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Observation and Improvement of Mobile-Assisted Learning of Students with Visual Impairment: An Action-Research Study

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Abstract

This study aims to develop a mobile-application-assisted learning environment for students with total vision loss. The mobile application to convert the texts in the field of view of the smartphone and tablet cameras into voice allowed for the identification of the students' ability to remember the content, and action plans were prepared to improve the process with the collaboration of various researchers. This was an action-research study. The study participants included four students with total visual impairment. Special education teachers employed in two private education institutions, a researcher, a validity committee, and a mobile software designer who presented all the software development outcomes to the research team were included in the action research team. The data collection instruments included observations, interviews, weekly meeting notes, document reviews, collaboration committee reports, and recall tests. The action research lasted for eight weeks, including two weeks of preliminary stand-alone observation after the employment of digital assistance technologies and determination of the experiences of students with visual impairment. Technical and formal improvements were made based on mobile application data collected at regular intervals. The findings demonstrated that the mobile application contributed to the improvement of reading speed, addition of intimate everyday language and interaction elements to the learning content, and integration of pausing and automatic repetition of significant topics, thus increasing recall performance. It was observed in flipped learning that students who prepared for the learning content before class compensated for their deficiencies in the classroom environment, were exposed to alternative examples, could discuss the learning content with their peers, and achieved the intended learning level, while the inclusion of metacognitive questions in learning texts led to student anxiety and motivational problems. The study findings revealed that using mobile applications alone was not sufficient for complete learning, but were effective as auxiliary learning materials.

Keywords

Visual impairment
Special education
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Instructional design
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Introduction

Today, students have the opportunity to work and take the initiative to contribute to national and global economies. Students with special needs can successfully learn and develop products with added value when they participate in learning environments that have adequate learning objectives (Hatlen, 1996; Spindler, 2005). However, a gradually higher proportion of the visually impaired population ends its education at lower levels due to their disability or other reasons and cannot achieve the expected level of textual or digital literacy (Kucur & Demirdöven, 2021; TÜİK, 2011). As they cannot learn by sight or imitation, special learning experiences should be provided for these students (Lewis & Iselin, 2002). The availability of applications and materials developed for individuals with visual impairment on digital media and mobile devices has significantly reduced the cost of access to these applications. Thus, interest in research on the achievements, learning, and recall of visually impaired individuals who can easily access these applications has increased (Hebebci, 2017). It is important to develop and use learning content and assessment tools that are adequate for students' competencies, starting from the beginning of the learning process for visually impaired individuals. Only when these facilities are available can there be improvements in learning motivation and sustainability (Şenel & Kutlu, 2018).

Visual disability is defined as the inability to use the visual sense at the full or desired level. This disability can also prevent the development of various skills and behaviours (Mann, 2006). However, accurate and effective learning processes and experience can eliminate these obstacles. Thus, it has been shown that a student with visual impairment could develop high cognitive skills and academic motivation and adapt to social life. To this end, the obstacles that hinder the exhibition of learning experiences and performances by the students with visual impairment should be removed (Tekkurşun Demir & İlhan, 2020). IT tools developed for students with visual impairment could help them overcome learning problems and eliminate the problem of exclusion from collaborative learning environments (Şimşek, Altun, & Ateş, 2010). The educational rights of visually impaired individuals are protected by law, as are those of individuals without disabilities. Thus, the development and employment of adequate curricula and instructional materials should be prioritised for those with special needs.

Although visually impaired individuals have low tactile reading speeds, they can understand and process what they hear (Grbovic, Stanimirov, Ayyıldız, Bankovic, & Jablan, 2022). Since the sense of sight has a high effect on learned content (Laird, 1985), it is clear that care and attention are required in the development of learning and instruction tools for individuals with visual impairment (Enç, 2005). Thus, the principle of equal opportunity in education would be fulfilled and instruction environments that would afford individuals with visual impairment access toall learning opportunities should be ensured (Zorluoğlu & Sözbilir, 2017). Digital applications and products specially developed or customised for individuals with visual impairments are important (Boyd Kimball, 2012). Certain initiatives aim to fulfil physiological requirements, such as laser walking sticks, ultrasonic transceiver walking sticks, and elimination or reduction of physical barriers. Others include braille prints and monitors, text reading software, screen focus software, and functional applications that could convert text to audio and audio to text that allow access and process data (Başkurt, 2015; Çiftçibaşı İyigün & Tortop, 2018; Tekindal & Arık, 2012). The contribution of commonly used digital technology tools such as audio book readers, touch screens, voice keyboards, voice mail applications, and voice search software to learning is limited (Akcil, 2018). Yalçın and Altunay Arslantekin (2019) emphasised the limitations of studies that focused on the listening performance of students with visual impairment and the limited number of studies that aimed to improve their performance. Improvements in software that converts text to audio allow accurate text reading and high-resolution image rendering. Thus, visually

impaired students can receive and process written audio content on digital devices. In these applications, the employment of a mechanical voice and static structure that cannot be tuned to user requirements (e.g. altering between texts, changing the source) could also lead to certain perception and learning problems (Taylor, 2009).

Several studies have been conducted to determine the effectiveness of text-to-speech software developed for blind individuals or those who experience reading difficulties (Essien, Uwah, & Ododo, 2021; Isewon, Oyelade, & Oladipupo, 2014; Kamaghe, Luhanga, & Kisanangiri, 2020). These studies focused on the presentation of software that does not allow user input, process monitoring, employment of software as an aid in the improvement of reading skills, determination of its effectiveness, and monitoring of the differences between software and human voice. Young, Courtad, Douglas, and Chung (2018) focused on reading speed and scores in a study conducted to improve the reading comprehension performance in a group with learning difficulties. Kamesh, Nazma, Sastry, and Venkateswarlu (2016) determined that software which converted text into audio or named the object in the view of the camera was useful in the daily lives of students with visual impairments and helped them overcome daily obstacles. Furthermore, certain studies have investigated the effectiveness of optical character recognition software and the technical advances in this field (Neto & Fonseca, 2014; Shah & Parshionikar, 2019). However, no action research has been conducted to improve the effectiveness or functionality of this software. Thus, it is beneficial to plan and gradually develop a sustainable and adaptable learning environment based on user initiatives and demands. The main aim of the current study was beyond determining the effectiveness of software that converts text to audio, which has been extensively studied. The holistic aim of this study was rather to determine the effect of digital eye-assisted learning on the recall levels of visually impaired students. Monitoring the mobile application 'Dijigöz', which converts the text recognised by the camera into audio, throughout the process, assessment of the academic achievements that are subjective for the participant but objective in terms of student acquisition, improvement of these achievements based on the views and suggestions of the validity committee, and reflection of these improvements in the learning process were the objectives of the present study. Thus, this study aimed to make improvements based on the requests and statements of the participants, observations, interview findings, and researcher diaries, as well as the views and recall achievement assessments of the course teachers. Conducting these activities based on instructional design also maintained instruction within the existing curriculum. The study was conducted with the action research design (Bogdan & Biklen, 2007; Fraenkel, Wallen, & Hyun, 2015; Ozan Leymun, Odabaşı, & Kabakçı Yurdakul, 2017; Pine, 2009), which aims to produce systematic solutions for an existing problem. In addition to application revisions, the instruction processes were reviewed weekly, and the instructional design was revised based on the study data. Conduction and analysis of the process by both the researcher and the instructor are important (Öztürk & Doğanay, 2019). Thus, the effective use of an improved mobile application in learning would allow the monitoring of the changes in students' recall achievements, and the final version of the mobile application would meet the standards for an effective instructional design. It was expected that the exemplary instructional framework presented in the current action research would contribute to the formal and informal education and learning of visually impaired individuals. Furthermore, the presence of students with various technology use levels and experiences and the resistance of students with a low interest in technology were considered limitations of the current study.

Based on the general aim of developing a mobile-application-assisted learning environment for students with complete vision loss, the following research questions were asked.

In a learning group that included visually impaired students, in which a periodically revised and improved instructional design was implemented,

1. What are the problems experienced by the students in the learning environment?
2. What are the expectations and suggestions of stakeholders for improving the learning environment and student motivation?
3. What is the impact of mobile software-assisted learning on students' recall performance?

Method

The Research Model

This study was designed using an action research method to ensure and monitor the improvements produced by a mobile application employed in the instruction of visually impaired students. This method allows for the monitoring of instructional activities and the determination of problem areas and their solutions (Creswell, 2007; Mcniff, 2013). Analysing the applicability of an action plan is the first step in action research. This process entails monitoring and analysing the results of each solution and developing a reasonable, justified, and functional action plan. This allows for a clear observation of the reflections of the solution actions (Fraenkel et al., 2015). In the present study, special education institutions were visited in the province where the author was employed to obtain information about the applications conducted by special education teachers and institution administrators with individuals with special needs, and determine the instructional problems associated with the author's field. One of these problems was the experience of individuals with visual impairments who independently read texts that were not adapted for them. In these learning groups, audio learning experiences or those conducted with special digital learning instruction tools were limited. Thus, a separate curricular unit was selected for each individual with special needs to determine the preliminary limits of instruction that would allow learning with text-to-speech software. The action research was designed based on stakeholders' views and students' technology acceptance levels.

Research Settings

This study was conducted at two private educational institutions in Siirt Province, Turkey. All private educational institutions in the province were visited, and students with full vision loss, active attendance, and mental skills associated with planned education were identified. Interviews were conducted with the students regarding the research aim, process, and related duties of students and course teachers. The study was conducted only with students who volunteered.

Participants

The research was conducted with all the participating stakeholders at different stages of the process. The study participants included four students with visual impairment, and the course teachers (one instructor from each institution), author, validity committee members, and mobile software developers were the stakeholders of the study. The real names of the individuals and institutions are not disclosed.

Students

This study was conducted with four students from different age groups. The students included children and young adults whose participation in this educational support program was approved by the Guidance Research Centre (RAM). These individuals did not have any impairments other than visual impairments that could hinder learning. The only participation criterion was ability to use a camera phone. Deniz was a 10-year-old male 3rd grade public school student. He attended inclusive education. He was diagnosed with 'corneal scar and opacity' and had total vision loss, and was assigned 'special needs status' (90% or more disability). There were no other defined requirements other than visual disability. He attended a special education and rehabilitation institution.

Berra was a 13-year-old, female 8th grade student at a public school who was preparing for high school selection exams. She had 93% loss of body function and was diagnosed with bilateral corneal leucoma and bilateral premature retinopathy. She was psychologically diagnosed with mild mental retardation, which was not an obstacle to learning, classroom attitudes, or behaviour as reported by the teacher or institution administrators. Consistent with the researcher's observations and diaries, this was supported by the fact that she was a good listener and achieved high recall. In addition, the design was planned, monitored, and revised based on the 'educational plan requirements', 'recommended support education programs', and 'educational objectives' detailed in the special education and evaluation board (support education) report.

Emine was a 13-year-old, female 8th grade student at a public school. Like Berra, she was preparing for high school selection exams. She was diagnosed with 'left phthisis bulbi and right corneal nephelion' and had 90% body function loss. The patient had no further health problems.

Kübra was a 23-year-old female MEB Open Education High School graduate preparing for college exams. She was diagnosed with 'bilateral P+, bilateral prephysetic eye' and had more than 90% body function loss. Her right ear had normal hearing, but the left ear had severe mixed hearing loss. During the study, the application was monitored with the healthy ear. Berra, Emine and Kübra continued support education at a B-class special education and rehabilitation institution.

Course Teachers

Ufuk was employed at an A-class Special Education and Rehabilitation Center for three years. Ufuk graduated from an undergraduate classroom instruction department and successfully completed a specialist certification program, and was a primary school teacher at Deniz. Rıza has been employed at a B-class Special Education and Rehabilitation Centre for five years. He graduated from an undergraduate classroom instruction department, provided active support to more than 20 students with visual impairment in a special education institution, and was certified as a specialist.

The Author

The author is a faculty member who has been employed at various public colleges for more than 10 years. The author took qualitative and quantitative research methods, advanced quantitative and qualitative data analysis, and action research courses during graduate studies. He is currently employed at the Department of Instructional Technologies and has published an interdisciplinary doctoral thesis and research on special education as well as national and international qualitative studies. He assumed different responsibilities at different stages of this study. He served as a non-participant observer during the pre-action and implementation phases. Initially, he observed the instruction conducted in the natural environment of the relevant institution with the consent of the volunteer participants. These observations were stored as pre-study data until the author was accepted by the participants. After his roles as a researcher and 'guest teacher' were accepted, implementation was initiated, observation and interview data were collected, action plans were implemented, and achievement tests were applied. The researcher monitored the implementation of the action plan without the involvement of the special education teacher during the implementation phase and recorded the observation data in a diary. He

provided consultation during the use of the mobile application and assisted student responses in the case of nonresponse or inadequate responses that would prevent the measurement of student recall with probe questions. He left the institution with the end-of-course student views and achievement test results. During the action plan implementation phase, the validity committee made decisions, revised the course teacher's action plans, and monitored the development of the action cycle. The author shared student and teacher views on the required improvements and revisions with the mobile software developer and applied software updates to the action plan curriculum every week.

Validity Committee

The validity committee included a special education specialist and faculty members in the social sciences and Turkish education departments. The members cooperated with the author on every aspect of the research. They were consulted about the integration of learning content and action plans when they were not in the author's field. These faculty members had action research experience and had completed qualitative research methods and data analysis courses in graduate studies, which improved the validity of the committee decisions. Thus, the committee could make a holistic contribution to action research by presenting different approaches to the data collected by different researchers.

Mobile Software Developer

Mesut Nafiz Şimşek was employed as a software engineer in a private company. He provided the software developed in this study to mobile operating system application providers free of charge. The Dijigöz application allows individuals with visual impairments to listen to texts at a reading speed that they determine. The software provides voice-over support and is known as a mobile application smart voice agent. The agent recognises and vocalises text, colours, and objects using an optical character recognition system. Because the camera could recognise various elements in the field of view and the developer was local and accessible, he was preferred as a software developer. During the study, the version included in the Android software development kit was improved and revised by the software developer. These revisions were implemented at specific intervals based on student, instructor, and researcher feedback.

Data Collection

Study data were collected between 14 October 2021 and 4 February 2022 during the courses attended by the students. During the weeks when a student was absent, data collection was postponed for a week. Qualitative data diversity (Bogdan & Biklen, 2007) was employed to ensure the validity and reliability of the action research. Field experts and a validity committee examined researcher notes and reports, instructor reports, student views, recall test results, and audio transcripts of the tests, and the related feedback laid the foundation for new action plans. Thus, various data types were included in the study to serve the aim of the research. The time spent in the field, the consistency of the study data, and the support provided by direct participant quotes are critical for increasing the credibility of qualitative research (Gürgür, 2016). The collected data are presented in detail, described, and analysed in terms of the research objectives to make sense of the data collected from various sources. Observations, interviews, document reviews, weekly meeting minutes, committee reports (collaborative plans), and recall tests were employed as data collection tools. More than one source was employed during the conversion of the data into findings and results.

Observations

Observation records ranged between 14 and 43 minutes per week for non-participant observations. Observation records, one of the significant data sources in this study, included the application process and the post-application achievement test. After the instructions, a break (10–15 minutes) was determined by the student and instructor at least 10 min before the recall test. Data outside the topic and scope of the study were never recorded. The applications were not video-recorded because four students in both private educational institutions did not consent. The researcher notes, field notes, and audio recordings of the recall tests were stored as auxiliary data. Sample photographs taken during pre-implementation are presented in Figure 1, and contextual data on the pre-implementation observation notes are presented in Table 1.

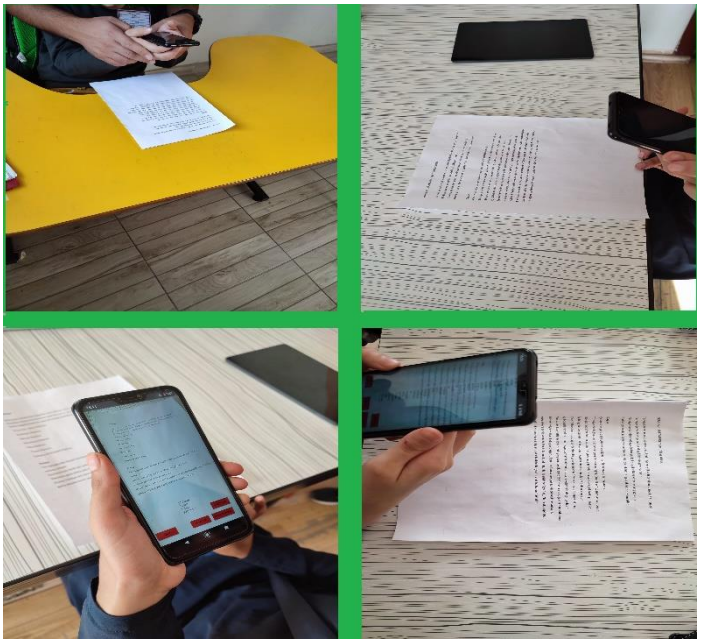

Figure 1. Images of Participants Using the Application and Experiencing the Conversion of Text to Audio during the Pre-Application Process

Table 1. Summary of Pre-Implementation Observation Records

Observation location and date	Observation focus	Observation Duration
Institution A Visual Special Education Class	Physical classroom features and course materials	≈20 min
Institution B Visual Impairment Class	Physical classroom features and course materials	≈20 min
Institution B Visual Impairment Class 14.10.2021 / 12.30	Berra, Emine, and Kübra's classroom activities and applications (non-participant observation)	≈45 min
Institution A Visual Special Education Class 14.10.2021 / 17.02	Deniz's classroom activities and applications	≈30 min
Institution B Visual Impairment Class 14.10.2021 / 12.35	Berra, Emine, and Kübra's classroom activities and applications (non-participant observation)	≈45 min
Institution A Visual Special Education Class 14.10.2021 / 17.16	Deniz's classroom activities and applications	≈15 min

Interviews

Pre-application interviews were conducted with the institution's administration, teachers, and students to collect preliminary data. During implementation, interviews were conducted with all students at the end of each class on the effectiveness of the mobile software and instruction plan. Interviews were conducted with course teachers using verbal recall tests. The pre-implementation interview data are summarised in Table 2.

Table 2. Pre-Implementation Interviews

Pre-Implementation	
Interviewee / Interview date	**Duration**
Institution A administrator/ 28.09.2021 / 17.41	29min 1s
Institution B administrator / 29.09.2021 / 09.06	10min 13s
Teacher Rıza / 29.09.2021 / 09.42	33min 30s
Kübra / 05.10.2021 / 12.30	≈8min (*NR)
Emine / 05.10.2021 / 12.49	≈6min (*NR)
Berra / 06.10.2021 / 13.50	≈5min (*NR)
Teacher Ufuk / 07.10.2021 / 09.00	14min 55s
Deniz / 08.10.2021 / 16.05	≈6min (*NR)

NR: Not recorded because the participants did not consent.

Document Review

The reports provided by health institutions and the RAM on the eyesight of the participants were reviewed to collect demographic data. Past evaluation reports and student report cards on academic achievements were also reviewed. Detailed data are presented in the 'Students' section.

Weekly Meeting Minutes

Evaluation meetings on the learning process were held separately with course teachers employed in the two schools. These meetings lasted between 6 and 21 minutes for each student attending School A. Post-class interviews that lasted between 3 and 15 minutes were recorded for the student attending School B. In these unrecorded interviews, critical facts that could have affected the new action plan, student requests, and opinions were collected. These data were critical for the study because of the discrepancy between student requests and instructional design, which would contribute to student achievement. The students' views about the mobile software and the recordings of the meetings conducted with the teachers required two different designs in certain weeks.

Committee Reports (Cooperative Planning Reports)

Validity committee planning reports were developed, in which problems emerged during implementation, and related solutions and suggestions for improvement were discussed. The application proposals that emerged during the collaboration between the author and instructor were finalised based on the views and suggestions of the committee and included in the action plans. Committee report development was initiated based on the pre-implementation data. Physical or online committee meetings started after the first week of data collection and lasted throughout the application, and the participants met every week to ensure continuity and data collection. Dynamic collaboration was achieved, in which all small- and large-scale field data were analysed. Action research was halted when there was a disagreement among the committee members regarding the meaning and analysis of the data. Committee meetings lasted between 21 and 55 minutes.

Recall Tests

These oral tests were developed in cooperation with course teachers after implementation of the instruction plan. As these tests were not used as an absolute evaluation of individuals with visual impairment, they were interpreted by combining them with student and teacher views and the author's observations.

Data Analysis

Action research requires an analysis process after an idea is developed (Bogdan & Biklen, 2007; Fraenkel et al., 2015). Systematic co-administration of the data collection and analysis processes are necessary (Yıldırım & Şimşek, 2018). In the present study, preliminary data laid the foundation for research planning. The descriptive analysis of the contextual responses that developed during the research is detailed in the 'pre-action', 'action baseline', and 'the whole study' sections. The research process and overall data analysis are thus presented in separate sections.

Research Process Data Analysis

Pre-action

The pre-research and research data analysis steps were as follows:

- Determination of students with total vision loss registered at the institution and their educational level
- Assessment about students with the course teachers
- Analysis of technology interest and usage among the students
- Review the curriculum on an individual basis and determine the subjects for which prior student knowledge is inadequate
- Determination of student demands and interests
- Review and detailed reporting of teacher syllabi

Action Baseline

- Analysis of class recordings and collaborative evaluation meetings conducted with teachers
- Determination of subject recall status
- The compilation of student and instructor views that would be presented to the committee and software developer
- Development and evaluation of instructional design

Overall Analysis

Weekly course records, recall test results, and student-teacher views were analysed chronologically. The responses to the general research question, 'What is the effect of the "Dijigöz" assisted learning on student recall level?', were analysed at this stage. Developmental status, new problems, and alternative suggestions for weekly action plans were analysed. The curriculum was improved and revised based on students' achievements and instructors' views. The analysis was completed using curricular design proposals, which comprised the final stages of the action process.

Action Research Stages

Action planning was initiated through the author's development of a syllabus based on the teachers' and students' views. The first two weeks of the 8-week course instructed to each student were excluded from the action cycle because only non-participant observations were conducted to ensure natural acceptance of the environment. The observational data shed light on the development of the first-course plan. The general steps of the action research are summarised below:

- Development of a sample instructional design-based syllabus along with field experts
- Printing texts about the instruction content in appropriate fonts and sizes for the Dijigöz application
- Discussion of the syllabus with the teacher and finalization of the syllabus

- Observation of the instruction conducted by the teacher by the non-participant author
- Determination of the post-class student recall performance
- Collection of student views and suggestions
- Collection of instructor feedback and recommendations
- Presentation of researcher reports (audio recordings and diaries) and student and instructor views of the committee
- Revision of the mobile software based on the requests
- Development of the next syllabus based on field expert and committee feedback

The data on the repetitive weekly periods of the action cycle, where the available opportunities and learning performances for the student and instructor were maximised, are detailed in the Findings section.

Findings

The findings section includes a presentation of the data based on the classification provided in the research data analysis section: pre-action, action, and overall research.

Pre-action

All participants learned through hearing. In addition to formal education, Kübra can use mobile software to read audiobooks, browse webpages, and listen to texts in learning environments. Although Deniz, Berra, and Emine were interested in digital technology, they were unable to use it effectively. Their technological experience was limited due to the limited opportunities available to course teachers. Occasionally, Emine watched course videos and materials using her sister's tablets. Deniz was an inclusion student who was deprived of direct and objective evaluation at her institution. Her family verbally informed her that her achievement level was between average and good. Emine had previously attained an average grade point of 85. The previous academic year's GPA of Berra, an 8th grade student like Emine, was 98, and her current grade point average was 95. Kübra's high school GPA was 69.26.

Four units included in the 3rd grade curriculum but not yet taught in formal and special education schools were included in the curriculum for Deniz and comprised Turkish vocabulary and reading comprehension, life in Turkey and natural life in a Life Studies course. For Berra and Emine, the semantics, idioms, proverbs, and sentence element units in the 8th grade Turkish curriculum were included in the instructions. Landforms, idioms, proverbs, and word and sentence semantics, which were among the learning objectives for which Kübra stated that her prior knowledge was low, were included in the instruction. After the non-participative observations, Kübra's activities were included in the study for three weeks; however, the data were excluded from the analysis because the teacher did not have clear knowledge of Kübra's level on the relevant topics. Kübra desired to contribute to the study but was unable to provide correct and comprehensive answers. Although she was informed of this, she requested to remain in the study, which was accepted. Similarly, it was observed that Deniz experienced motivation problems since the courses were instructed between 16.00 and 18.00 in Center A and the last class was on Friday; her interest in learning was reduced after her interest in practice faded, and she talked about her social environment and daily problems instead of responding to teachers' questions. The data collection from Deniz was halted in the 4th week and the students were informed. Due to the low prior knowledge levels of Berra and Emine, their desire to learn, and because they provided comprehensive and illuminating data, the study continued with these two students. At Centre B, instruction was planned based on the curriculum developed for Berra and Emine. Related topics were instructed to the students on a weekly basis.

Action

During the first two weeks before the implementation of the action plan, non-participatory observations were conducted in the classes of the participating students, and a document review was conducted in the private education institution. It was determined that the curricula were not consistent with compulsory and standard frameworks. It was observed that when the curriculum of the previous period was not completed, it was included in instruction in the next semester. It was observed that the students were not instructed according to the standard curriculum for their grade. The non-instructed content in the curricula was determined and topics in which the students had inadequate prior knowledge as specified by the instructor were included in the syllabus. The students' views of these topics demonstrated that it would be better to include Turkish and Social Studies topics because these would be included in high school and university selection exams. The instructions were conducted based on student requests, instructor views, and related curricular topics using mobile software. The steps of the action plan are illustrated in Figure 2.

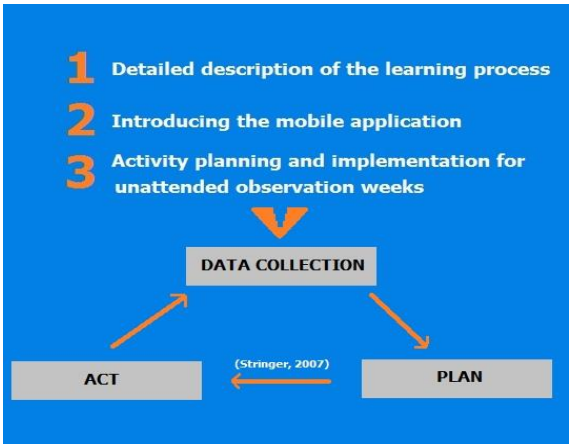

Figure 2. General Action Plan (Adopted from Stringer, 2007)

The functions of the mobile app were introduced to the students. During the two-week observation period, all participant data that would be the basis of the actual application were collected. According to Stringer (2007), it is essential to collect all the relevant data and draw an overall picture in the initial step. During the planning stage, the reasons for the data collection were questioned. In the final stage, the plan was developed, implemented, and monitored. A summary of the critical stages of planning the action plan is presented in Figure 3 in the next section. In this section, the observations during the pre-reaction period are presented. It was clear from Berra's statement that 'I do all my homework by listening to every topic, if the application will read them, I will understand them without my teacher' (Preview week 1 interview data) that the students believed that the mobile application could be sufficient during the pre-action period. This view was supported by Emine and Kübra. On the pre-action period, Deniz stated the following: 'I don't know this, I didn't understand. Ufuk teacher should be here as well' (preview week 1 interview data), demonstrating that employment of the application should be prioritised in the course preparation process or thereafter for Deniz. It was determined that the raw data collected at the committee and researcher meetings were not sufficient for the development of definite action plans and that the first-week data were significant for implementation. It was decided to hold planning meetings with the instructor before each class during the application, where the author would participate as non-participative observer or guest lecturer. The first week, which did not include interventions, was initiated after the topic was determined. The content was developed by field experts and instructed with the application. The next section discusses learning problems, weekly revisions, and action improvements based on the overall study findings.

Overall Research

After determining the physical facilities of the instruction environment, the learning styles of the students, the instruction content, and the instruction topics, syllabi were developed by the author and the validity committee based on instructional models (Aldoobie, 2015; Branch, 2009). When systematic and planned action plans are developed for a learning environment, it is important to employ instructional models that prioritise the critical elements (Johnson, 2008). The first-week syllabi were the same for Berra and Emine, who were at similar levels, whereas different syllabi were developed for Deniz and Kübra. An outline of the syllabus is shown in Figure 3.

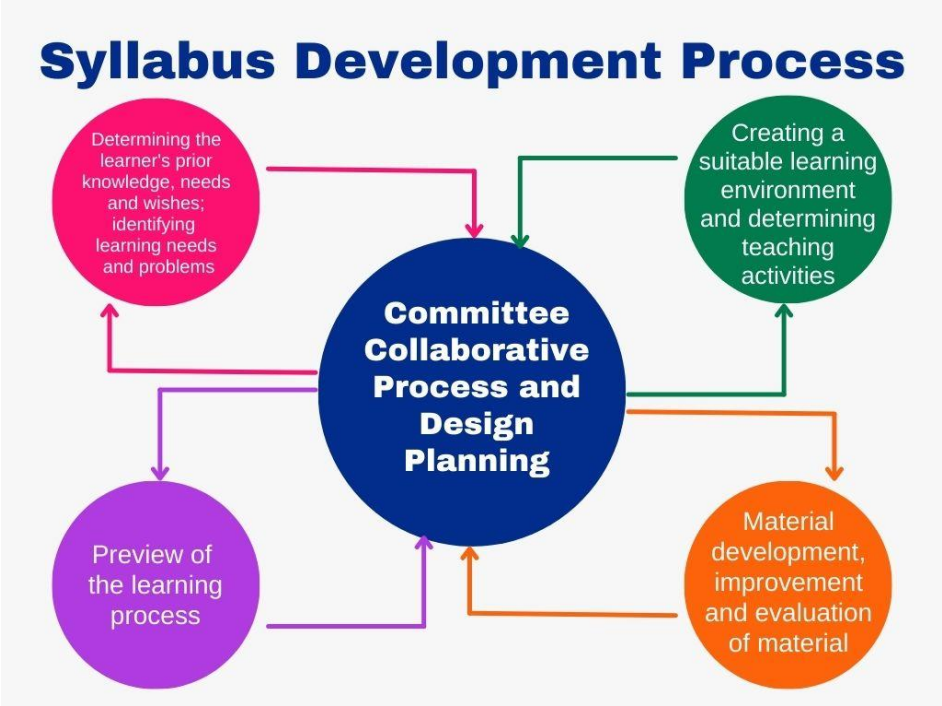

Figure 3. A Sample Syllabus Development Process

The learning environment that served the whole instruction, the transcripts of student and instructor views, compilation of researcher's reports, and status of the action plan are presented in two sections: 'Software content and application' and 'Instructional design'.

Software Content and Application

During the two-week non-participatory observation, it was determined that all students could point the camera to the A4 paper, which included the learning content, with the assistance of the teacher. The application could recognise the content in a short time and read it aloud. Thus, students could listen to the entire content. Deniz and Kübra, who were excluded from the study, used the application during participation. Deniz gave few correct answers to the questions whereas; Kübra answered all questions and provided related examples. This attracted the attention of researchers, instructors and committees. Thus, the data collected from Deniz and Kübra were recorded up to that stage, and subsequent data were not included in the study. The weekly findings on Berra, Emine, and software use can be summarised as follows:

Weeks of Observation (Weeks 1–2)

The data and findings collected during the weeks of observation before the development and implementation of the action plans are presented below.

Researcher diaries 14.10.2021 Note2: '*The application was introduced in the first week. They were excited. They could not use it on their own. The teacher could not always be with them. That was not the objective.'*

Deniz's statement '*It reads the spaces as well, I understood, but... I could have understood all if it was shorter*' meant that the text was too long for Deniz. Since the content was reasonable for one class hour, it was not clearly explained by the researcher, teacher, or committee, and the revisions were left to the monitoring-implementation stages of the action plan.

Emine's statement about the application that 'It omitted several sections when reading, certain letters were wrong' was supported by other participants, instructors, and the author. This was attributed to the test font. This was valid for all participants.

During the meeting conducted with Berra, she stated the following: 'This topic was not taught before, it was a bit difficult to understand. It was slow, but I understood some; I did not understand the rest', demonstrating that Berra experienced learning problems and anxiety in topics that were not previously taught. Anxiety was an observational finding determined by the instructor. Thus, the instructor and author tried to reduce students' anxiety by explaining that the study was not an exam or would not determine student achievement, but was instead a scientific study.

Regarding the pre-implementation stage Kübra stated the following: 'So I was familiar with different software like VoiceOver. I used it all the time. The sound was familiar. However, I think this is useful too', demonstrating that she was used to other text-to-speech software programs. The instructor observed that her motivation for the application was low.

Instructional Design

Instruction was initiated based on views, feedback, and recommendations from the pre-implementation week, committee reports, and the 1st week syllabus. The teacher provided information on the topic and value of learning in daily life and initiated the class after explaining the objectives and related achievements. Participants were allowed to listen to the text by holding their phones at an accurate angle. After the lecture was completed, a break of 10–15 min was given, and recall questions were asked individually to each student in a separate setting. The weekly findings and related nodes determined based on the various data sources are presented below.

Week 3

During the first class, the students experienced certain learning problems. However, the students' excitement, fear, curiosity, and uncertainty about the study were minimised, suggesting that the similarity of the data collected after this stage to the real-life data improved. We ensured that the content was provided without repetition. Students who listened to the text once were asked by the teacher to tell them what they remembered in order to determine their recall levels. At the end of the class, the students generally could not answer the recall questions asked by the instructor. This was due to low motivation and indifference in the case of Deniz, whereas Kübra repetitively stated that other applications were more functional and that they read the text at higher speeds. The instructor claimed that it would be better to try a shorter text for Deniz, and the second-week syllabus was revised with the approval of the committee, the 2nd week syllabus was revised. Emine and Berra stated that the software read the text quite slowly, and that they were bored and forgot the beginning of the text. Ufuk stated that Deniz was shy, tired, and slept throughout the class, while Rıza stated that reading speed was an important criterion for the students and that significant progress could be achieved by improving reading speed. Based on the 1st week of data, the reading speed was set to 0.5, 1, 1.5, 2, and 3 speed intervals at five levels, and the decision was communicated to the mobile software developer.

Week 4

Before the weekly activity, a sample Turkish course text on a different topic was provided to all the participants. They were allowed to determine their desired reading speed on the mobile application based on the latest revisions. Each sentence was organised as a separate line in the text, which indirectly affected reading speed. The application can convert all standard text into speech, but the ends of

sentences and lines are not always the same. The application could not identify the end of the sentence and continued to read the next sentence. However, listening is a basic learning requirement. Meaningful learning could be achieved by understanding and interpreting the message conveyed by the source (Taşer, 2012). Thus, it was necessary to intervene in the uniform structure of the text, which indirectly affected the reading speed. The weekly course content was separated sentence by sentence, and a space was deliberately left at the end of the sentence. Both the students and teachers requested revisions, and the clarity of the text improved, extending the students' attention span.

After the reading speed was revised, Deniz maintained the standard reading speed (1×), Emine and Berra preferred a 1.5 × reading speed, and Kübra preferred the 2× reading speed. Although the planned instruction and content were similar to those in the first week, the content was completed at least 0.33 times faster in the cases of the three students besides Deniz. The students' recall improved, which was supported by the test results. The responses to the question 'Can you tell us what you remember about the topic?' and the answers to the complementary questions about the content improved over the previous week. All students perceived the revision positively because they could adjust their reading speed based on their current motivation, fatigue, and learning needs.

The content was selected from curriculum topics for each student. The recall test questions were based on application objectives and achievements. Thus, it is difficult to achieve standard scores on weekly recall tests. The committee and author collaborated to develop learning texts and recall questions with similar difficulty levels. In this week, Deniz laughed as she said the following: 'I already know what opposite means. I don't want to answer. Oh mom, why did you wake me up!' Her low motivation persisted, and she resisted providing adequate study data. Deniz was excluded from the study, since it was decided that she was allowed a reasonable orientation period of four weeks. She continued to participate in the technology-assisted program; however, her data were not recorded. This decision was based on the institution's inability to change Deniz's class hours or dates. Emine, Berra, and Kübra achieved the highest learning content recall scores. The views of Emine and Kübra that instruction started immediately without preparation were shared with Berra, and it was determined that Berra experienced the same problem, and it was decided to develop the text in the daily language and provide information about the topic to raise interest in the text content for the next week.

Week 5

An introduction to the topic, its significance in daily life, and second singular and plural possessive suffixes were included at the beginning of the lecture text for all participants. Textbooks sometimes start directly with these topics. While topical texts were presented before and at the beginning of the action plan, expressions in daily language were added to the instruction materials based on the participants' views and suggestions. The transitions between the topics were presented to the students in sincere language, and the lecture concluded with good wishes. The resulting increases in student motivation and positive emotions towards the application were significant throughout the week. The students welcomed the changes, stating that these changes avoided the mechanical and simple narrative of the application. Sincerity, warmth, listenability, and sustainable interest were considered achievements by students and instructors. However, no significant increase or decrease was observed in students' recall performance. At the beginning of the study, critical content was taught using a single narrative, similar to standard content. However, it has frequently been reported that listening is the most effective method for individuals with visual impairment in comprehension and learning (Nolan, 1963; Yalçın & Altunay Arslantekin, 2019). In the action plan, the students were instructed again on the significant and critical points using a similar approach to the text. This was suggested by the instructor and committee and welcomed by some of the students, who stated that they could focus on that section because it was interesting.

Regarding the learning process, Kübra and Emine stated that the reading speed was reasonable; however, the intelligibility of the text, which was read continuously, was difficult. It was determined that the lack of time to think and take notes was a significant problem. Berra stated the following about a question in the text: 'It asked the question and answered it without waiting. I knew the answer, but it did not wait.' Thus, the possible contributions and limitations of adding a stop function to the application and incorporating interactive elements into the text were discussed with each participant and instructor. All the students stated that the questions were fine, but the difficulty level was also important. Kübra stated that she studied the previous and current week topics, and mastered the topics: 'Sir, I knew the topic this week, I studied for the exam. However, in your project, I only answered based on what I heard, and not what I knew.' In a meeting with Rıza and Kübra, it was decided to exclude Kübra from the study because she had prior knowledge of the topics planned for the following weeks, which could have affected the study. Until the end of the action plan, she participated in activities when she wanted to; however, the data were not recorded. Based on stakeholders' views, it was decided to include a stop-continue function and topical questions that ranged between basic and metacognitive levels in the software.

Week 6

After this week, instruction prioritised student views because improvement decisions were made based on student recommendations. In the 6th week, interactive textual elements were added to support the learning process. Based on the suggestion that the teacher should understand the comprehension levels without a recall test, topical questions were included in the text and the students were asked to respond. The students were expected to pause the application and think about and answer the questions. Although the benefits of this revision, such as contributing to and reinforcing learning, were obvious based on the difficulty of the problem, it was also argued that it could lead to anxiety and fear. Therefore, the development of these questions is an area that should be carefully studied. Furthermore, the ability to pause and play reading was included in the application, whereas reading was uninterrupted prior to this revision. After this update, it was observed that the students could take notes during the lecture, think about the last read statement, and have sufficient time to answer the questions in the allotted time.

Regarding this week's activity, Emine stated the following: 'Teacher, I stopped the app for all questions, whether I knew the answer or not. However, those I didn't know were a little difficult. I know now.' Berra stated that she experienced exam anxiety when answering questions with high levels of difficulty. During the general evaluation interviews on the action plan of this week, it was determined that learning was not completely achieved; they asked the teacher questions after the lecture, and they wanted the teacher to instruct the topic again. Berra's statements supported that observation: 'Both Rıza teacher and it instructed well. However, Riza teacher performed better. For example, if he instructs him on the same topic, we would ask him, for example, but we cannot ask it (meaning the mobile application). At least after it is over, I think it would be better if we could ask Rıza teacher what we did not understand before it asks us'. Rıza stated the following: 'I can instruct the topic after the application; it would be reinforced better. It would be easier since they are used to it. We can always use it as support.' Thus, the issue was presented to the committee, and it was decided to alter the process. Although the process was similar to the flipped learning model, a flexible approach with an expanded framework was adopted because certain critical factors were impractical (impossibility of conducting group activities since there were only two participants, inability of the students to ask questions to the instructor via e-mail, and lack of project writing/product development experience). The method allows students to plan and implement learning content before the class in a discipline, and alternative and detailed learning content can be taught in the class. Students who can access adequate knowledge of the course content in flipped learning arrive at a physical classroom with high readiness (Akçayır & Akçayır, 2018). It was observed that the recall levels of the participants who started the instruction with

the mobile application before the class asked questions to the course teacher and listened to the teacher's instruction during the class increased. This was included in the students' views and statements of the course teacher, who also applied the recall test. Thus, impressions about the presentation of the mobile application-integrated learning content in a flipped learning environment and the execution of the course that included student questions and reinforcement were recorded.

Week 7

As of this week, the final action plan was preserved, but questions with high difficulty were removed from the text and not presented to users before the class. In the first hour of the two-hour class, students listened to the text on the application. It was ensured that they took notes on the sections that they did not understand. Emine and Berra met at the beginning of the second class, discussed the topic, and exchanged views on sections that they had not understood. They attempted to improve their topical learning by asking Rıza questions. Rıza stated the following: 'Actually, they did not ask that many questions at the end of the class, but I asked them questions to determine their learning level; they were good. They could not do it on their own; they wanted it', reflecting an improvement in student learning. The recall test demonstrated that learning was quite high compared to previous weeks. Because the questions the students asked were partially repetitive, the increase in student performance was evident. Berra stated, 'This week was great; you can ask if you want.' Emine: 'It is better now; it is better when Rıza teacher is included.' The researcher's diary entry indicated that learning anxiety of the students was reduced, and student motivation increased: 'They are relaxed this week, obviously they will have the teacher instruct again without asking too many questions.' The high learning performance of the students paved the way for the decision to continue the same activities with new content the next week.

Week 8

After the students listened to the learning content, they were asked questions about the content that they did not comprehend by the instructor to overcome learning problems. It was observed that the examples provided by the teacher regarding this content contributed to their recall performance. It should be noted that students were highly satisfied and motivated in class. In summary, during the two weeks in which certain flipped classroom criteria and applications were adopted, the recall performance learning objectives were at the desired levels. Both the instructor and the author suggested that this approach was in the best interest of the student.

This flexible learning and instruction approach, which was not limited by an absolute instructional design, was terminated at the end of the 8th week, when there were no improvements or revision suggestions. Thus, based on the views of all stakeholders, it was reported that maximum benefits were achieved. The complete flow of the study from the preliminary development to the reporting stages and general study findings are summarised in Figure 4.

Figure 4. Common Meaning Clusters That Correspond to the Study Findings

The beginning of the process reflected low levels of cognitive and psychological readiness and negative emotions such as anxiety, concern, fear, and the inability to fulfil expectations among students with total vision loss. This was triggered by previous learning experiences and environmental differences. The research team initially employed an improvement process to improve cognitive well-being, learning, and recall. Weekly data and action plans led to a plan map that attracted students' interest, was associated with daily life and learning goals, and could provide confidence and satisfaction in learning (Keller, 1987), which emphasised motivational elements and allowed the students to realise that they were a part of the process. Action research can only be concluded when a balance is achieved (Cohen, Manion, & Morrison, 2017; Manfra, 2019). This is a critical point for action research without a desired, adequate, and maximal structure and improvement plans. This point, where a sustainable learning environment is accepted by the participants, is critical. When the data are saturated, they tend to become repetitive, and as all alternative available tools are tested, the process becomes ready for reporting. This stage reflects contextual significance, but it is limited to providing clues for similar research groups.

Discussion and Conclusion

This study was designed to monitor and improve the experiences of students with complete vision loss while learning textual content using a mobile application. Certain plans and programs were implemented to achieve the learning objectives. It was determined that the text-to-speech software was only Internet-based or limited to digital texts, and the students had never used software that could directly read texts in the camera's field of view. Before the application, the interest and experience of the students in technology were determined and their usage was monitored during the pre-implementation stage. It was determined that they could use mobile technologies and access software when required, and it was observed that students generally employed smartphones as assistants in learning and used ready and recorded materials. They did not use external textual resources, however, limiting their learning processes. The instruction plan was improved based on student interventions, instructor recommendations, committee views, and the author's design. Students could listen to the texts anytime and anywhere, which leads to positive emotions. The ability to learn independently contributes to motivation. When the primary pre-implementation problems regarding the mobile application were resolved and the demands of students with special needs were met based on teacher and committee recommendations, their recall performance improved. The changes between

achievement levels, which indicate the difference between prior knowledge and recall performance, increased during the final weeks of the application. The changes adopted in the application that affected student achievement were as follows: inclusion of an option to change the reading speed, addition of a reasonable pause between sentences, adoption of a narrative style in daily language, addition of the ability for the user to pause reading, addition of questions and interactive elements in the text, and repetition and emphasis of important sections. The students requested that the teacher not be excluded from the process during the use of the application and that they be involved in instruction, which was acceded to based on stakeholder views. A comparative analysis was not possible due to the lack of a control group. Furthermore, it was observed that metacognitive questions could lead to stress, and students could panic when listening to the rest of the text. It was observed that when answers were provided without waiting for an answer in the text, this contributed to recall success because of learning rather than memorisation. Thus, the scenario in which the response was expected was excluded from the final design, and other design changes were finalised after partial revisions. Software and action cycle revisions are presented below.

- Reading speed adjustment

Students could use speed settings ranging from 1.5 to 3× when they focused on learning. Compared to the previous weeks, the recall levels did not improve significantly; however, their performance was better. The improvement was associated with the maximum content listened to per unit time. The answers to the end-of-course recall questions partially met expectations. Students and instructors reported positive views. It was determined this was due to the increase in the hearing performance of individuals with visual impairment in time (Cumurcu, Karlıdağ, & Almış, 2012; Enç, Özsoy, & Çağlar, 1987).

- Insertion of pauses between the sentences

Insertion of a pause was considered valuable to increase intelligibility and perception during listening and speaking, and leave time for interpretation (Emiroğlu & Pınar, 2013). At the beginning of the study, the application read the entire text, which led to dissatisfaction among the students. This was rectified by switching to a reading system that paused between sentences, similar to human speech. Reading sentences with pauses in between them leads to better comprehension and interpretation. Thus, realistic reading and listening experiences were provided to the students.

- Improvement of the text with daily speech characteristics

Karadüz and Sayın (2015) investigated the effects of narratives on various learning groups in their study. They emphasised the significance of motivation and curiosity in learning performance. In this study, students' impressions improved with the inclusion of unexpected, sincere, and realistic expressions in the text. Although the students' willingness and interest increased, their recall performance did not show a similar improvement. In addition, allowing students to intervene in the application flow contributed to certain motivational elements such as interest and attention.

- Repetition of important sections

The significance of listening to the important or incomprehensible sections when reading or listening has been indicated (Şenel & Topuzkanamış 2018). The most common cognitive strategy employed by visually impaired individuals was relistening. The participants also complained that the software interrupted topics that they had already comprehended through repetition, leading to attention problems. As this revision led to imprecise outputs, further contextual studies are required for similar target audiences.

- Inclusion of questions and interactive elements

Günel, Kıngır, and Geban (2012) highlighted the significance of asking questions in scientific enquiries and meaningful learning processes. Furthermore, they reported that the questions contributed to critical thinking skills, which in turn contributed to the generation of ideas and products. It has also been argued that quality learning processes are supported by questions and enquiries (Krystyniak & Heikkinen, 2007). Thus, the inclusion of quality, functional, and level-adequate questions that can trigger metacognitive behaviour is important in learning. In this study, the difficulty of the questions included in the text was of critical importance. Learning was reinforced by easy and moderately difficult questions, while difficult questions led to negative emotions such as anxiety and low motivation.

- Addition of pausing function

Karatay and Uzun (2019) reported positive effects of notetaking on meaningful learning and recall in their study. When time is available to take notes and to determine the gaps in learning, in-depth learning could be possible (Şahin, Aydın, & Sevim, 2011). Similarly, when students could pause the reading in the current study, they could discuss the learning problems associated with the text with the instructor. Therefore, a revision that could positively affect learning and recall performance was adopted.

- Implementation of the flipped learning approach

The interest and motivation of individuals with special needs improve in technology-assisted learning environments (Yaman, Dönmez, Avcı, & Yurdakul, 2016). This study aimed to monitor students after overcoming the novelty effect (Jeno, Vandvik, Eliassen, & Grytnes, 2019). In this process, the students' interest in the course and their learning motivation increased. In addition to the learning setting, the learning environment expanded with the support of the application. The common denominator of student statements for the 5th and 6th weeks was that the software alone was insufficient for learning. Although the students made significant progress, the importance of teacher assistance was emphasised. Thus, the last revision included the adoption of the flipped instruction method.

The flipped learning method allows students to study learning content in a planned and disciplined manner before class, and alternative and detailed learning content can be taught in the classroom. Students who had previously studied course content arrived significantly ready in the physical classroom environment for flipped learning (Akçayır & Akçayır, 2018). Awidi and Paynter (2019) and Zainuddin (2018) reported increases in student motivation and achievement in flipped classrooms. Şahin (2020) demonstrated that middle school students, primarily female students, performed better in flipped learning environments than students in conventional learning environments. Similarly, in this study, female students exhibited positive learning and recall performance during instruction. This method led to a similar performance during the repetitive course week, indicating that it was a sustainable process.

Suggestions

Studies conducted with students with special needs include critical and specific properties owing to the nature of qualitative research. This study has some limitations. Thus, the recommendations for future practices and research are limited.

Practical Suggestions

1. The design elements and applications employed in the present study, whose effectiveness was determined for students with complete vision loss, can also be employed for students with different levels of visual impairment.
2. Training for parents and teachers of visually impaired digitally illiterate individuals can be organised based on the functions and outputs of similar software.
3. Applied courses could be organised to improve the digital literacy of individuals with visual impairment without motivation to integrate technologies into learning.
4. Well-structured mobile application-assisted instructional designs could be employed for students at different learning levels based on their readiness levels and educational needs, and on the curricula and objectives suggested by RAM.

Research Suggestions

1. Future research should investigate the effectiveness of this application in students with visual impairments and different mental and physical disabilities.

In this study, a simple prototype of the flipped learning model was implemented in the final action plans. The effectiveness of a well-structured flipped learning model with improved interactive elements and student projects should be investigated in a larger group of visually impaired individuals. The quality of smart voice agents increasingly approaches that of real human voices (Abdulrahman & Richards, 2022). The mechanical voice employed in this study could lead to vocalisation and comprehension errors, as it is not like a human voice. Thus, participants could be interrupted when listening to the learning content. This is a limitation of this study.

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