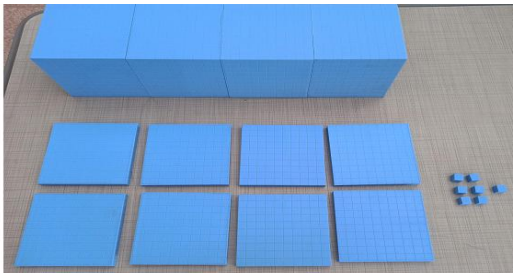


Figure 1. Proportional modeling through base ten blocks for 4302 + 505 (G4)

Utilizing non-proportional model in the base 10. PMTs used non-proportional modeling for base 10 addition through wooden sticks (G5) and geometry strips (G6). According to this, G5 has assigned the numerical values of thousands, hundreds, and ones to identical wooden sticks, respectively, as shown in Figure 2; while G6 has assigned the numerical values of thousands, hundreds, and ones to different colored geometry strips, as seen in Figure 3.

Figure 2. Non-proportional modeling through wooden sticks for 4302 + 505 (G5)

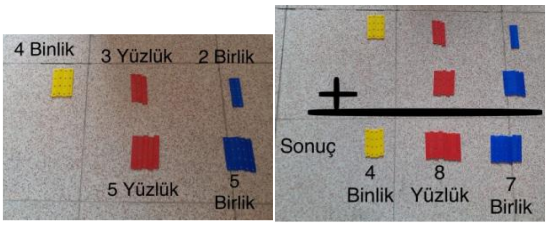


Figure 3. Non-proportional modeling through geometry stripes for 4302 + 505 (G6)

This method of representing numerical values of digits with materials provided an abstract representation rather than directly concretizing the relationships between place values of digits.

Utilizing mix model in the base 10. G1 used the algebra tiles through a mixed modeling approach to perform the given addition operation. As shown in Figure 4, in this usage, the hundreds and ones were modeled with a non-proportional modeling approach, while the thousands were modeled with a proportional modeling approach with the equivalence representing ten hundreds.

Accordingly, the group first added 2 and 5 in the ones place to obtain 7 units and represented this with 7 small square algebra tiles. Since both numbers had 0 in the tens place, they obtained 0 as the result. In the hundreds place, when they added 3 hundreds and 5 hundreds, they represented 8 hundreds with 8 large square algebra tiles. Finally, in the thousands place, they modeled 4 thousands as four stacks, each consisting of ten hundreds. In other words, the group used ten green tiles representing a hundred for each of the 4 thousands in the number 4302. Through this process, they obtained the number consisting of 7 thousands, 8 hundreds, 0 tens, and 4 units.

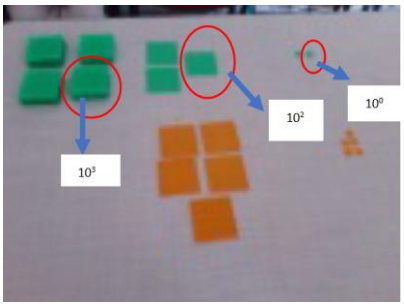


Figure 4. Mix modeling approach through algebra tiles for 4302 + 505 (G1)

The PMTs took advantage of the ability to represent the thousands place, the highest place value, more easily and perhaps to represent the relationship between the hundreds and thousands places more clearly through proportional representation. We can also say that they utilized the flexibility of representing relatively smaller numbers in the ones and hundreds places with fewer materials through non-proportional modeling. The manipulative they used is not suitable for establishing a physical multiplicative relationship between the ones and tens places or between the tens and hundreds places. However, G1 found it appropriate to show this multiplicative relationship only between the hundreds and thousands places.

Representing Approaches in the Base 6

Utilizing proportional model in the base 6. The use of proportional model for addition operation in the base 6 has only used by G2. The group represented how the addition was performed using base ten blocks in Figure 5. We understand that they grouped the blocks for the digit 6^3 as 216, for the digit 6^2 as 36, and for the digit 6^1 as 6 on pieces of base ten blocks. For instance, for representing 216, they used two hundreds block, one ten block and six-unit blocks. In the end, as seen in Figure 5, they represented the result of the operation through the material.

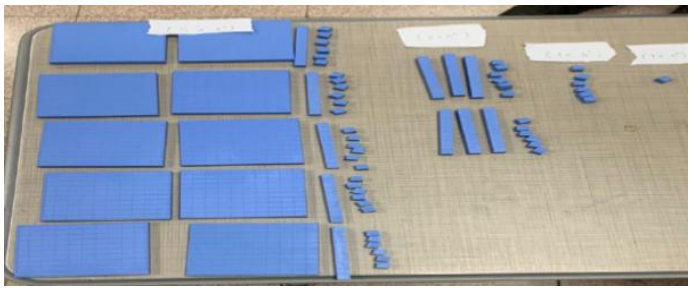
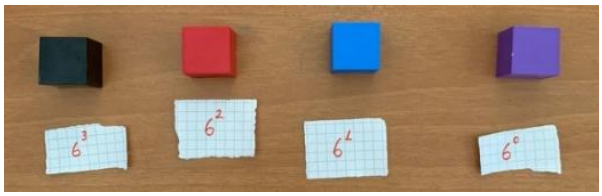


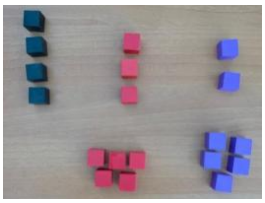
Figure 5. Proportional modeling through base ten blocks for $(4302)_6 + (505)_6$ (G2)

The proportional modeling approaches used in base 10 and base 6 share a foundational logic, where numbers are added according to their place values, with carry-over to the next place value as necessary. In the base 10 model, PMTs typically employed base ten blocks to represent the numbers and directly summed the values at each place without requiring any carry-over. This made the process straightforward and less complex. In contrast, the base 6 model also utilized base ten blocks, but with the added complexity that when the sum at any place value reached 6, a carry-over to the next place value was necessary. For example, when adding 6 and 1, a remainder of 1 was recorded, and 1 was carried over to the next place value. This made the base 6 operations more intricate and required careful attention to the concept of carrying over.

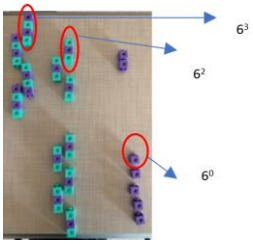
Utilizing non-proportional model in the base 6. In the addition process in base 6, G5 preferred to use non-proportional model. Although the materials used were different, the common idea in this model was the use of materials with non-proportional correspondences to represent the place values of the given numbers in base 6. The group assigned each digit of the number to a different color of unit cubes or connected unit cubes (Figure 6a and c). Then, the calculations were performed using unit cubes and connected unit cubes to represent the numbers without carrying out the exchanges (Figure 6b and d). In their explanations, the students focused on the use of the non-proportional model and detailed the steps of the operation. Accordingly, when adding 5 units and 2 units, they determined that they obtained a total of 7 units, at which point they converted 6 units into a single unit of the next higher place value, and carried over 1 unit to the next column. Similarly, when they reached 8 in the 36s place, they converted 6 groups of 6^2 into one unit of 6^3, and transferred it to the 216s place, ultimately arriving at the final result of 5211. Throughout this process, they utilized the six-times relationship between place values to perform exchanges. While the PMTs' ability to clearly articulate the steps of their operations suggests that they could make sense of their procedural processes, it also raises the concern that they might be limited in demonstrating the multiplicative relationships and exchanges between place values through the use of manipulatives.



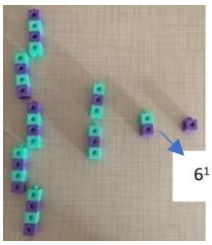
a. Representing digits of the base 6 with unit cubes



b. Representing the numbers $(4302)_6 + (505)_6$ with unit cubes



c. Representing the numbers $(4302)_6 + (505)_6$ with connected unit cubes

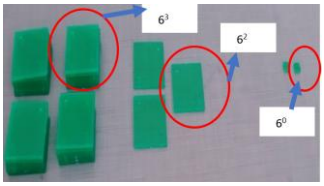


d. Representing the result of $(5211)_6$

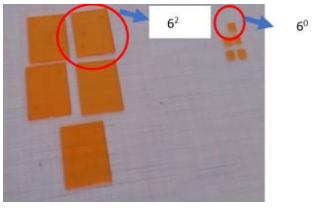
Figure 6. Non-proportional modeling through unit cubes and connected unit cubes for $(4302)_6 + (505)_6$ (G5)

When examining the representations made with unit cubes in Figure 6a, we observe that unit cubes of different colors, despite being the same size, are used to represent different place values. However, when these different colors are used to represent each addend (Figure 6b), the corresponding place values do not match with the unit cubes of the appropriate color. Accordingly, Accordingly, each addend in the 6^0 place is represented by a blue cube, which corresponds to the 6^1 place. In the other representation using connecting unit cubes (Figure 6c and d), both different colors and varying numbers of connecting unit cubes were used to represent the addends and the total place values. The increase in the number of connecting unit cubes as the place value increases (1 purple, 1 purple and 1 green, 2 green and 1 purple, 2 green and 2 purple) seems to have been used as a mental cue by the PMTs. We can suggest that these representations support the visualization of the numerical values of the places directly, but the visualization of the place values themselves in a less direct manner.

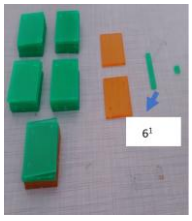
Utilizing mix model in the base 6. G1 has used a mixed modeling approach for addition in the base 6 system. They arranged the algebra tiles in base-6 as the square algebra tile represents 6 × 6 units or the 6^2 place, the rectangular algebra tile represents 6 × 1 units or the 6^1 place, and the smallest algebra tile represents the 6^0 place or a single unit. As can be seen from these explanations, although a proportional perspective was initially adopted, the multiplicative relationship was reflected in the manipulative only between the 6^2 and 6^3 place values. As shown in Figure 7, the group modeled 6^3 digits, with a height of 6. Since the green x^2 algebra tile represents 6^2, the 6^{3rd} place digit in this model is also proportional to a height of 6. However, the relationships between the other place values were assumed to be proportional but were represented non-proportionally. The green tile is associated with the 6^2nd digit and the small green tiles are associated with 6^1st digit using a non-proportional approach.



a. Representing $(4302)_6$ through algebra tiles



b. Representing $(505)_6$ through algebra tiles

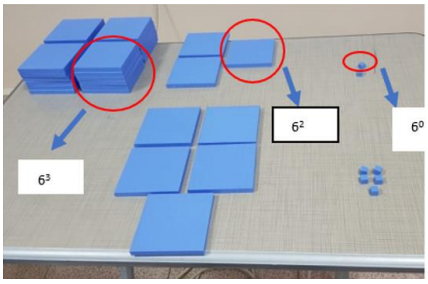


c. Representing the result of $(5211)_6$ through algebra tiles

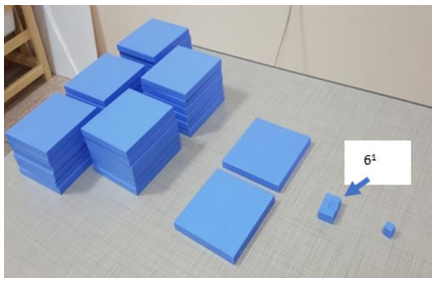
Figure 7. Mix modeling approach through algebra tiles for $(4302)_6 + (505)_6$ (G1)

G1 used a mixed approach in their use of second material choice as well. It would be more accurate to say that they used a proportional approach in a mixed way on the material. The same group employed a similar approach with base-ten blocks using a mixed model, as they did with the previous use of algebra tiles. They arranged the base-ten blocks by modeling their sizes after 6^0, 6^2, and 6^3, corresponding to the ones, hundreds, and thousands places, respectively.

Figures 8a shows the representations of numbers in base 6 using base ten blocks. The representation of 2 in the 6^0th place and the representation of the 6^1 place value with 6 unit cubes are proportional. Instead of the base equivalent of 36 for the 6^2nd place, one hundred block was used as if it is base 10 representation. Therefore, each 6^2 corresponds to one hundred, just as the hundreds place corresponds to 10^2. Figure 8b shows the representation of the number obtained after the exchange operations between 6^1, 6^2 and 6^3.



a. Representing $(4302)_6$ and $(505)_6$ with base ten blocks



b. Representing the result of $(5211)_6$ through base ten blocks

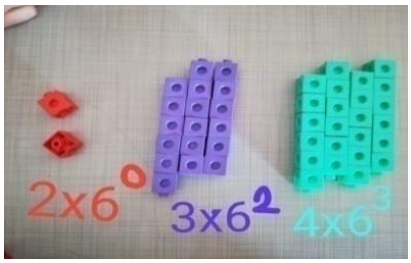
Figure 8. Mix modeling through base ten blocks for $(4302)_6 + (505)_6$ (G1)

G3 is another group who utilized mixed approach. The group used a combination of unit cubes and connected unit cubes. The number of cubes appears to be assigned to the base number. The digit representations of G3 are represented in Figure 9. Accordingly, 6^0 and 6^1 share a proportional relationship in both color and quantity whereas 6^1, 6^2 and 6^3 address non-proportional relations among each other. Therefore, G3 utilized mixed approach for $(4302)_6 + (505)_6$.

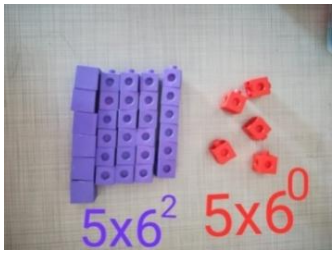
6^0 6^1 6^2 6^3

Figure 9. The digit representations for $(4302)_6 + (505)_6$ (G3)

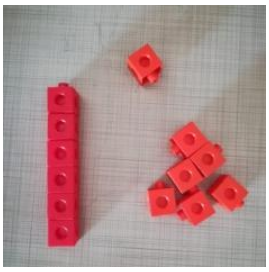
As represented in Figure 10, it was observed in Figure 10-a that the PMTs wrote the digit placement of the numbers differently. The group wrote the digits of the other addend $(505)_6$ in their correct places (Figure 10-b). Although the equivalence between 6^0 and 6^1 was explained using the materials (Figure 10-c), the transitions between 6^0 and 6^1, 6^2, and 6^3 were not represented by them.



a. Representing $(4302)_6$ with connected cubes



b. Representing $(505)_6$ with connected cubes

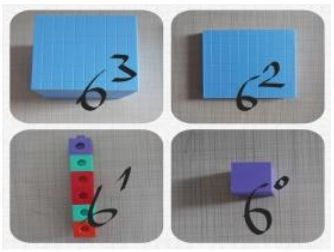


c. Representing the exchange between 6^0, 6. 6^0 *and* 6^1

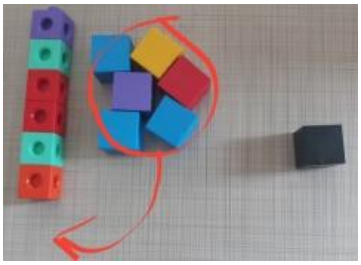
Figure 10. Mix modeling through unit cubes and connected cubes for $(4302)_6 + (505)_6$ (G3)

The absence of a visual material for the inter-place value changes, except for the 6^0 place in G3, suggests that they performed the operation through procedural transformation and determined the result accordingly.

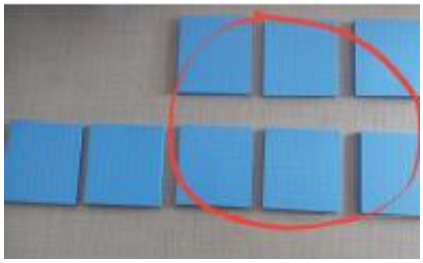
The other group, G4 utilized mixed approach. The group used base ten blocks, connected cubes, and unit cubes to represent ones and 6^1s places proportionally (Figure 11-a, b), but the other places (Figure 11a-c-d) using a non-proportional modeling approach. As shown in Figure 11, they used base ten blocks to represent the 6^2 and 6^3 places as numerically unequal but pseudo-equivalent:



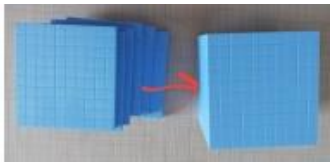
a. Representing the digits of base 6 using the concrete materials



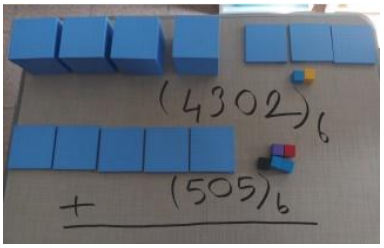
b. Representing the exchange of 6^0, 6. 6^0 *and* 6^1



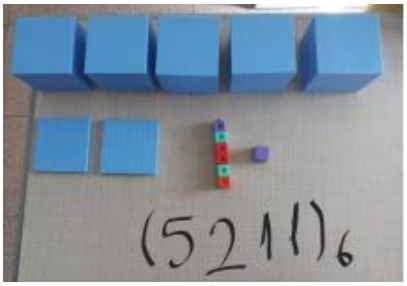
c. Emphasizing the exchange between 6 times 6^2 *and* 6^3



d. Emphasizing the equality of 6 times 6^2 *means* 6^3



e. Representing $(4302)_6$ and $(505)_6$ with the concrete materials



f. Representing the result of $(5211)_6$ with the concrete materials

Figure 11. Mix modeling through unit cubes, connected cubes, and base ten blocks for $(4302)_6 + (505)_6$ (G4)

G4 emphasized the exchanges between the digits in a base-6 numeral system through concrete materials. Additionally, the group modeled the numbers $(4302)_6$ and $(505)_6$ using concrete materials and demonstrated the result of their addition as $(5211)_6$. This method enabled students to visualize the different place values through concrete materials.

PMTs' place value representations for the operation of 10202 – 1121 in Bases 3 and 10

Representing Approaches in the Base 10

Utilizing proportional model in the base 10. Subtraction operation at the base 10 has been performed by proportional model approach by all groups through the base ten blocks. G1 describes how subtraction is performed by decomposing numbers using base-10 blocks. Initially, the number

10202 was decomposed into ten thousands, hundreds, and units. The number to be subtracted, 1121, was separated into thousands, hundreds, tens, and units. The subtraction process began with the units place; subtracting one unit from two units left one unit remaining. Since there were zero tens, two tens could not be subtracted, and thus, one hundred was converted into ten tens to continue the operation. These steps were similarly repeated for other place values, resulting in the final answer of 9081 as represented in Figure 12.

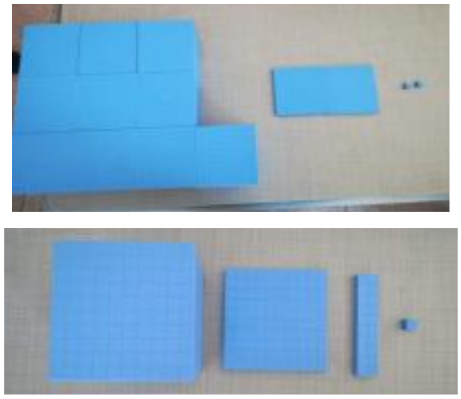


Figure 12. Proportional modeling through base ten blocks for 10202-1121 (G3)

Utilizing non-proportional model in the base 10. PMTs have provided non-proportional modeling for subtraction in base ten using coffee sticks (G5) and geometry strips (G1) as represented in Figure 13.

a. Representing 10202 and1121 with wooden sticks

b. Representing the result of 9081 with wooden sticks

c. Representing 10202, 1121, and the result of 9081 with geometry strips

Figure 13. Non-proportional modeling through wooden sticks (G5) and geometry strips for 10202-1121 (G1)

As shown in Figure 13a and b, G5 associated baskets with place values and sticks with the numerical values of the digits. Specifically, the pink basket was associated with the unit, hundreds, and thousands digits, while the green basket referred to the tens and thousands digits.

Another material used in this representation is geometry strips. G1 used geometry strips to represent the longest strip as thousands, medium-length strips as tens, and the shortest strips as units, as shown in Figure 13c. Unlike the use by G5, the geometry strips representing the values of the digits have different colors, and no additional material was used to represent the place values.

Representing Approaches in the Base 3

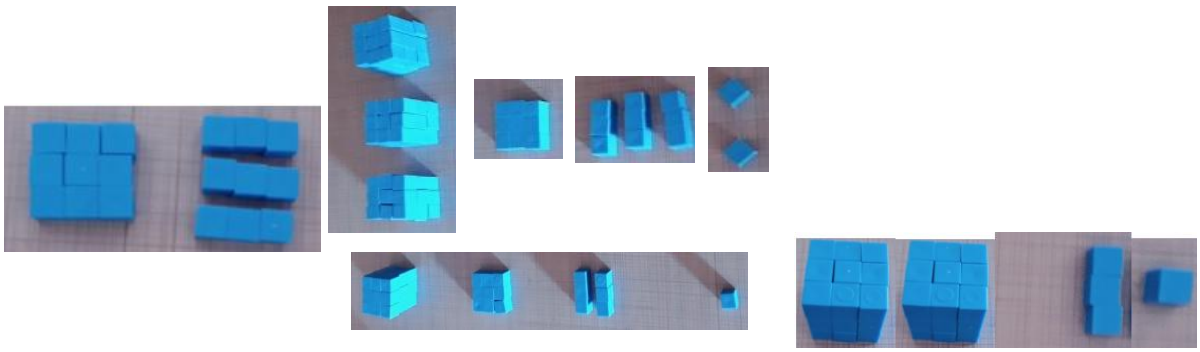
Utilizing proportional model in the base 3. The use of proportional model for subtraction operation in the base 3 has applied by G1, G2, and G6. The groups represented the operation using base ten blocks, unit cubes and connected unit cubes. All the ways of utilizing the concrete materials were shown in Figure 14, 15, 16, and 17.

G1 has performed the solution by creating the place values in base 3 using unit cubes as shown in Figure 14 and 15. According to this approach, the group combined three unit blocks from the base-ten blocks to represent 3^0 as a whole and used it to denote 3^1. They represented 3^2 by arranging nine unit blocks into a 3 × 3 square. For 3^3, they formed a cube, while for 3^4, they placed three separate 3^3 cubes (Figures 14a and 14b). The number $(1121)_3$ results in a model represented by one unit, two groups of three, a square of size (3 × 3), and a cube of size (3 × 3 × 3) (Figure 14a).

a. Modeling $(1121)_3$ b. Modeling $(10202)_3$

Figure 14. Proportional modeling through unit cubes for $(10202)_3$ and $(1121)_3$ (G1)

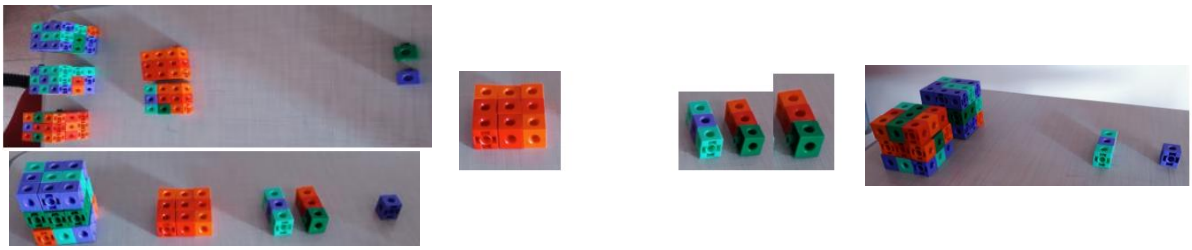
The subtraction of the numbers was modeled by exchanging larger base cubes for smaller units when necessary, reflecting the process of borrowing in base 3. Accordingly, participants initially performed a multiplicative pattern between the 3^2 place and the 3^1 place, as demonstrated in Figure 15a. Subsequently, a multiplicative pattern between the 3^4 place and the 3^3 place was performed, as shown in Figure 15b. Finally, by utilizing this multiplicative pattern, the result was visualized as shown in Figure 15c.



a. Modeling the multiplicative pattern between 3^2 and 3^1 b. Modeling the multiplicative pattern between 3^4 and 3^3 and representing $(10202)_3$ and $(1121)_3$ c. Modeling the result of 10202-1121 as $(2011)_3$

Figure 15. Proportional modeling through unit cubes for the exchanges and the result of $(10202)_3$ - $(1121)_3$ (G1)

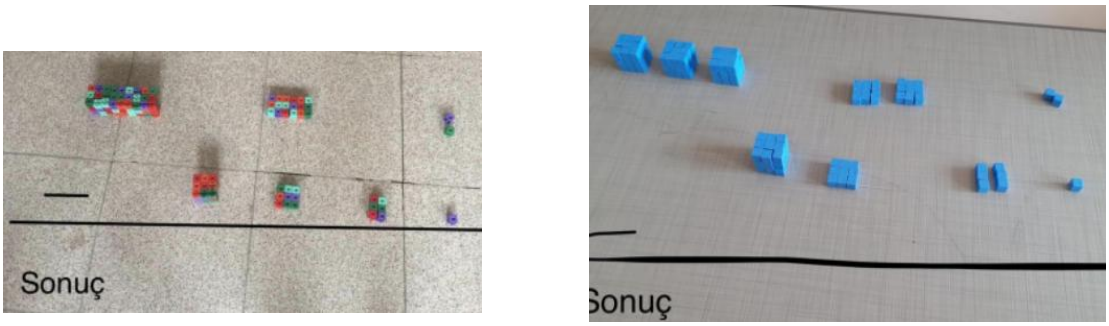
As shown in Figure 16, G1 has performed the same steps in connected unit cube as well. Indeed, we can understand that G1 did not consider two kinds of approaches, a non-proportional modeling or mix model approach, rather the group has flexibly used the proportional approach in two kind of materials. Therefore, it can be said that it was not always the case that PMTs developed an alternative approach for using a second material.



a. Modeling $(10202)_3$ and $(1121)_3$ b. Modeling the multiplicative pattern between 3^2 and 3^1 c. Modeling the result of $(10202)_3$- $(1121)_3$

Figure 16. Proportional modeling through connected unit cubes for $(10202)_3$- $(1121)_3$ (G1)

The modeling of G6 is identical to G1's modeling except for one point. The only difference is that in the representation of the number 102023, they show the 3^4 digit as 1.3^4 instead of 3.3^3, as shown in Figure 17a even though in Figure 17b, it is represented as 3.3^3:



a. Representing $10202)_3$ and $(1121)_3$ with connected cubes b. Representing $10202)_3$ and $(1121)_3$ with unit cubes

Figure 17. Proportional modeling through connected unit cubes and unit cubes for $(10202)_3$- $(1121)_3$ (G6)

The G2 group has only represented the solution proportionally in the presentation of the material (Figure 18). The result of the operation, which is 20113, has been modeled as 2.3^3, 1.3^1, and 1.3^0 based on 2 groups of 27, 1 group of 3, and 1 unit of 1.

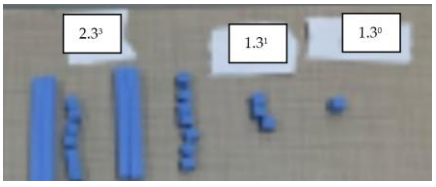


Figure 18. Proportional modeling through base ten blocks for $(10202)_3$- $(1121)_3$ (G2)

Utilizing non-proportional model in the base 3. G3 and G5 used non-proportional models. As shown in Figure 19, the participants matched specific place values with certain colors (Figure 19 a-c) or a certain number of connected unit cubes (Figure 19 d-f), or different colored connected unit cubes based on the base (Figure 19 g-k). In these representations where the trading process is not explicitly shown, the result of the operation are concretized as shown in these figures.

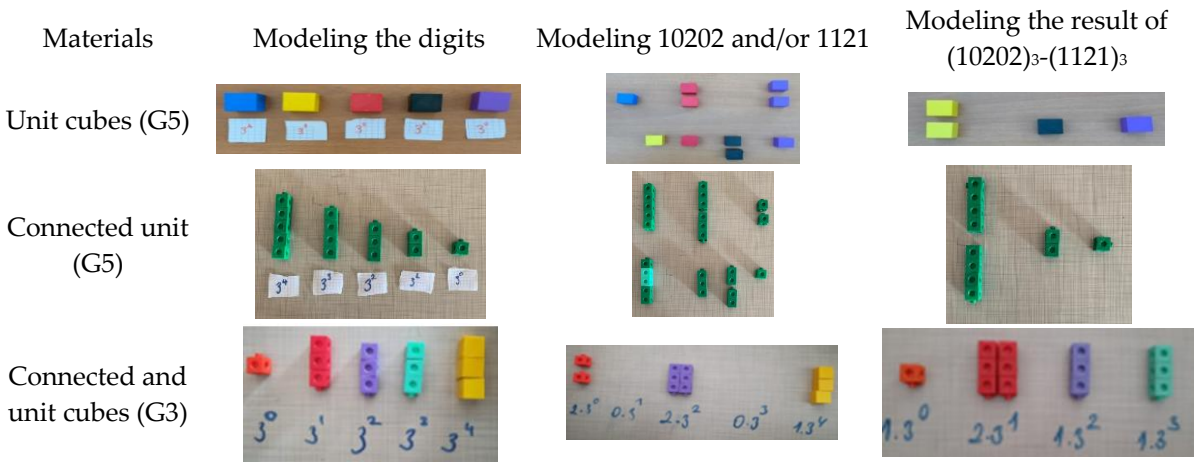


Figure 19. Non-proportional modeling through unit cubes and connected unit cubes

Utilizing mix model in the base 3. Only Group G4 used this model for subtraction in base 3. Accordingly, in Figure 20, it can be observed that students represented the ones place and threes place for numbers 3^0, 3^1 and 3^2, respectively, using an equal number of unit cubes and connected unit cubes, which correspond to the equivalents of 1, 3 and 9. For numbers 3^3 and 3^4, they accepted the use of base ten blocks corresponding to 100 and 1000, selecting a kind of non-proportional material to represent these numbers:

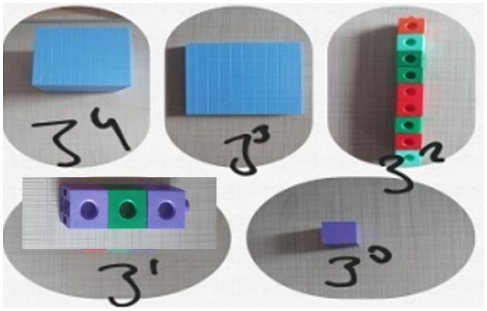
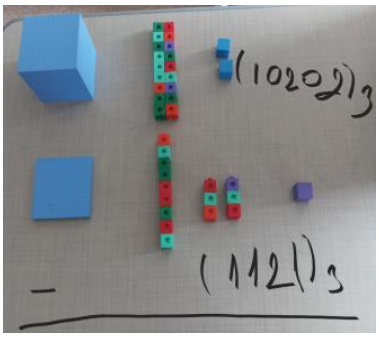
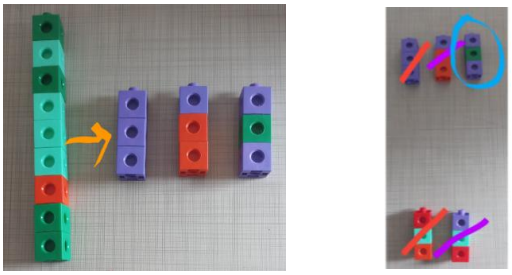


Figure 20. Assigning values of digits with mix model approach through base ten blocks and connected unit cubes (G4)

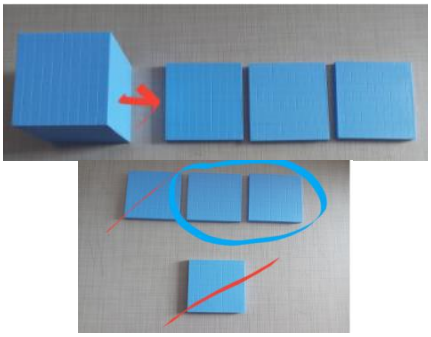
G4 wrote down the number representations and performed the necessary exchanges to carry out the subtraction operation, based on the representations shown in Figure 21.



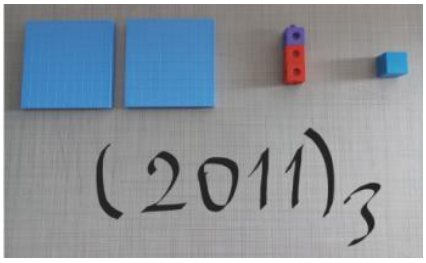
a. Representing 10202-1121 in Base 3



b. Transforming 3^2 to three 3^1 and making subtraction



c. Transforming 3^4 to three 3^3 and making subtraction



d. Modeling the result of $(10202)_3$-$(1121)_3$

Figure 21. Mix model approach for giving meaning to place value and 10202-1121 (G4)

Discussion and Conclusion

The aim of this study is to examine how prospective teachers conceptualize the place value concept in different number bases and how they utilize concrete materials in this process. The finding of the study that prospective middle school mathematics teachers (PMTs) used concrete materials to represent place value through both proportional and non-proportional models aligns with existing research on the importance of multiple representations in mathematics education, demonstrating that such representations support conceptual understanding. Multiple representations offer learners different perspectives on a mathematical concept, helping them develop a deeper understanding and make connections between different ideas (Lesh et al., 1987). In the context of place value, concrete materials can serve as a complementary, tangible representation that makes the concept more accessible to learners, in addition to more abstract models (Fuson & Briars, 1990; McNeil & Jarvin, 2007; Moyer, 2001). Accordingly, one of the main findings of the study is that prospective teachers not only used proportional and non-proportional models, as described in the literature (Van de Walle et al., 2018), but also structured their understanding of place value through a hybrid model. It can be said that the use of the hybrid model emerged as a particularly effective strategy for PMTs, as it allowed them to take advantage of the strengths of both proportional and non-proportional models for representing place value. It can be argued that PMTs were able to deepen their understanding of place value and develop a more flexible approach to problem-solving by starting with one model and then transitioning to another. This further demonstrates the ability of PMTs to adapt and refine their understanding of place value.

The findings of the study reveal those prospective teachers (PMTs) experienced difficulties in maintaining a diversity of materials across different base systems. This issue may stem from the PMTs' lack of sufficient experience in selecting and utilizing appropriate materials. Although concrete materials can enhance students' understanding of mathematical concepts, when these materials are not appropriately chosen the process of conceptual understanding can become complex and challenging for students (Carbonneau et al., 2013; Moyer, 2001). Although working with base systems posed challenges

for PMTs, it can be argued that these challenges contributed to the expansion of their mental schemas regarding number systems. In this context, the inability of PMTs to maintain material diversity regardless of the base system highlights the difficulties they face in the process of constructing mathematical meaning. This situation underscores the need for PMTs to further develop their pedagogical content knowledge and material usage skills (Ball et al., 2008; Shulman, 1987).

Findings of the study showed that algebra tiles, wooden sticks, and geometry strips were the least preferred concrete materials by the groups for representing place value whereas unit cubes, connected unit cubes, and base ten blocks were the most frequently chosen materials. Among these materials, base ten blocks were the only material used across all different bases. The preference for base ten blocks can be attributed to their explicit representation of place value relationships. The different sizes of the blocks (units, rods, flats, etc.) directly correspond to the place values in the base-10 system, making it easier for learners to visualize and understand the concept (Hiebert & Wearne, 1992; Ross, 1989). Algebra tiles, wooden sticks, and geometry strips might have been less preferred due to their lack of an explicit connection to place value. These materials can be more versatile for various mathematical concepts (Clements, 2000), but they may not be as immediately recognizable as base ten blocks when representing place value. The versatility of base ten blocks is likely a key factor in their widespread use across different bases. These materials can be adapted to represent different place value systems, making them a valuable tool for teaching place value in various contexts (Fuson & Briars, 1990).

Algebra tiles were exclusively used in mixed modeling by only one group for addition (in base 10 and base 6) and subtraction (in base 3). In the addition operation conducted in base 10, proportional modeling was applied only between the hundreds and thousands place values, while non-proportional representation was utilized for the other place values. Similarly, in base 6, although a proportional approach was initially adopted, the multiplicative relationship was reflected in the manipulative only between the 6^2 and 6^3 place values. This suggests that the group initially intended to use proportional modeling but, due to the lack of appropriate materials, adopted algebra tiles as a proportional tool across different place values, thus creating a mixed model. Therefore, the use of a mixed model through algebra tiles likely originated from an attempt to implement proportional modeling. The geometric shapes of algebra tiles presented a challenge in representing the proportional relationship between the hundreds and thousands place values. While algebra tiles, with their square and rectangular shapes, are effective for emphasizing the concept of area and facilitating students' understanding of algebraic expressions by allowing them to visualize, manipulate, and relate concrete and symbolic representations (Çaylan, 2018; Okpube, 2016), they may not always clearly convey the proportional relationships between different place values.

Another way in which the mixed model was utilized was through the use of base ten blocks, connected unit cubes, and unit cubes in the base three system. Here, a proportional relationship was established between 3^0, 3^1, and 3^2, while a pseudo-proportional relationship was formed between 3^2, 3^3, and 3^4. Thus, similar to the previous use in the base six system, the mixed model draws from proportional modeling. Although there were enough interlocking unit cubes or unit cubes to represent proportions numerically, prospective teachers found it appropriate to use the geometric shapes of base ten blocks and algebra tiles to establish the multiplicative relationship between place values in two-dimensional and three-dimensional forms. Consequently, the design of base ten blocks may have paved the way for the adaptation to algebra tiles in representing place value.

Limitations and Recommendations

The sample of 24 junior prospective mathematics teachers might not be representative of the entire population of prospective mathematics teachers, potentially limiting the generalizability of the findings. The study was conducted in Turkey, and the findings might not be applicable to other regions or countries with different educational systems or cultural contexts. The fact that participants completed the activity in groups might affect the individual contributions and understanding of place value, making it difficult to assess individual learning outcomes. The four-week duration of the study might not have been sufficient to observe long-term changes in place value understanding. While the math laboratory provided a variety of concrete materials, the availability of these materials might have been limited, affecting the participants' choices and experiences.

By incorporating concrete materials into this activity, it may have provided prospective teachers with an opportunity for a deeper understanding of place value, similar to research studies that encourage the exploration of arithmetic operations in different bases using number line models (Roy, 2014) or contextual situations (McClain, 2009; Yackel et al., 2007). In line with these findings, activities that support prospective teachers' conceptual thinking in understanding and explaining mathematics without relying on memorization can be developed to facilitate their learning.

Considering the limitations and advantages of concrete materials, prospective teachers can be given the opportunity to express their thoughts using correct mathematical language. In this way, prospective teachers can be enabled to implement concrete material usage in their future classrooms with a deeper awareness. During this process, inquiries about the mathematical use of concrete materials can be conducted in mathematics education courses at the university level in teaching methods courses in mathematics education departments. To encourage prospective teachers for representing place value with more than one concrete material can be helpful for meaningful understanding. Considering that even adults seek help in making sense of unfamiliar situations without concrete representation, supporting the use of concrete materials by prospective teachers in mathematically focused topics can be beneficial.

We recommend that it is useful to provide concept-specific horizon content knowledge support to PMTs in order to support them in having a broader perspective on the mathematics they learn. We hope that this study, in which we reveal and support horizon content knowledge structuring as place value, will be an inspiration for knowledge structuring of other mathematical concepts. In this context, having prospective teachers explore the concept of place value through concrete materials not only facilitates their deep understanding of this crucial concept but also aids in developing strategies for effectively teaching it to students.

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Original Article

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Teacher's conceptualizations of different meanings of pure imaginary numbers *

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Abstract

This study examined in-service teachers' understanding of the pure imaginary number ib, particularly in its Cartesian form. This study was part of a broader design-based research study, which involved the development of a professional development (PD) program aimed at exploring five in-service teachers' understanding of various forms of complex numbers. Data collection included pre- and post-written sessions along with interviews after the PDs. Data pointed to change in teachers' conceptualization of i where some could not reason algebraically or geometrically initially. Upon completion of the PD, however, all participants identified i as one of the roots of the quadratic equation, $x^2 + 1 = 0$ and were able to represent it geometrically as the point (0, 1) on the Complex plane. Additionally, all participants recognized the operator interpretation of i as a 90-degree rotation. One participant also noted dilation meaning of b when multiplied with i and another participant reasoned on the repeated addition meaning. The results further highlighted specific challenges teachers faced in conceptualizing the pure imaginary number. Collectively, the results underscore the importance of addressing the pure imaginary part of the Cartesian form and the operator meanings of complex numbers in teacher education. Furthermore, these results suggest that quantitative reasoning could serve as a foundational way of thinking for making sense of complex numbers, including the unit i.

Keywords

Cartesian form of Complex numbers

Teacher knowledge

Quantitative reasoning

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Introduction

School curricula at different levels require working with different types of number systems as understanding the relationships between these systems is essential (CCSM, 2010). Among these, the complex number system is the most comprehensive, since it extends the real number system. The significance of complex numbers spans mathematics, physics, engineering, and various applied fields, making them a particularly important topic in science, technology, engineering, and mathematics (STEM) education. In particular, complex numbers are crucial in the learning of advanced mathematics and physics topics as well as in the learning of concepts of different fields of engineering including quantum physics (Karam, 2020), relativity, electromagnetic theory, signal processing (Atmaca et al., 2014), hydrodynamics and electrical circuits (Benítez et al., 2013). Therefore, a robust conception of complex numbers has an important role in both accessing to and being successful in interdisciplinary fields (Anevska et al., 2015).

In literature, it is argued that a comprehensive understanding of complex numbers requires interpreting them both geometrically and algebraically. Geometrically, a complex number can be viewed as a point on the Complex plane or as a vector (Fauconnier & Turner, 2002). Algebraically, it is an expression in the form $a + ib$ that "should be conceptualized as one number, i.e., the expression $a + ib$ is a single entity combining a real number and an imaginary number" (Nordlander & Nordlander, 2012, p. 633). According to Sfard (1991), complex numbers can be considered as mathematical objects within a well-defined set where all elements share a common structure. Some researchers point to the challenges students face in conceptualizing complex numbers. Glas (1998) suggests that complex numbers often appear to be formal, abstract constructs to students that lack intuitive meaning or connection to real-world experiences. This abstraction can make it difficult for students to visualize complex numbers or understand their practical relevance. Nordlander and Nordlander (2012) further note that students frequently question the real-life applicability of complex numbers and struggle to grasp what they represent. To address these difficulties, researchers emphasize that students have a need to see the imaginary unit to consider any number as a complex number. Therefore, developing a meaningful comprehension of the Cartesian form, particularly the pure imaginary component, is crucial. In this paper, we specifically focus on teachers' conceptualization of the different meanings of the pure imaginary component within the Cartesian form.

Sfard (1991) argued that conceptualizing complex numbers requires a person firstly to recognize that $i = \sqrt{-1}$, in the Cartesian form. Kontorovich (2018a) further stated that the radical sign $\sqrt{}$ "…initiates polysemy-a phenomenon in which the same concept or symbol can be interpreted in discrepant manners depending on the context in which they are used and on the curricular norms associated with the context" (p. 17). For instance, in the field of real numbers, $\sqrt{9}$ is equal to 3, aligning with the definition of a function where each input has a unique output. In contrast, within the complex number system, the square root becomes a multi-valued function and both -3 and 3 are considered to be roots of 9 (Kontorovich, 2018b). In this regard, scholars argue that i must be comprehended as one of the square roots of (-1), requiring a shift in the classroom discourse where the expression '$\sqrt{-1}$ is not a number' no longer holds (Nachlieli & Elbaum-Cohen, 2021). Furthermore, conceptualizing of i as a vector and a point $(0, 1)$ is essential (e.g., Karakok et al., 2015). This geometric interpretation connects also the unit i with the ib component of the Cartesian form, where b is any real number. Particularly, conceptualizing ib as the multiplication of i with a real number can lead to interpretation of i "as a rotation of the real line through 90°" (Harding & Engelbrecht, 2007, p. 967), which produces Complex plane. This perspective further clarifies that real numbers are a subset of complex numbers and points the isomorphism between the Complex plane and the Cartesian plane, which can lead to an understanding as complementary rather than conflicting representations (Kontorovich et al., 2021). Therefore, researchers suggest that it is beneficial for both students and teachers to flexibly shift between these geometric and algebraic interpretations (Kontorovich et al., 2021).

Mathematics teachers are key figures in educating students who need to understand complex numbers, especially in STEM-related fields (NCTM, 2000). In this regard, we investigated teachers' different conceptualizations of i and ib both algebraically and geometrically before and after the completion of a PD study. This study contributes to the literature in the following ways.

First, there are few studies on the conceptualization of pure imaginary numbers. However, for example, a study on teachers' conceptualization of different forms of complex numbers revealed that teachers had difficulty in making sense of pure imaginary numbers as both points and vectors (Karakok et al., 2015). Researchers also reported that teachers merely considered complex numbers as algebraic manipulations done with i. In addition, some eminent researchers have theoretically discussed the construction of the Cartesian form of complex numbers (e.g., Harel, 2013; Sfard, 1991) and examined it from an algebraic point of view (e.g., Nordlander & Nordlander, 2012; Panaoura et al., 2006). Also, in a previous study (Karagöz Akar et al., 2023b) working with the same teachers in the same PD, we reported on only the preliminary results after the completion of the study. In addition, we mostly discussed teachers' dwelling on real number concepts while reasoning with multiplication of i with real numbers, concluding a biased reasoning with complex numbers. Regarding the data on teachers' biased reasoning, in this study, providing a detailed analysis, we elaborated on and explicated further reasons as to how teachers might have the complex number bias.

Secondly, deviating from all the aforementioned research, in this study, we not only reported on data before and after the PD providing a development on the teachers' different conceptualizations of i and ib but also on their difficulties. Here, contributing further to the field, we specifically reported on the changes in teachers' conceptualization of i as one of the roots of $x^2 + 1 = 0$ both algebraically and geometrically before and after the PD, which was regarded as an important step in understanding complex numbers (Sfard, 1991) and was reported as a missing knowledge base of high-school students (Kontorovich, 2018b; Nachlieli & Elbaum-Cohen, 2021). Also, comparing data from different teachers, we reported on the meanings of ib as rotation operator, dilation operator and repeated addition of multiplication.

Third, the meaning that teachers attributed to the units of i and ib both as vectors and points in the complex plane was examined from a quantitative reasoning perspective. Finally, previous studies emphasized that complex numbers historically emerged from mathematicians' consideration of the roots of cubic polynomials (e.g., Harel, 2013; Nahin, 2010). In this study, examining complex numbers as roots of quadratic equations through quantitative reasoning supports the statement that "complex numbers are the only roots that any polynomial equation has!" (Harel, 2013, p. 35) and is consistent with the Fundamental Theorem of Algebra. In the following section, we elaborate on how we extend the field further and how we envision complex numbers through the lenses of quantitative reasoning.

Conceptual Framework

Literature on Complex Numbers

A comprehensive understanding of complex numbers requires knowledge of algebraic and geometric representations (see Table 1) across Cartesian, polar and exponential forms. This understanding also involves recognizing the connections between these representations and having the flexibility to transition among them (Karakok et al., 2015).

Table 1. Representations of Different Forms of Complex Numbers (Reproduced from Karakok et al., 2015, p.329).

Representation	Form			
	Purely imaginary	**Cartesian**	**Polar**	**Exponential**
Algebraic	$i, \sqrt{-1}$, (0,1)	$a+ib, (a,b), z$	$r(\cos\theta + i\ \sin\theta), z$	$re^{i\theta}$
Geometric	A point on the complex plane, a rotation operator	A point on the complex plane, a vector with a magnitude of $\sqrt{a^2+b^2}$ and an angle of $\tan^{-1}(\frac{a}{b})$ with the positive real axis, a rotation and dilation operator	A point on the circle centered at the origin with radius r, a vector with magnitude of r and an angle of θ with the positive real axis, a rotation and dilation operator	A vector with magnitude of r and an angle of θ with the positive real axis, a point on the circle centered at the origin with radius r, a rotation and dilation operator

However, existing research highlights the challenges that both students (Çelik & Özdemir, 2011; Nordlander & Nordlander, 2012; Panaoura et al., 2006; Soto-Johnson & Troup, 2014) and mathematics teachers face when working with complex numbers. Specifically, several studies report that teachers often struggle to establish connections between different representations (Conner et al., 2007; Karakok et al., 2015; Nemirovsky et al., 2012). This has led researchers to emphasize the importance of integrating both algebraic and geometric perspectives when teaching and learning complex numbers.

Soto-Johnson and Troup (2014) investigated how mathematics majors reason algebraically and geometrically about complex-valued equations. Their findings revealed that students predominantly relied on algebraic reasoning. However, when explicitly prompted to consider the geometric aspects of the equations, they were able to engage with these perspectives effectively. Therefore, authors concluded that encouraging students to reason both geometrically and algebraically fosters a deeper integration of the two forms of reasoning (Soto-Johnson & Troup, 2014). Similarly, Nordlander and Nordlander (2012) conducted a study involving engineering undergraduates and high school students and found that many students struggled to grasp the fundamental nature of complex numbers—specifically, the idea that any number can be considered a complex number. The researchers argued that making the imaginary unit i explicitly visible is crucial for helping students conceptualize numbers as part of the complex system (Nordlander & Nordlander, 2012). In another study, Nachlieli and Elbaum-Cohen (2021) explored twelfth-grade secondary school students' understanding of complex numbers. They emphasized that a critical aspect of this understanding involves recognizing that "..the word number also signifies objects of the type $a+ib$, where a and b are real numbers, and i is one of the square roots of (-1)..." (p. 5). Their findings suggest that when teachers actively question and prompt students to engage in reflective and investigative thinking, it can facilitate a discursive shift from real to complex numbers, allowing students to reason about these numbers in both algebraic and geometric terms. Further supporting these observations, Panaoura et al. (2006) found that secondary school students tend to view the algebraic and geometric representations of complex numbers as separate entities rather than as alternative forms of the same mathematical object. The researchers suggested that this difficulty may stem from the way complex numbers are typically introduced, with minimal emphasis on visual or geometric interpretations (Panaoura et al., 2006).

Research on secondary mathematics teachers (Conner et al., 2007; Karakok et al., 2015) has also highlighted challenges in their conceptualization of complex numbers, particularly regarding the Cartesian, polar, and exponential forms. In a study with three in-service teachers, Karakok et al. (2015) found that one teacher struggled to visualize complex numbers as points on the Complex plane. For instance, when asked to represent i geometrically, the teacher was uncertain whether it was located one unit above the origin. Another teacher viewed i merely as a symbol and described complex numbers in

terms of algebraic manipulations involving i. Both teachers also experienced difficulty in connecting the vector representation to the Cartesian form. These findings suggest that the teachers primarily perceived complex numbers through algebraic operations rather than through their geometric interpretations. Similarly, prospective teachers faced challenges in making connections between complex numbers and their roots of quadratic equations (Conner et al., 2007). In another study, Nemirovsky et al. (2012) investigated prospective secondary mathematics teachers' geometric reasoning about complex numbers. By using a physical classroom floor setting, they encouraged teachers to explore the geometric meaning of addition and multiplication of complex numbers. This hands-on approach enabled the participants to conceptualize multiplication by i as a 90-degree rotation on the Complex plane. Building on these findings, Saraç (2016) worked with a prospective secondary mathematics teacher and examined how she developed the Cartesian form of complex numbers through quantitative reasoning. The results revealed that the participant successfully conceptualized complex numbers as a single entity within a well-defined set—specifically, as the roots of any quadratic equation with real coefficients. Notably, contrary to Karakok et al.'s (2015) findings, this prospective teacher accurately identified i as the point (0,1) on the Complex plane (Saraç & Karagöz Akar, 2017).

In addition to these studies, researchers have suggested several instructional approaches to enhance students' understanding of complex numbers. For example, Edwards et al. (2021) proposed using 3D graphical representations to visualize the complex zeros of a quadratic function. Murray (2018) recommended employing geometric transformations, specifically using reflections from the vertex of a quadratic function, to help learners distinguish between real and non-real (imaginary) roots. Other studies emphasize the value of digital tools such as Computer Algebra Systems (CAS), Computer-Aided Assessment Systems (CAA) (Gaona et al., 2022), and GeoGebra (Caglayan, 2016; Seloane et al., 2023). These technology-based and visual approaches have been shown to improve students' ability to conceptualize complex numbers and to understand the roots of both quadratic and complex equations from a geometric perspective.

The aforementioned studies indicate that teachers and students need to develop a robust understanding of complex numbers paying special attention to the algebraic and geometric meanings of complex numbers, and specifically of the unit i. Although providing important insights, these studies did not specifically focus on the different meanings of pure imaginary numbers. In this study, we report on in-service teachers' conceptualizations of pure imaginary numbers. In addition, we propose that quantitative reasoning might provide a robust thinking process in the development of teachers' conceptions of complex numbers. We do this in the following ways: First, we situate any complex number from the perspective of quantitative reasoning framework (Thompson, 1990, Thompson & Carlson, 2017). With this perspective, in this paper, we consider complex numbers as the quantification of the roots of any quadratic equation with real coefficients (Karagöz Akar, et al., 2024; Karagöz Akar et al., 2023, Karagöz Akar et al., 2023a; Saraç & Karagöz Akar, 2017). In this respect, as recommended in the literature (e.g., Kontorovich, 2018b; Nachlieli & Elbaum-Cohen, 2021), we report on data showing the change in teachers' making sense of i before and after the completion of a PD study. Secondly, situating the meaning of i from the point of view of quantitative reasoning, we elaborate on how vectors could be a mediator for making sense of i as a point. This is especially important as in-service teachers were reported having difficulties in making sense of i both as a point and as a vector (Karakok et al., 2015). In addition, the College Board of Mathematical Sciences (CBMS) emphasized that "complex numbers can fall into the chasm between high school and college, with high school teachers assuming they will be taught in college and college instructors assuming they have been taught in high school" (CBMS, 2012, p. 64). Therefore, reasoning about the pure imaginary numbers from the point of view of quantitative reasoning might provide the field a new lens on top of the conventional way of thinking about them as stated in most of the high school curricula such as "know there is a complex number i such that $i^2 = -1$, and every complex number has the form $a + ib$ with a and b real" (CCSSM, 2010, p. 60). It is in this regard that we scrutinized the following research questions:

1. What are in-service teachers' conceptualizations of i algebraically and geometrically before and after a PD program focusing on quantitative reasoning?
2. What different meanings of ib do teachers have algebraically and geometrically upon completion of a PD program focusing on quantitative reasoning?

In the following section, we explain the constructs of quantitative reasoning and how we conceptualize complex numbers through the lenses of quantitative reasoning.

Quantitative Reasoning

Quantitative reasoning refers to an individual's "analysis of a situation into a quantitative structure" (Thompson, 1990; p. 13). Moore et al. (2009) defined quantitative reasoning further as "…the mental actions of an individual conceiving a situation, constructing quantities of his or her conceived situation, and both developing and reasoning about relationships between these constructed quantities" (p.3). Quantity, quantification, and quantitative structure are paramount notions within quantitative reasoning.

In a person's mind, quantity is a measurable attribute of an object (Thompson, 1990). A person has a mental image of an object and its measurable attributes (qualities) (Thompson, 1994) by explicitly or implicitly conceptualizing an appropriate unit. From this perspective, we understand complex numbers as the union of two quantities as directed distances (Karagöz Akar et al., 2024). This understanding arises from analyzing a mathematical object, such as quadratic functions, and breaking it down into a network of quantities and quantitative relationships, which include the roots and the x-coordinate (abscissa) of the vertex with their distances to each other and from the origin (see Figure 1). The quantitative structure is then viewed as a network of quantities and quantitative relationships, where "quantitative relationship is the conception of three quantities, two of which determines the third by a quantitative operation" (Thompson, 1990, p. 11). Therefore, quantitative operations are mental operations that construct quantities. Quantification refers to the entire process of constructing quantities and quantitative relationships. We further elaborate on how we conceptualize complex numbers connected with quadratic functions through quantitative reasoning as follows.

As Moore et al. (2009) emphasized, conceiving a situation requires envisioning an object and its attributes, such that the mental image "could be an image interpreted from a problem statement or a mathematical object (e.g., a graph)" (Moore et al., 2009, p.3). In this regard, the parabolas located on the coordinate system are the object of thought in this study, with elements such as the roots and the abscissa of the vertex having measurable properties. That is, given any quadratic equation $ax^2 + bx + c = 0$ with real coefficients; two roots of the quadratic equation are of the form $x_{1,2} = \frac{-b \mp \sqrt{b^2-4ac}}{2a}$, where $(b^2 - 4ac)$ is called the discriminant (Δ), $-\frac{b}{2a}$ is the abscissa of the vertex and $(\frac{\sqrt{\Delta}}{2a})$ is the distance from $(-\frac{b}{2a}, 0)$ to the roots on the x-axis (Hedden & Langbauer, 2003). $\frac{\sqrt{\Delta}}{2a}$ is regarded as a quantity whenever the learner evaluates the measure of the distance between the abscissa of the vertex and the roots. Similarly, whenever a person evaluates the distances of the roots to the origin, the roots are also considered a quantity.

In this paper, we contend that such a conception of quadratic roots could promote the notion that complex numbers are the roots of quadratic equations with real coefficients, members of a well-defined set (Sfard, 1991). For this we dwell on two main constructs of quantitative reasoning, namely covariation and multiplicative object (Thompson et al., 2017) in the following way.

First of all, algebraically, "we know that all complex numbers have the form $x + iy$, where x and y are real numbers. Real numbers being all those numbers which are positive, negative, or zero" (Panaoura et al., 2006, p. 683). We also consider algebraic representations such as $x + iy$, (x, y), and z and geometric representations such as a point on the complex plane (Karakok et al., 2015). Then, given any complex number, $z = x + iy$, one can assign meanings to x and y such that x refers to $-\frac{b}{2a}$ algebraically and the abscissa of the vertex of any quadratic function geometrically; and y refers to $\frac{\sqrt{-\Delta}}{2a}$ algebraically and the distances of the roots to $(-\frac{b}{2a}, 0)$ geometrically (see Figure 1). Saldanha and Thompson (1998) defined the notion of covariation as someone's "…holding in mind a sustained image of two quantities' values (magnitudes) simultaneously" (p. 299). Then, the notion of a multiplicative object builds on a person's image of the covariation of quantities where a person conceives a multiplicative object such that she "… tracks either quantity's magnitude with the immediate, explicit, and persistent realization that, at every moment, the other quantity (quantities) also has (have) a magnitude(s)" (Stevens, 2019, p. 42). Thus, a person might decompose the quadratic formula and think of x_1 and x_2 considering $\frac{-b}{2a}$ as the x-coordinate of-the-vertex (as well as the symmetry axis), and its distance to the roots, $\frac{\sqrt{\Delta}}{2a}$ located on the real number line (see figure 1). Considering the x coordinate of the-vertex with its distance to the origin and its distance to the roots is then a quantity in the mind of an individual (see Figure 1). Thus, one might conceive the roots of any quadratic equation as a quantity, having a distance to the origin and a distance to the x coordinate of the vertex (i.e., $\frac{\sqrt{\Delta}}{2a}$). In other words, on can conceive three quantities: 1) the distances of the roots and the x-coordinate of the vertex to the origin and 2) the roots' distances to the x-coordinate of the vertex. Then, quantitative relationships among these quantities entail envisioning how the roots and the x-coordinate of the vertex are positioned on the number line as a point and as distances related to each other.

Thus, from the notion of multiplicative object, one might consider that the ordered pair (x, y) or $(-\frac{b}{2a}, \frac{\sqrt{-\Delta}}{2a})$ is a single entity with two components that combines the magnitudes of two quantities simultaneously (Thompson et al., 2017), where each point is an element of the set of roots of any quadratic equation with real-coefficients. In this regard, we consider complex numbers quantitatively as a measure of the distance of roots (i.e., all the possible roots of quadratic equations) from the origin on the Complex plane.

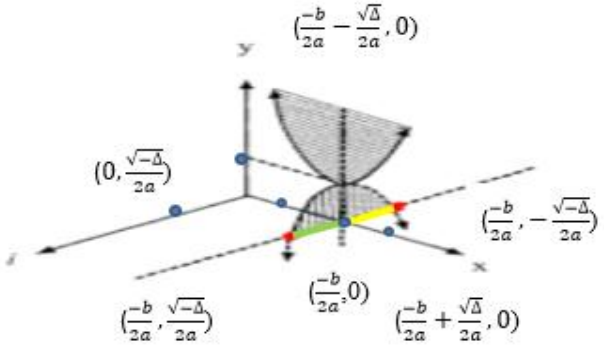


Figure 1. Locating all the roots of a quadratic equation with real coefficients on the plane (Modified from Melliger, 2007)

In this structure, one can also conceive one part of the formula, $\sqrt{-1}\frac{\sqrt{-\Delta}}{2a}$ in two ways: She can envision $\sqrt{-1}$ as one of the roots of $x^2 + 1 = 0$ and assign a numerical value to $\frac{\sqrt{-\Delta}}{2a}$ as 1, considering that the other part of the formula, $\frac{-b}{2a}$, is zero. This might further enable to think of the geometric meaning of $\sqrt{-1}$ as referring to $(0, 1)$ on the imaginary axis with one unit distance above the origin. This image

has the potential to trigger an understanding of $\sqrt{-1}$ as a multiplier and $\frac{\sqrt{-\Delta}}{2a}$ as a multiplicand since $\sqrt{-1}$ can be considered as 90 degrees (i.e., a *rotation operator*) counter-clockwise rotation of any real number of the form $(\frac{\sqrt{-\Delta}}{2a}, 0)$ and locating them on the imaginary axis as $(0, \frac{\sqrt{-\Delta}}{2a})$. This image also aligns with what Descartes considered: superimposing the real line onto itself, turning all the points 90 degrees, which would yield the coordinate plane (R^2) (Fauconnier & Turner, 2002). This image can further afford thinking of $\frac{\sqrt{-\Delta}}{2a}$ as a multiplier (the operator) and $\sqrt{-1}$ as a multiplicand as the person knows that $\frac{\sqrt{-\Delta}}{2a}$ is a real number. As stated previously, it is essential to simultaneously consider the algebraic and geometric meanings of complex numbers in order to comprehend any form of complex numbers.

Method

This study is part of a design-based research (DBR) that aimed at enhancing teachers' content knowledge of complex numbers through a PD study. We carried out classroom teaching experiments, followed by a multi-case study (Yin, 2014). In this paper, we present the findings from the multi-case study, emphasizing teachers' existing knowledge base related to their different meanings of the pure imaginary number before and upon completing the PD.

Participants and Data Collection Process

This study involved five secondary school mathematics teachers with 2 to 10 years of teaching experience and degrees in secondary mathematics education. The selection process began with ten teachers completing an open-ended written assessment on complex numbers (pre-written session). In this session, participants were asked to provide algebraic and geometric definitions of quadratic functions and equations, different representations of complex numbers, and vectors. Based on our analysis of their responses, eight participants were purposefully selected according to their background knowledge aligned with the pedagogical goals of our study (Simon, 2000): 1) They demonstrated knowledge of quadratic functions and the definition and expression of vectors. 2) They either did not mention complex numbers in the Cartesian, polar, or Euler forms, or did not explain the relationships between these representations. Nevertheless, five participants declared their availability to attend the study.

As shown in Table 2, the study included four teaching sessions, each lasting between 120 and 150 minutes.

Table 2. Data Collection Procedure

Sessions	**Focus of the Sessions**
Pre-written session	Analysis of participants' background knowledge
PD session 1	Cartesian form, graphs of and distances within different parabolas
PD session 2	Cartesian form and geometric representation of complex numbers
PD session 3	Definition and properties of vectors and polar form of complex numbers
PD session 4	The Euler form of complex numbers
Post-written session	Analysis of participants' current knowledge
Semi-structured interviews	The participants' current conceptualization of the connections among different forms of complex numbers (30-45 min.)

The first two sessions focused on examining the Cartesian form of complex numbers in relation to quadratic equations through quantitative reasoning (Saraç & Karagöz Akar, 2017). The third session covered the polar form, while the final session addressed the Euler form.

In the context of DBR investigations, the focus was on the theory of quantitative reasoning by examining complex numbers within a quantitative structure. In this structure, complex numbers are understood as a union of two quantities, which are directed distances and are the roots of any quadratic equation with real coefficients. After the participants came to a definition of complex numbers in relation with the roots of any quadratic equation with real coefficients and located them as points on

the Complex plane (see figure 1) in PD session 2, specific to the pure imaginary numbers in PD session 3, we asked them to consider the definition of a vector and then think about the qualities of the located points. Once they considered these issues, they could justify how they could think of complex numbers as vectors. At this point, we asked them to evaluate the roots of the equation, $x^2 + 1 = 0$, in terms of the components of the roots of any quadratic equation, namely, $\frac{-b}{2a}$ and $\frac{\sqrt{-\Delta}}{2a}$. They evaluated that numerically $\frac{-b}{2a}$ was equal to 0 and $\frac{\sqrt{-\Delta}}{2a}$ was equal to 1. Given their knowledge of the fact that complex numbers could be represented as vectors with quantities of distances to the origin and with angle measures to the horizontal axis, this allowed them to further conceive that i can be represented as a vector and a point (0, 1) on the Complex plane.

After the PD sessions ended, a post-written session was conducted. Then, the first author, who also facilitated the PD, carried out video-recorded semi-structured interviews to gather data on how participants understood the connections among different forms of complex numbers. The interviews lasted between 30 and 45 minutes. Additionally, participants' written artifacts were collected. Regarding the meaning of i, the pre and the post-written sessions included the following questions "Could you explain what the number i is? Could you show it on the complex plane? Please algebraically and geometrically explain i^2. Justify your answer." Also, in the post-interview, a sample of questions were "How can we represent i geometrically? How do we express i squared (i^2) algebraically? How do we express it geometrically? The multiplication of i and square root minus delta over two a, ($i.\frac{\sqrt{-\Delta}}{2a}$) where is that number on the Complex plane?"

Data Analysis

For data analysis, we employed the constant comparative method (Clement, 2000). The research team collectively reviewed the participants' written responses and transcripts of all interviews, and we watched video recordings when necessary to identify and characterize how teachers conceptualize complex numbers both algebraically and geometrically. Each participant's statements in the transcripts, which ranged from a single sentence to an entire paragraph for each interview question, served as our units of analysis. We conducted the analysis using the premises of quantitative reasoning. Specifically, we focused on how teachers understood complex numbers quantitatively, such as representing a complex number i as one unit distance from the origin, and how they explained its meaning as an operator. We first analyzed the data for each participant individually and then examined the responses to each question across different participants. We created narratives that illustrated how participants conceptualized complex numbers i and ib through quantitative reasoning, comparing and highlighting the similarities and differences in their thought processes.

Results

In the following sections, first we provide results from pre-and post-written sessions related to the different conceptualizations of i which include the definition and geometric representations (See Table 3). Then, we share data from the interview regarding one of the participant's difficulty in locating i on the Complex plane. We also provide data on teachers' responses on the algebraic and geometric meanings of the powers of i before and after the PD. Additionally, we share data on two participants' handling the complex number bias. We finalize this section by presenting different meanings of ib and i with the examples from interview data.

Defining and Representing i as a Point on the Complex Plane

All the teachers could define *i* in the following ways before and after PD as indicated in Table 3.

Table 3. Teachers' Responses Regarding Definition and Geometric Meaning of *i* Before and After PD

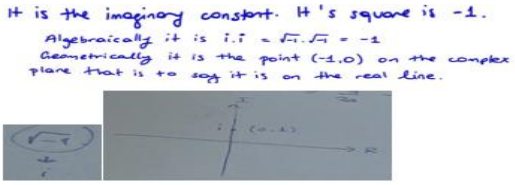
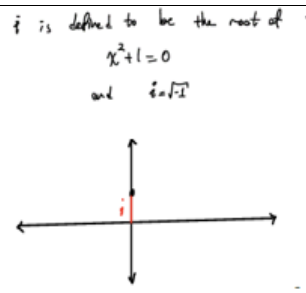
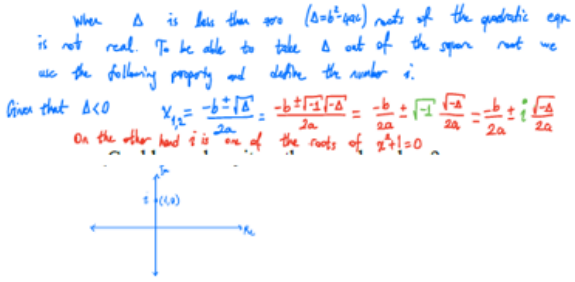
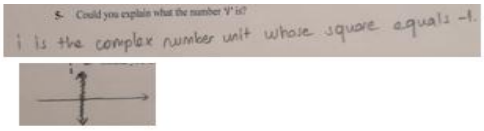
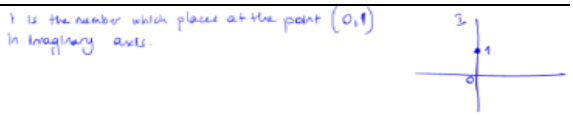
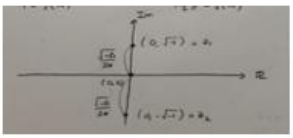
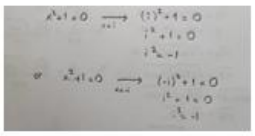
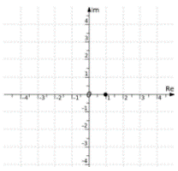
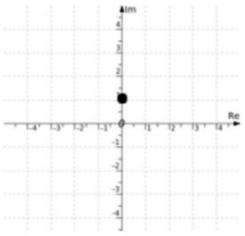
	Before PD	After PD
T1		
T2		
T3		
T4	*i* is an imaginary number which equal to $\sqrt{-1}$. In other words, its square $i^2=-1$. When the complex numbers are shown in the complex plane x-axis represents the real part and the y-axis represents the complex part. "i" is the square root of -1. In the complex plane that has a one-unit distance from the origin on the y-axis is the place of "i".	"i" and its conjugate "-i" are the roots of the quadratic equation $x^2+1=0$. In the complex plane, these two complex numbers indicate the point that $\sqrt{-1}$ unit distance from the abscissa of the vertex (x=-b/2a) which has the value 0.  

Table 3. Continued

	Before PD	After PD
T5	In real numbers set, square roots of negative numbers cannot be defined because there are no real numbers whose squares are negative. To define them, square root of -1 is defined as imaginary. a. Could you show it on the complex plane? Real part is 0 and the imaginary part is 1. 	The number "i" is one of the roots of quadratic equation $x^2 + 1 = 0$. In real numbers set, square roots of negative numbers cannot be defined because there are no real numbers whose squares are negative. Square root of -1 is defined as imaginary number. a. Could you show it on the complex plane? The number "i" is a complex number where the real part is 0 and the imaginary part is 1. This is how we show it on complex plane: 

As the table indicated, before the PD, all the teachers either defined i as $\sqrt{-1}$ or $i^2 = -1$. Only, T2 pointed to i as the root of the quadratic equation, $x^2 + 1 = 0$. Also, data showed that three of the teachers geometrically pointed to i on the complex plane. In addition, T4 and T5 pointed to the fact that geometrically i is one unit from the origin on the imaginary axis.

On the other hand, after the PD, in their answers in the post-written session, T2, T4 and T5 not only stated that i is one of the roots of the quadratic equation, $x^2 + 1 = 0$ but also could consider $i = \sqrt{-1}$. However, T3, provided the following definition i is the number which places at the point $(0, 1)$ in the imaginary axis". It is important to point that teachers' use of the expression "one of the roots…" together with data on how they located i on the complex plane as (0,1) has merit as teachers need to know that although we accept $\sqrt{-1}$ as the principle root, - $\sqrt{-1}$ is also another root of $x^2 + 1 = 0$. This was specifically shown in T4's written statement such as "i and its conjugate - i".

Similarly, regarding the geometric representation of i, all the teachers except T4 could locate i as a point $(0, 1)$ on the Complex plane. Compared to the data before PD, participants' use of $(0, 1)$ to show i on the complex plane indicated a development on their part. However, T4 wrote $(0, \sqrt{-1})$ and stated that $(0, \sqrt{-1})$ points to $\sqrt{-1}$ unit distance on the imaginary axis. So, we further inquired how she reasoned about placing i on the complex plane.

A Possible Difficulty About Showing i Geometrically

We now present data on T4's reasoning regarding representation of i on the Complex plane during the post-interview. T4 again defined i as one of the roots of the quadratic equation, $x^2 + 1 = 0$. She also stated that i is the number whose square equals -1 and noted that it is equivalent to $\sqrt{-1}$. In her drawing, T4 first represented i by writing it as $(0, \frac{\sqrt{-\Delta}}{2a})$ and then provided an example. She also labeled the points $3i$ and i on the imaginary axis (see Figure 2):

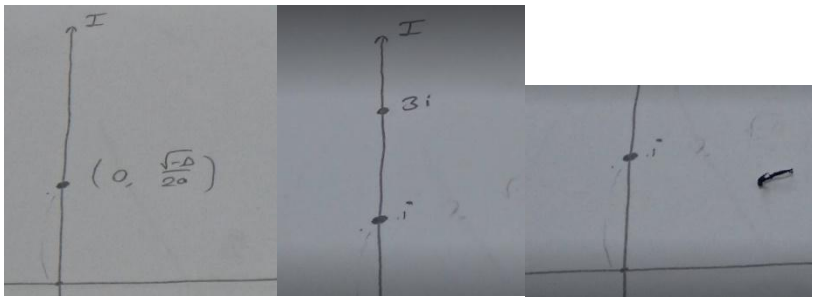


Figure 2. T4's Attempts for Geometric Representation of "i"

Then, hesitantly she questioned if she can use $(0, 3)$ instead of $3i$. She further stated that i was 1 unit above the origin on the imaginary axis.

Discussion continued:

R: Then what happens if you show as a point?

T4: I can't, I don't know, I can't be sure about that $(0, 1)$.

R: Why? You weren't sure about $(0, 3)$ either, were you?

T4: Yes, I wasn't sure about $(0, 3)$ either because we talked about something, for example, we said that we can say $3i$ and i as distance, for example, we couldn't compare them in terms of size. Yes this is 1 unit of distance (referring to the distance between i and the origin) this is 3 units of distance (referring to the distance between $3i$ and the origin in Figure 2) but when I show it as a point, I am not sure if I can write $(0, 3)$ like a coordinate.

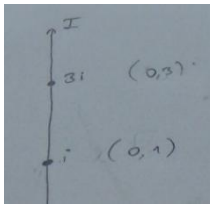


Figure 3. T4 locating i as (0, 1) and $3i$ as (0, 3)

As the data and Figure 2 and Figure 3 indicated, T4 experienced difficulty in representing i as a point on the imaginary axis. She recognized that i was one unit and $3i$ was 3 units above the origin and that they were positioned at specific distances on the imaginary axis. In addition, she understood that in the binomial form, $x+iy$, the first component referred to the real part, $-\frac{b}{2a}$, while the second component referred to the imaginary part, $(\frac{\sqrt{4ac-b^2}}{2a})$ (see Figure 2). She also noted that in the case of i, the first component was equivalent to 0 and the second component was equal to 1 when considering numerical values. However, from the PD discussions, she remembered that complex numbers cannot be ordered in the same way real numbers can. This realization led her to question whether it was feasible to represent i on the imaginary axis as $(0, 1)$, despite knowing it was one unit above the origin, located on a unit circle. Specifically, she contemplated that if she used $(0, 1)$ or $(0, 3)$ for representing i and $3i$ respectively, it would revert back to real numbers, which can indeed be ordered (for example, 1 is smaller than 3). More importantly, she understood that if she used $(0, 1)$ as shown on $\mathbb{R}^2$, to represent i, it might contradict the understanding that complex numbers cannot be ordered. As a result, she was uncertain if she could express $3i$ as $(0, 3)$. She appeared to be thinking that points on the imaginary axis ought to be represented by imaginary symbols.

When prompted to reflect on her earlier drawing of the roots on the Complex plane, T4 recalled that complex numbers can be represented as ordered pairs of real numbers. This realization allowed her to represent the binomial form $x+iy$ as (x, y) on the Complex plane, enabling her to express i as $(0, 1)$. Despite the progress, T4 continued to struggle with comparing the magnitudes of i and $3i$ indicating an

incomplete understanding of the magnitude of complex numbers. A significant observation is that T4's attempts to compare real and complex numbers based on the property of ordering are conceptually invalid when viewed within $\mathbb{R}^2$ and the Complex plane. Unlike the real number system, where numbers can be arranged in an ordered sequence, no such inherent ordering exists in $\mathbb{R}^2$ or the Complex plane. This limited understanding suggests that T4 may be applying familiar real-number concepts inappropriately to the more abstract structure of complex numbers.

Meaning of i and b as Operators

Powers of i Algebraically and Geometrically

We share data both from the pre-written and the post-written session in which the participants were asked to explain i^2 both algebraically and geometrically. Data in Table 4 shows that, in the pre-written session, some teachers' answers pointed that although they could write and state i^2 as equal to -1, they did not know how to show it on the Complex plane geometrically. Particularly, for the geometric meaning of i^2, except T5, they stated "I do not know" or they left it blank. In addition, we considered T1's answer as insufficient as we could not tell if she answered the question or if she explained i both algebraically or geometrically. Contrarily, in the post-written session, all the participants could explain the powers of i algebraically by referring to i as equal to $\sqrt{-1}$. All of them also reasoned that i refers to a 90-degree rotation counter clockwise geometrically.

Table 4. Teachers' Responses Regarding Algebraic and Geometric Meaning of i^2 and powers of i Before and After PD

Expressing powers of 'i'	**Before PD**	**After PD**
Use of algebraic meaning	T1 $i^2 = i.i$ that's why we show it as I did in option a. T2 Please algebraically and geometrically explain i^2. Justify your answ $i = \sqrt{-1}$ $i^2 = \sqrt{-1}.\sqrt{-1}$ $= -1$ T3 I do not know. T4 **Left blank.** T5 **Algebraically,** $i^2 = (\sqrt{-1})^2 = -1$	T1 **Algebraically it is** $i.i = \sqrt{-1}.\sqrt{-1} = -1$ T2 T3 T4 T5 **Algebraically,** $i^2 = (\sqrt{-1})^2 = -1$
Use of operator meaning	T1 **Left blank** T2 Please algebraically and geometrically explain i^2. Justify your answ I don't know T3 I do not know. T4 **Left Blank.** T5 **Geometrically,** $i^2 = -1$ **is a number where imaginary part is 0 and real part is -1. On complex plane, the number will be at -1 on real(x) axis.**	T1 Geometrically it is the point (-1,0) on the complex plane that is to say it is on the real line. T2 T3 T4 T5 **Geometrically,** $i^2 = -1$ **is a number where imaginary part is 0 and real part is -1. On complex plane, the number will be at -1 on real(x) axis.**

Complex Number Bias

During the interview, all participants but T1 provided valid explanations as to how they reasoned both algebraically and geometrically. T1 could mention both the operator and the dilation meanings of multiplication of complex numbers. However, her explanations pointed to complex number bias when reasoning about i algebraically. As exemplary, we also provide data from T5 on her reasoning about i algebraically to further compare it with T1's reasoning.

When asked how they interpreted i^2 in the interview, T5 provided the following explanation:

> T5: Because i was equal to $\sqrt{-1}$. Therefore, the number we called i^2 became$\sqrt{-1}.\sqrt{-1}$. This gave us the number -1. Minus one is a real number. So, if we write this as a complex number, in the format $x + iy$, it becomes 0+, sorry,$-1 + 0i$. That's why I said we can show it as a number, as a point on the x-axis, at a distance of 1 unit form 0, on the left side, the negative side. So, I said directly it will be on the real axis.

As the excerpt showed T5 could state that i^2 is equal to -1. Her statement about the cartesian form of complex numbers, $x + iy$, and corresponding it with $-1 + 0i$, and thinking about -1 as part of the cartesian form algebraically pointed that she not only realized that real numbers are part of complex numbers but also she knew that as a number -1 referred to 1 unit distance from the origin. This further suggested that she could reason about a power of i quantitatively. However, she did not clarify how she understood or derived the equality $\sqrt{(-1)}.\sqrt{(-1)} = -1$ and the researcher did not ask for further explanation. T5's previous statements, where she identified i as the number whose square equals -1, may have influenced her reasoning for writing this equality.

However, T1's explanations about i^2 pointed to complex number bias:

> T1: Let's write (i^2) algebraically. Algebraically, it is multiplying ($\sqrt{-1}.\sqrt{-1}$). Our rules in real numbers are valid here. We can multiply two numbers inside a single root. It becomes ($\sqrt{1}$). So it's one. Um, where do we put it? The result is a real number, so we multiplied two imaginary things, and the answer came out real. Then I'll show on the real (see Figure 4)

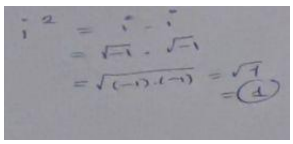


Figure 4. T1 writing about i^2

> That's here somewhere (referring to Figure 5), I'm trying to make these things equal. (i^2) will be at $(1, 0)$ isn't it? Yes. Because (i^2) is positive. I mean, I think that we cannot write (i^2) under it (talking about how to label the point $(1, 0)$) because it is (i^2). This is $(1, 0)$. One minute, (i^2) would be -1, right? My mind is burning now. One minute. I multiplied i with i, that is (i^2). The (i^2) has to be -1. Sorry, it won't be like this. This will be -1.

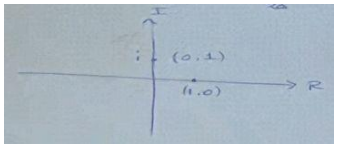


Figure 5. T1 locating i on the Complex plane

As the data showed T1 reasoned with the rules utilized in real numbers such that she considered that $\sqrt{a}.\sqrt{b} = \sqrt{a.b}$ in real numbers also is valid for complex numbers. This suggested that she held complex number bias. This is because, $\sqrt{a}.\sqrt{b} = \sqrt{a.b}$ if a and b are both positive or at least one of them is negative or zero. However, $\sqrt{a}.\sqrt{b} \neq \sqrt{a.b}$ if a and b, both are negative. On the other hand, once she

thought of i as the number whose square is -1, she corrected herself. Discussion got more interesting when the researcher asked how T1 reasoned: she corrected herself by giving an example from real numbers, multiplying $\sqrt{2}$ with $\sqrt{2}$ and concluded that she was wrong in saying that $\sqrt{-1}.\sqrt{-1}$ would be equal to 1. She even commented on i^3 and stated that it would be equal to $(0,-1)$ on the Complex plane. Then the researcher asked:

R: Okay. Can you tell me again why you changed your mind here?

T1: I changed my mind here because of this: This is not a real thing (referring to $\sqrt{-1}$). i is not a negative number. i is something like root negative one (see Figure 6)

That's why I changed my mind. Because if i was the number -1, the square of -1 will come out as 1 anyway. There is no problem there. But this is defined as root -1 anyway, there is no such thing normally. But there are two expressions inside the root. Both are the same. It is like, as if the roots have canceled out each other. So it's like it turned into a square. That's why I changed my mind. 'Cause if I do this it'll be like I'm squaring -1. Then it will be as if I have defined it like this.  But it is not like that 

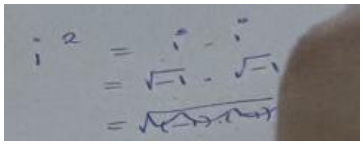


Figure 6. T1's Algebraic Explanation on i^2

Providing an example from real numbers, T1 reasoned that $\sqrt{a}.\sqrt{a} = a$ for any non-negative real number and explained that the result of $\sqrt{(-1)}\sqrt{(-1)} = -1$. However, her explanations still related to the rules held in non-negative real numbers. That is, her explanations were not mathematically valid and she did not provide a legitimate proof. To summarize, T1's explanations indicated that she seemed to think the same properties hold for the radicand in both real and complex numbers.

Different Meanings of "ib"

As we stated earlier, all the participants pointed to multiplying i with i as referring to a 90-degrees counter clockwise rotation after the PD. In this section we provide data from T1 as exemplary for not only to point to how one participant reasoned about the rotation operator but also about the dilation operator meanings of multiplication within complex numbers. It is also necessary to point that as the data below indicated, T1 knew that in the cartesian form of complex numbers, $x + iy$, x referred to $\frac{-b}{2a}$ and y referred to $\frac{\sqrt{-\Delta}}{2a}$. In addition, we provide data from T4 to compare her reasoning to T1's reasoning where T4 seemed to be thinking and transferring the repeated addition understanding of multiplication while reasoning about ib.

Discussion with T1 on the meaning of $\sqrt{-1}.\frac{\sqrt{-\Delta}}{2a}$ followed:

R: This i times $\frac{\sqrt{-\Delta}}{2a}$

T1: Where will it be?

R: What does it correspond to, yeah, where will that number be?

T1: On here (showing a point on imaginary axis). It is on the imaginary axis. It depends on the value of the coefficient. So for instance, if $\frac{\sqrt{-\Delta}}{2a}$ is 3, I'll be pointing at "$3i$". Or like I'll be pointing at $-3i$. It's not a real number (referring to i), but it has a real coefficient. I can say it is getting bigger or smaller according to that. Saying getting bigger or smaller may not be very accurate, as I said, because of the definition of i, it may not be like is i bigger than $3i$, but we can assume its distance as the distance to zero and we can place it (talking about real number times i) Since that is positive, we can place it.

R: Okay. You're telling me… you say that when I multiply it with i, I can place ib here (pointing to the imaginary axis). I'm asking you if you can explain $\frac{\sqrt{-\Delta}}{2a}$ when multiplied with i.

T1 continued her thinking suggesting that she struggled to articulate the geometric meaning of multiplying a real number with i. She even considered that when she multiplied $\frac{\sqrt{-\Delta}}{2a}$ with i, $-\frac{b}{2a}$ was zero and she knew that $\frac{\sqrt{-\Delta}}{2a}i$ was on the imaginary axis. Then, the researcher prompted her twice to explain the meaning of multiplying a real number with i . She then responded:

T1: Okay, for example $\frac{\sqrt{-\Delta}}{2a}$ was on this line (referring to the real axis). Because it was real. When I multiply it with i, shall I say if it rotates, what shall I say? It went this way. It moved to the imaginary axis. It rotated, it rotated. It rotated, from here (meaning the real axis) to here (meaning the imaginary axis). Rotated ninety degrees, yes.

The data revealed that T1 initially interpreted the expression $\sqrt{-1}\frac{\sqrt{-\Delta}}{2a}$ as multiplying i with a real number, focusing on multiplication with a scalar rather than recognizing it as a real number being multiplied with i, which represents a rotation operator. This interpretation may have been influenced by the syntactic structure of the expression, where the order of multiplication symbolically suggests that the real number acts on i. T1 appeared to view $\sqrt{-1}$ as the multiplicand and $\frac{\sqrt{-\Delta}}{2a}$ as the multiplier, implying that the real number scales or dilates i along the imaginary axis. Several factors likely contributed to this understanding. First, during the interview, T1 consistently interpreted the Cartesian form of complex numbers as vectors. She explicitly described i as a unit vector corresponding to (0, 1) and comprehended $\frac{\sqrt{-\Delta}}{2a}$ as a distance from the origin. This vector-based interpretation might have allowed her to position multiples of i as points on the imaginary axis. Second, she referred to $(-\frac{b}{2a})$ as zero and identified $\frac{\sqrt{-\Delta}}{2a}$ as a real number. This suggested that she connected this reasoning to the geometric interpretation of complex roots of quadratic equations, reinforcing her making sense of $\frac{\sqrt{-\Delta}}{2a}$ as a scalar acting on i, dilation meaning of multiplication. On the other hand, the data also indicated that T1 struggled to conceptualize i as a rotation operator. It was only after the researcher explicitly directed her attention to this distinction multiple times that T1 acknowledged the geometric meaning of i as a multiplier. Once prompted, she recognized that multiplying a real number with i rotates it 90 degrees, thereby locating it on the imaginary axis. This shift in understanding suggests that T1 was capable of reasoning about the multiplication of i with real numbers in two distinct ways—both as a dilation and a rotation operator—although she required external prompting to articulate the latter perspective. More importantly, T1's consideration of 3 in $3i$ as a distance to zero and $\frac{\sqrt{-\Delta}}{2a}$ in $\frac{\sqrt{-\Delta}}{2a}i$ as a distance on the real number line suggested that she reasoned on iy component of the cartesian form of complex numbers, $x + iy$ quantitatively. We argue that such consideration yielded T1 to explain her reasoning behind multiplication of i with a real number both as a dilation and rotation operator as she was able to locate both i and y on the complex plane as $(0, 1)$ and $(0, y)$ respectively.

Comparatively, T4 reasoned as the following about $\frac{\sqrt{-\Delta}}{2a}i$ while thinking about the polar form:

T4: Okay, I will say 1 to this (see Figure 7). I add the vector 1 as much as $|z|cos\theta$ and I make the x component from here, when I express it in binomial form it becomes $|z|cos\theta$.. Then I can apply it here, for example, i, (adding) as much as yi. When I combine the units there, $|z|sin\theta$ there, this time I get yi. When I move that y by $|z|cos\theta$ and add it to the end, for example, I arrive at this point (showing the location of the complex number) and there, I can show it as $|z|sin\theta$ too (showing dotted lines in the figure).

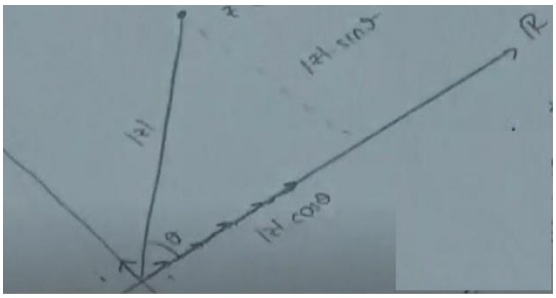


Figure 7. T4 representing repeated addition of $\frac{\sqrt{-\Delta}}{2a}i$ with reference to $i|z|sin\theta$

Data pointed to some important conclusions: First, similar to T1's reasoning, T4's thinking of i as 1 unit on the imaginary axis suggested that she seemed to be thinking iy component of the cartesian form of complex numbers, $x + iy$ quantitatively. Particularly, T4 seemed to consider that $\frac{\sqrt{-\Delta}}{2a}i$ where y is equal to $|z|sin\theta$ is a distance on the imaginary axis. More importantly, comparing to T1' s reasoning, T4's thinking of $\frac{\sqrt{-\Delta}}{2a}i$ pointed that T4 seemed to be repeatedly adding the (1, 0) vector on the real axis to form the x-component while adding repeatedly the (0, 1) vector on the imaginary axis to form the y component of $x + iy$. That is, T1's data showed that her reasoning involved multiplication of a real number with i as a dilation operator whereas T4's reasoning involved multiplication with repeated addition. As a final remark, data also suggested that T4's reasoning on the x component as a vector with repeated addition of the unit vector (1, 0) and on the y component as a vector with repeated addition of the unit vector (0, 1) seemed to enable her to think of $x + iy$ as a vector addition.

Discussion and Suggestions

The study's findings revealed that after completing a PD that focused on the connections between various forms of complex numbers, in-service teachers developed both algebraic and geometric interpretations of i. Specifically, results showed that prior to the PD, none of the teachers could state i as one of the roots of $x^2 + 1 = 0$ whereas upon completion of the PD, all the participants not only could recognize i as the principal root but also could conceptualize it as a vector and a point on the Complex plane. Also, all teachers were able to describe i as a rotation operator. Additionally, one participant demonstrated a more advanced understanding by interpreting ib in two ways: as i performing a 90-degree rotation on b and as b acting on i as a dilation operator. On the other hand, another participant could explain ib by repeated addition of the unit vector (0, 1). Results further pointed to a teacher's biased thinking on the algebraic meaning of $\sqrt{-1}\sqrt{-1}$. In addition, different from earlier research, data showed how in-service teachers could or could not overcome their difficulties on their own considering complex numbers as the quantification of the roots of quadratic equations. We acknowledge that this study was conducted with only five in-service teachers. However, results point to some important insights about how they conceptualized different meanings of i and ib. In what follows, while discussing the results of the study, we also point to the implications for further research on and teaching of the algebraic and geometric meanings of i.

Defining and showing i as a point on the Complex plane

Results showed that T2, T4 and T5 identified i as one of the roots $x^2 + 1 = 0$ in their definitions. As exemplified, T4 even algebraically pointed $\pm i$ as the two roots. In addition, T1 also had an awareness of i as one of the roots of $x^2 + 1 = 0$. Results importantly extend previous research as researchers emphasized that i needs to be conceptualized by students and teachers as one of the square roots of -1 (Kontorovich, 2018b; Nachlieli & Elbaum-Cohen, 2021) since both teachers and students need to be aware of the different interpretations of the radical sign in different number sets (Kontorovich, 2018b). However, results also showed that all participants described $\sqrt{-1}$ as equal to i. Since i is considered as the principal root of $x^2 + 1 = 0$ in formal mathematics, these conceptualizations of the teachers can be considered as valid (e.g., Kontorovich, 2018b; Usiskin et al., 2003).

Going beyond the algebraic manipulations, data particularly pointed that in-service teachers were able to link the roots of $x^2 + 1 = 0$ to their conceptualization of complex numbers as the quantification of the roots of any quadratic equation with real coefficients. That is, as specifically shown by data from T4 in table 3 and in Figure 2 and Figure 7 and in T1's explanations, while considering i and ib they both referred back to the numerical values of $(-\frac{b}{2a}, \frac{\sqrt{-\Delta}}{2a})$ where they stated that $-\frac{b}{2a}$ would be equal to zero. This suggested that they were able to conceive the quadratic formula quantitatively (Stevens, 2019) where they considered such as $\frac{\sqrt{-\Delta}}{2a}$ as the vertical distance from 0. This further suggested that they were able to both consider $(-\frac{b}{2a}, \frac{\sqrt{-\Delta}}{2a})$ as a union of $(-\frac{b}{2a}, 0)$ and $(0, \frac{\sqrt{-\Delta}}{2a})$ but also i as a vector with pointwise representation $(0, 1)$. This suggested that they conceived i as a multiplicative object (Thompson et al., 2014), the union of two quantities. This was specifically evident in T4's overcoming her difficulty in positioning i on the Complex plane. In fact, whenever she thought that as points such as $(0, 1)$ and $(0, 3)$ referred to one of the roots of a quadratic equation, she recalled that she could use ordered pairs of real numbers to show i as $(0, 1)$. Though, the use of $(0, \sqrt{-1})$ in locating one root of $x^2 + 1 = 0$ might be a natural tendency on the part of learners. Taking this into consideration, while teaching quadratic equations, we argue for the simultaneous utilization of both algebraic and geometric meanings of the roots. Specifically, we recommend both teachers and teacher educators to provide opportunities for their students to consider the pointwise representation of the roots, as ordered pairs, on the horizontal axis in $\mathbb{R}^2$.

These findings suggest that understanding $\mathbb{R}^2$ as a quantitative structure may support a clearer comprehension of the isomorphism between $\mathbb{R}^2$ and the Complex plane. This is particularly significant when we consider T4's difficulty, which indicates she may not have recognized that each ordered pair in $\mathbb{R}^2$corresponds uniquely to a complex number, reflecting a one-to-one relationship between these two structures (Kontorovich et al., 2021). Given this, we advocate for creating opportunities for teachers and students to first conceptualize $\mathbb{R}^2$ in a quantitative manner (Karagöz Akar, Zembat et al., 2022), treating points not just as static locations but as multiplicative objects (Saldanha & Thompson, 1998; Stevens & Moore, 2017; Thompson et al., 2017). This approach could enhance their ability to perceive the structural equivalence between the Cartesian plane and the Complex plane.

Results also showed that T1 considered that the rule $\sqrt{a}.\sqrt{b} = \sqrt{a.b}$ in real numbers also is valid for complex numbers, indicating a complex number bias (Karagöz Akar et al., 2023b; Kontorovich, 2018a). In addition, although T5 could verify $\sqrt{-1}\sqrt{-1}$ as equal to -1, there was not enough data to conclude whether she could provide a valid explanation on that. On the other hand, even though T1 could provide an explanation to resolve her difficulty about $\sqrt{-1}\sqrt{-1}$, her explanation further evidenced her complex number bias. Therefore, we comply with Nachlieli and Elbaum-Cohen (2021)'s suggestion and with an emphasis on the polysemy of the radical sign (Kontorovich, 2018a), and further recommend teacher educators and teachers to include a discussion about the importance of taking into consideration of i as one of the square roots of -1, the principal root, while teaching and doing research on different forms of complex numbers.

Meaning of i and b as rotation and dilation operators

In the case of multiplication with i, the results align with and expand on previous research (Nemirovsky et al., 2012; Soto-Johnson & Troup, 2014), showing that all participating teachers could interpret i as a 90-degree rotation operator. This understanding enabled them to visualize the powers of i on the complex plane. Notably, one teacher (T1) demonstrated a more advanced conceptualization of ib by recognizing both the rotation and dilation meanings. Specifically, she could view i as the multiplier and b as the multiplicand, and vice versa. Comparatively, T4's reasoning suggested that she used repeated addition meaning of multiplication while interpreting ib. T1s dual interpretation of ib suggests a deeper understanding of the connection between the geometric and algebraic meanings of complex numbers while the repeated addition suggests a limited meaning, which we call for further investigation.

Previous studies have indicated how physical environments, such as a classroom floor, can support pre-service teachers in understanding the multiplication of a complex number by i, leading them to interpret i as a 90-degree rotation operator (Nemirovsky et al., 2012). However, Soto-Johnson and Troup (2014) found that while two undergraduate mathematics majors recognized that multiplying two complex numbers involves both rotation and dilation, their understanding remained incomplete. Although they could verbally explain the geometric meaning of this multiplication, they struggled to produce corresponding diagrams that connected the geometric interpretation with algebraic representations. Similarly, T1 had difficulty in recalling the knowledge that i, as a multiplier, could act on any real number b by rotating it 90-degree counterclockwise. In addition, Tekin (2019) studied how a pre-service teacher developed a meaning for multiplication of complex numbers by focusing on both rotation and dilation separately and in-juxtaposition to each other. However, the participant in her study had already an understanding of multiplication of i with a real number both as a rotation and dilation operator. Further research is needed to investigate how learners develop an understanding of multiplying i by a real number from both the multiplier and multiplicand perspectives. Clinical design-based research studies, such as teaching experiments, could provide deeper insights into how this dual meaning emerges.

Considering operator meanings of rotation and dilation in multiplication is crucial, as research on rational number multiplication identifies two reasoning models: repeated addition and multiplicative reasoning. The repeated addition model is viewed as limited and elementary (Fischbein et al., 1985), while multiplicative reasoning involves understanding multiplication as "times as much" (Thompson & Saldanha, 2003). This advanced reasoning requires recognizing the product in relation to both the multiplier and the multiplicand (Karagöz Akar, Watanabe et al., 2022). In addition, previous studies indicate that pre-service teachers often struggle to grasp multiplication multiplicatively (e.g., Karyağdı, 2022). The findings from this study, particularly T1's ability to interpret i with both the multiplier and multiplicand meanings and T4's repeated addition meaning, suggest the need to extend research on multiplication to the domain of complex numbers. Investigating how learners conceptualize the multiplication of i with real numbers could reveal new reasoning models and clarify how such understanding develops. This line of inquiry is particularly important, as the teachers' explanations imply that a dual interpretation of multiplication with i may be rooted in a quantitative understanding of quadratic roots, their relationship with vectors, and a quantitative conceptualization of the Complex plane.

In relation with the aforesaid discussion, results also point that at least two teachers, T1 and T4, conceived ib as a single entity quantitatively. This was evidenced in how T1 showed ib as points on the Complex plane by pointing to the algebraic form with regards to the quadratic roots and also in how she reasoned about ib by utilizing multiplication. Similarly, this was shown by T4's reasoning about ib as repeated addition of the unit vector, i. So, we argue that a conception of ib as a single entity quantitatively has also importance from an algebraic point of view. Algebraic structure sense includes seeing an algebraic expression as an entity and dividing an entity into sub-structures (Hoch & Dreyfus, 2004) as well as "seeing the elements of a set as objects upon which the operations act" (Novotná et al.,

2006, p. 249). So, a teacher's conceiving ib as a single entity quantitatively suggests that quantitative reasoning might help study secondary teachers' mathematical meanings (Thompson, 2016) for the algebraic structures (Smith III & Thompson, 2007; Thompson 2011). Thus, using the lenses of quantitative reasoning, we further propose research where many domains of secondary teachers' algebraic knowledge are understudied and underspecified (Warren et al., 2016). This is further important since having a coherent picture of how mathematical ideas (Ball et al., 2008) and mathematical structures in the curriculum are connected is essential for teachers (Warren et al., 2016).

As a final note, since this study solely focused on five in-service teachers' conceptualizations of different meanings of i and ib, based on the aforementioned discussion, we propose to do further research on students' and (preservice) mathematics teachers' conceptualizations of different meanings of i and ib with developing hypothetical learning trajectories in design based studies and with a larger number of participants.

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