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Development of Project-Based Learning Model Assisted by Mobility Orientation Technique Application (ATOM) for Students with Hearing Impairments

Dewi Ekasari Kusumastuti[1], Mirnawati[2], Eviani Damastuti[3], Dewi Juwita Susanti[4], Tenty Jahrina Ramli[5], Sulistyo Rini[6]

[1] Universitas Lambung Mangkurat, Banjarmasin, Indonesia; dewi.kusumastuti@ulm.ac.id
[2] Universitas Lambung Mangkurat, Banjarmasin, Indonesia; mirnawati.plb@ulm.ac.id
[3] Universitas Lambung Mangkurat, Banjarmasin, Indonesia; eviani.damastuti.plb@ulm.ac.id
[4] Universitas Lambung Mangkurat, Banjarmasin, Indonesia; dewi.susanti@ulm.ac.id
[5] Universitas Lambung Mangkurat, Banjarmasin, Indonesia; tentyjahrina@ulm.ac.id
[6] Universitas Lambung Mangkurat, Banjarmasin, Indonesia; sulistyo.rini@ulm.ac.id

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ABSTRACT

Students with hearing impairments often face unique challenges in mobility orientation learning, particularly in mastering sighted guide techniques. This study aims to analyze their learning needs and develop a feasible, practical, and effective Project-Based Learning (PjBL) model supported by the Mobility Orientation Technique Application (ATOM). The research adopts the ADDIE development model, encompassing analysis, design, development, implementation, and evaluation stages. The study involved expert validations, product trials with students, and effectiveness testing through pre- and post-assessments. The analysis stage identified key learning needs among students with hearing impairments. The developed PjBL model, assisted by ATOM, was evaluated for feasibility through expert validation. Material experts rated it 4.34 and media experts 4.77 on a 5-point scale, indicating high feasibility. In product trials, the model received a practicality score of 3.11 from students, reflecting its ease of use and implementation. Effectiveness was demonstrated by a 21.7% increase in students' post-test scores, showing significant improvement in understanding sighted guide techniques. The results suggest that the integration of ATOM into a PjBL framework effectively addresses the learning needs of students with hearing impairments, offering a practical and impactful instructional approach in the mobility orientation course. The PjBL model assisted by ATOM is a feasible, practical, and effective learning solution for enhancing mobility orientation skills in students with hearing impairments, and holds promise for broader application in inclusive education settings.

Corresponding Author:
Dewi Ekasari Kusumastuti
Universitas Lambung Mangkurat; Kalimantan Selatan; Indonesia; dewi.kusumastuti@ulm.ac.id

1. INTRODUCTION

Education is a fundamental right that enables individuals to fully develop their potential, including those with disabilities or special needs. The Indonesian government, through Law No. 8 of 2016, Article 10, affirms that persons with disabilities are entitled to access quality education at all levels and across all educational pathways—both inclusive and specialized (Government of Indonesia, 2016). This legal mandate is further reinforced by the Ministerial Regulation of Research, Technology, and Higher Education No. 46 of 2017, which underscores the importance of enhancing the quality of educational services for Students with Special Needs (SSN) in higher education settings. SSNs, including individuals with hearing impairments, often require tailored instructional strategies, assistive technologies, and adaptive learning environments to ensure full participation and engagement in academic programs (Ministerial Regulation of the Republic of Indonesia, 2017).

In higher education, the challenges faced by students with hearing impairments are significantly more complex than those encountered by their peers. These challenges include limited access to auditory information, restricted vocabulary, difficulty comprehending abstract concepts, and inadequate proficiency in sign language among both lecturers and classroom assistants (Taufiqurrahman, 2022; Yamauchi, Taira, & Trevorrow, 2016). At Universitas Lambung Mangkurat, for instance, three third-semester students with hearing impairments enrolled in the Special Education program during the 2024–2025 academic year experienced these very challenges. The difficulties were particularly evident in the Mobility Orientation course, specifically when learning the sighted guide technique—a skill essential for teaching students with visual impairments.

Mastering sighted guide techniques is crucial for future special education teachers, especially those working with children who are blind or visually impaired. These techniques facilitate not only mobility but also positive social interaction and independence for visually impaired learners (Susanti et al., 2024). However, existing instructional approaches for teaching these techniques often do not accommodate the needs of students with hearing impairments. As a result, there is a pressing need to modify instructional content and delivery methods to enable hearing-impaired learners to both understand and teach sighted guide techniques effectively.

A promising solution to this gap is the application of Project-Based Learning (PjBL) supported by digital technology. PjBL is an active learning strategy that encourages students to work collaboratively on real-world problems and projects. It promotes critical thinking, communication, and problem-solving skills—attributes that are essential for inclusive education (Kristanti, Subiki, & Handayani, 2016; Hartini et al., 2017). For students with hearing impairments, PjBL also fosters peer learning and mutual support, which are especially beneficial in heterogeneous classroom settings.

Incorporating digital technology into the PjBL framework further enhances its effectiveness. Tools like the Mobility Orientation Technique Application (ATOM) can assist hearing-impaired students in understanding and practicing mobility skills more independently. ATOM supports multimodal content delivery and provides interactive modules that aid in learning complex techniques such as the sighted guide method. Prior studies have shown that integrating technology into PjBL not only increases student engagement but also improves cognitive skills and learning outcomes (Hermanto, Sarwi, & Yusuf, 2021; Rati et al., 2017). This aligns with the goals of inclusive education by ensuring that learning environments cater to the diverse needs of all students.

Despite the recognized benefits of PjBL and assistive technology, there remains a research gap in the development of instructional models that specifically combine PjBL with mobility orientation tools like ATOM for students with hearing impairments. Most existing research either focuses on the general use of PjBL or its application among students with other types of disabilities. There is limited evidence-based guidance on how to adapt PjBL to mobility-oriented instruction for hearing-impaired learners in higher education. This study addresses this gap by developing a novel instructional model that integrates ATOM within the PjBL structure to support learning in the mobility orientation course.

The novelty of this research lies in the integration of a specialized digital application (ATOM) directly into the learning syntax of a PjBL framework. This innovation not only adapts the instructional

content to suit the needs of students with hearing impairments but also ensures that they acquire practical skills necessary for their future professional roles as inclusive educators. By embedding ATOM into each stage of the PjBL cycle—from project planning and implementation to presentation and evaluation—this model offers a structured yet flexible approach to inclusive instruction.

Based on the context and challenges previously discussed, this study seeks to explore several key areas related to the education of students with hearing impairments, particularly within the context of mobility orientation. The research focuses on understanding the specific learning needs of these students, especially as they relate to mastering sighted guide techniques—an essential skill for future special education teachers working with visually impaired learners. Additionally, the study investigates how a Project-Based Learning (PjBL) model, when supported by the Mobility Orientation Technique Application (ATOM), can be designed to effectively address these unique needs. It also aims to assess the feasibility, practicality, and overall effectiveness of the developed instructional model in enhancing the learning experiences and outcomes of students with hearing impairments.

The primary objectives of this research are to identify the particular learning challenges faced by students with hearing impairments in the context of mobility orientation, to develop an instructional model that integrates the PjBL approach with the ATOM application, and to evaluate how well this model supports student engagement and improves educational outcomes. Through this investigation, the study aims to contribute meaningful insights and practical solutions for inclusive education, ultimately promoting equal learning opportunities for all students regardless of their physical or sensory limitations.

Ultimately, this research is expected to make a meaningful contribution to the field of special education by offering a replicable instructional model that supports inclusive learning. It also suggests that educational institutions and policymakers consider incorporating technology-assisted PjBL models into teacher training programs for inclusive education. Workshops, collaborative learning environments, and integration of digital tools should be encouraged to ensure that all students—regardless of ability—receive equitable, high-quality education and are well-prepared to become educators themselves.

2. METHOD

This study was conducted on third-semester students with hearing impairments in the 2024/2025 academic year, enrolled in the Special Education Program at Universitas Lambung Mangkurat. The research employs the Research and Development (R&D) method. According to Sugiyono (2016), Research and Development is a research method used to produce a specific product and test its effectiveness. The development method in this study adapts the ADDIE development model, which was introduced by Robert Maribe Branch, aiming to design a Project-Based Learning model assisted by an application. The ADDIE model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The ADDIE model design used in this study is explained in detail in Figure 1 below.

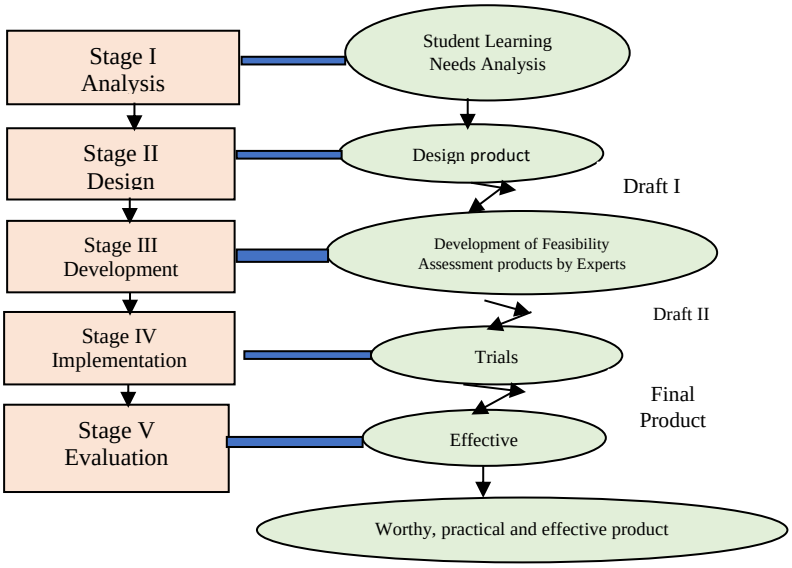

Figure 1. ADDIE Model Design (Branch, 2009)

To produce a feasible Project-Based Learning model assisted by the Mobility Orientation Technique Application (ATOM), the development stage includes validation by media experts and subject matter experts. In addition to feasibility, the product must also be practical. Therefore, during the implementation stage, an assessment is conducted on the aspects of appearance, learning process, and content by students with hearing impairments as users.

The collected data consists of assessment scores and descriptive evaluation notes. The data is analyzed using qualitative descriptive and quantitative methods. Quantitative data is collected through assessment questionnaires on the Project-Based Learning model assisted by ATOM, which is then converted into numerical values using a Likert scale based on evaluations from media experts, subject matter experts, and users. The evaluation results for each aspect of the product are analyzed using quantitative descriptive analysis, with percentage calculations and categorization presented in Tables 1 and 2 below.

Table 1. Eligibility Assessment Scores and Criteria by Media Experts and Material Experts

Formula	Average Score Range	Classification
$X > X_i + 1{,}8\ Sb_i$	X > 42	Very worthy
$X_i + 0{,}6\ Sb_i < X < Xi + 1{,}8\ Sb_i$	3,4 < X ≤ 4,2	Worthy
$X_i - 0{,}6\ Sb_i < X < Xi + 0{,}6\ Sb_i$	2,6 < X ≤ 3,4	Enough
$X_i - 1{,}8\ Sb_i < X < Xi + 0{,}6\ Sb_i$	1,8 < X ≤ 2,6	Not enough
$X < Xi - 1{,}8\ Sb_i$	≤ 1,8	Very less

(Source: Widoyoko, 2017)

Table 2. Practicality Assessment Scores and Criteria by Users

Range	Category	Conversion
3,25 ≤ X ≤ 4,00	Very Practical	Practical
2,5 ≤ X < 3,25	Practical	
1,75 ≤ X < 2,5	Less practical	Not Practical
1,00 ≤ X < 1,75	Very Less Practical	

(Source: Widoyoko, 2012)

In addition, to ensure the effectiveness of the developed product, the evaluation stage employs an effectiveness test using a quasi-experimental design, specifically the One-Group Pre-test Post-test

Design. This design involves the administration of a pre-test, implementation of the intervention, and a post-test to assess the effectiveness of the Project-Based Learning model assisted by the Mobility Orientation Technique Application (ATOM) (Creswell, 2012)

3. FINDINGS AND DISCUSSION

3.1 Findings

A preliminary study on the development of an application-assisted learning model was previously conducted by the researcher. This study was carried out in the Special Education Study Program at Universitas Lambung Mangkurat. The findings of this preliminary study identified the learning needs of students with hearing impairments. Based on these findings, the researcher designed and developed the Project-Based Learning model assisted by the Mobility Orientation Technique Application (ATOM) as an accessible learning tool for students with hearing impairments. The ADDIE instructional design model was employed in developing this application, consisting of five stages: Analysis, Design, Development, Implementation, and Evaluation.

3.1.1 Analysis Stage

The first stage conducted by the researcher in this study was the analysis stage. This stage aimed to identify the learning needs of third-semester students with hearing impairments in the Special Education Study Program at Universitas Lambung Mangkurat. By understanding these needs, the researcher could design an application-assisted learning model to help students with hearing impairments grasp the sighted guide technique in mobility orientation courses. This stage was carried out by distributing questionnaires, which students with hearing impairments completed with the assistance of volunteers.

Based on the questionnaire results, the learning needs of students with hearing impairments in mobility orientation instruction include: (a) the availability of PowerPoint presentations using simple language, (b) the availability of tutorial videos on sighted guide techniques, (c) the presence of sign language interpreters in the tutorial video explanations, (d) teaching methods that actively engage students with hearing impairments, and (e) explanations of the body parts used in sighted guide techniques before practical exercises.

Therefore, students with hearing impairments require an instructional model that facilitates their engagement in collaborative activities. Through group-based learning, these students benefit from peer tutoring support and can actively participate in the learning process. Given that the sighted guide technique is a practical skill that necessitates hands-on mastery, the group activity framework should incorporate structured tasks that require students to directly apply the sighted guide technique.

A skill is more effectively acquired when a model is provided as a reference. In this regard, students with hearing impairments require instructional media containing tutorial videos that feature models demonstrating the roles of both a sighted guide and a visually impaired individual. To ensure easy and repeated access, these instructional materials should be integrated into an application. To enhance comprehension, the video content should be supplemented with subtitles, sign language interpretation, and a glossary to explain complex terminology. The glossary should include visual descriptions and sign language interpretations to further support understanding.

3.1.2 Design

Based on the analysis conducted in the preliminary study, the researcher identified the learning needs of students with hearing impairments in acquiring the sighted guide technique within the Mobility Orientation course. These findings serve as important considerations for the researcher in designing and developing an application-assisted instructional model to support students with hearing impairments in learning the sighted guide technique in the course.

The application-assisted instructional model developed in this study is the Project-Based Learning Model Assisted by the Mobility Orientation Technique Application (ATOM).

Therefore, the instructional model's syntax incorporates the use of technology through an application. A visualization of this model is presented in **Figure 1** below.

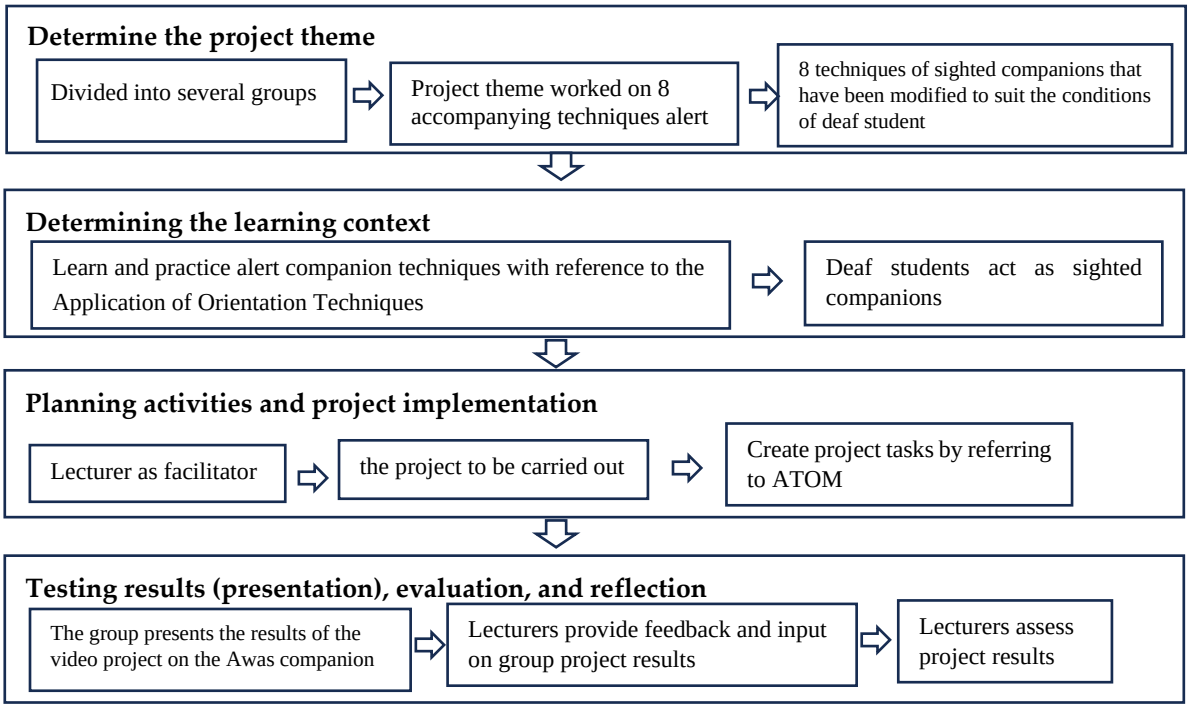

Figure 2. Design of Project-Based Learning Model Assisted by ATOM for College Students with Hearing Impairments

The diagram above illustrates the integration of the Mobility Orientation Technique Application (ATOM) into the syntax of the Project-Based Learning Model. The ATOM application serves as a learning medium to facilitate students with hearing impairments in mastering the sighted guide technique. A visualization of the ATOM application is presented in the following figure.

Figure 2. Login Page

Figure 3. List Page

Figure 4. Main Page

Figure 5. Material and Quiz Page

Figure 6. Page of Material to be Studied

Figure 7. Video Player Page

Figure 8. Glossary Page

Figure 9. Quiz Start Page

Figure 10. Quiz Page

Figure 11. Quiz Results Page

Based on the figure above, the Mobility Orientation Technique Application (ATOM) consists of the login page, registration page, main page, material and quiz page, specific learning material page, video player page, glossary page, quiz start page, quiz page, and quiz result page. To access the content within the application, students with hearing impairments must enter their email and password on the login page. However, before doing so, they must first create an account by registering on the registration page. Once they have created an account and successfully logged in, they can access the main page, which contains the following menu options: "Next," "Log Out," "User Guide," and "Developer Information." Before clicking the "Next" button, it is recommended to read the user guide and developer information to understand how to use the application and to identify the developer of the application. Then, the material and quiz page can be accessed after clicking the "Next" button. The material and quiz page contains the menu for the eight sighted guide techniques (including: the technique of offering assistance to a visually impaired person, the technique of navigating narrow pathways, the technique of hand grip transition, the technique of changing direction, the technique of opening and closing doors, the technique of guiding to a seat, the technique of ascending and descending stairs, the technique of boarding and disembarking vehicles) and a quiz menu that consists of 20 multiple-choice questions (with multiple-choice options featuring images of a deaf model as the sighted guide and a visually impaired person as the guided individual), where the score is immediately displayed upon quiz completion and recorded as quiz history. Within each sighted guide technique menu, there are submenus for “technique video,” “glossary,” “next,” and “back.” To ensure that students with hearing impairments can easily understand the content of the technique videos, they are supplemented with subtitles and sign language interpreters, and the movements of the model in the video are slowed down and shown from the front, back, and side views. The glossary is equipped with images, written descriptions, and sign language interpretation.

3.1.3 Development Stage

The development stage is carried out by submitting the design of the Orientation and Mobility Technique Application (ATOM) to the partner for development. Once the application is completed, the Project-Based Learning Model Assisted by the Orientation and Mobility Technique Application (ATOM) is validated by Material Experts and Media Experts. The following presents the validation results from the material experts and media experts regarding the Project-Based Learning Model Assisted by the Orientation and Mobility Technique Application (ATOM).

1) Material Expert Validation

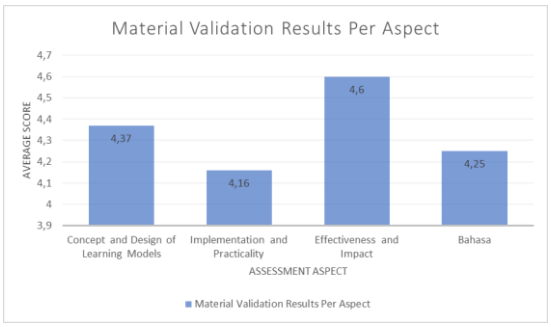

Figure 12. Bar Chart of Material Expert Validation Results

Based on Figure 12, it can be concluded that the assessment of the Project-Based Learning Model Assisted by the Orientation and Mobility Technique Application (ATOM) from the aspects of concept and instructional model design, implementation and practicality, effectiveness and impact, and language received an average score of 4.34, which falls into the "Highly Feasible" category for use as an application-assisted learning model for students with hearing impairments in the sighted guide technique material.

2) Media Expert Validation

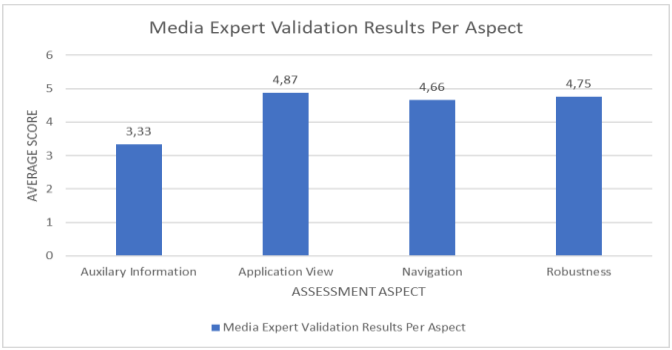

Figure 13. Bar Chart of Media Expert Validation Results

Based on Figure 13, it can be concluded that the assessment of the Project-Based Learning Model Assisted by the Orientation and Mobility Technique Application (ATOM) from the aspects of auxiliary information, application appearance, navigation, and robustness received an average score of 4.77, which falls into the "Highly Feasible" category for use as an application-assisted learning model for students with hearing impairments in the sighted guide technique material. After obtaining the validation results, the next step was for the researcher to submit the Orientation and Mobility Technique Application (ATOM) product to the partner for revision based on input from media experts. The media expert suggested adding the institution's logo to the application. Meanwhile, the material expert provided input regarding the importance of establishing effective communication between students with hearing impairments and students with visual impairments. However, the material expert's suggestion did not alter the existing content.

3.1.4 Implementation Stage

The implementation stage is marked by the trial of the Project-Based Learning Model Assisted by the Orientation and Mobility Technique Application (ATOM) for third-semester students with hearing impairments in the Special Education Study Program at Universitas Lambung Mangkurat. This stage was conducted over five sessions using a blended learning approach, incorporating both offline and online learning methods. The offline learning activities took place on campus, while the online learning

activities were facilitated through the Learning Management System (LMS) of Universitas Lambung Mangkurat (ULM), specifically LMS Moodle SIMARI. The details of the implementation process are elaborated in the subsequent section.

1) First Meeting
   a) Offline Learning Activities
      Project Theme Selection: Regular students and students with special needs were divided into groups of 5–6 members, ensuring a balanced composition. Each group included 1–2 students with special needs, with the requirement that deaf and blind students be integrated into the same group. All groups reached a consensus that the project theme to be developed would focus on eight sighted guide techniques.
   b) Online Learning Activities
      (1) Students learn the PowerPoint materials on sighted guide techniques through LMS Moodle SIMARI
      (2) Students download and install the Mobility Orientation Technique Application (ATOM).
      (3) Each group representative reports the group name and members and summarizes today's lecture in the discussion forum on LMS Moodle SIMARI.
2) Second Meeting
   c) Offline Learning Activities
      (1) Establishing the learning context: In groups, regular students and students with special needs study the eight techniques of sighted guide assistance through the Mobility Orientation Technique Application (ATOM) and then practice them in class.
      (2) Planning activities: The lecturer acts as a facilitator (e.g., providing guidance, overseeing discussions, and assisting with group consultations), while each student group designs a project plan for a video demonstrating sighted guide techniques (with group seating arranged in a circle), referring to the Mobility Orientation Technique Application (ATOM).
   d) Online Learning Activities
      Each group representative uploads the results of their group discussion (such as the division of tasks for each member in project implementation) and provides a summary of the day's lecture in the discussion forum of LMS Moodle SIMARI.
3) Third Meeting
   a) Offline Learning Activities
      Project Implementation: Regular students and students with special needs collaboratively create a project video on sighted guide techniques, referring to the Assistive Technology for Orientation and Mobility (ATOM) application.
   b) Online Learning Activities
      (1) During the process of creating the project video, representatives from each group submit behind-the-scenes footage of the video production to the designated Google Drive link, report their progress, and share any challenges encountered in the discussion forum on LMS Moodle SIMARI.
      (2) The lecturer provides feedback in the SIMARI discussion forum
      (3) The lecturer informs all groups that the completed sighted guide technique project videos must be submitted one day before the next meeting via the Google Drive link provided on LMS Moodle SIMARI.
4) Fourth Meeting
   a) Offline Learning Activities
      (1) Project Outcome Assessment (Presentation**):** Each group takes turns presenting the results of their sighted guide technique project video.
      (2) Evaluation and Reflection**:** (a) The lecturer provides feedback and suggestions on each group's project outcomes, as well as discusses follow-up actions based on the feedback

received. (b) The lecturer assesses each group's sighted guide technique video using a pre-developed evaluation instrument.

b) Online Learning Activities

(1) Students report the feedback and suggestions received from the lecturer and other groups regarding their presentation and project outcomes, as well as the follow-up actions taken based on the feedback, in the discussion forum of LMS Moodle SIMARI.

(2) Students write a conclusion in the discussion forum of LMS Moodle SIMARI.

5) Fifth Meeting

The group submits the revised project video on sighted guide techniques to the Google Drive link provided on LMS Moodle SIMARI.

After the implementation phase is completed, students with hearing impairments are asked to evaluate the Project-Based Learning Model Assisted by the Orientation and Mobility Techniques Application (ATOM) through a Google Form linked to LMS Moodle SIMARI. The evaluation results are presented in the bar chart below.

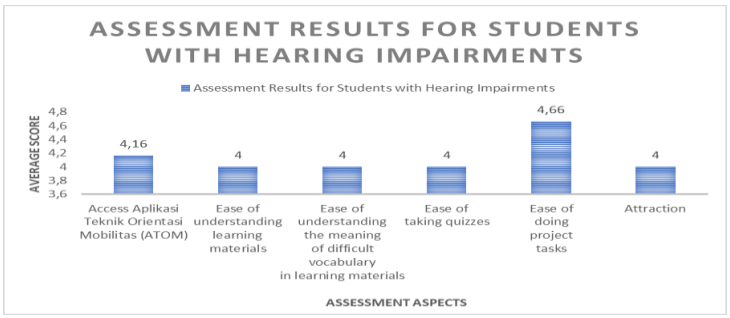

Figure 14. Bar chart of assessment results for students with hearing impairments

Based on the evaluation by students with hearing impairments, the Project-Based Learning Model Assisted by the Orientation and Mobility Techniques Application (ATOM) was assessed across several aspects: accessibility of the ATOM application, ease of understanding learning materials, ease of comprehending difficult vocabulary, ease of completing quizzes, ease of completing project assignments, and overall engagement. The model received an average score of 3.11, categorizing it as practical for use as an application-assisted learning model for students with hearing impairments in the subject of sighted guide techniques.

3.1.5 Evaluation Stage

The evaluation conducted in the development of the Project-Based Learning Model Assisted by the Orientation and Mobility Techniques Application (ATOM) includes feasibility evaluation through validation by subject matter experts and media experts, as well as practicality assessment by students with hearing impairments during product trials. Effectiveness evaluation was carried out through a test on sighted guide techniques within the mobility orientation course. This stage aims to evaluate and test the developed application, ensuring that ATOM meets the specific needs of students with disabilities and functions effectively as an assistive tool for enhancing their orientation and mobility skills. The effectiveness test was conducted by measuring students' competency through a pre-test before implementing the Project-Based Learning Model Assisted by ATOM and a post-test after implementation, using 20 multiple-choice questions. The purpose of this test was to determine the effectiveness of the developed learning model. The summary of pre-test and post-test results for students with disabilities is presented in Table 2 below.

Table 3. Recapitulation of Pre-Test and Post-Test Data Results

No.	Name	*Pre-Test*		*Post-Test*		Improvement	
		Skor	%	Skor	%	Skor	%
1.	RA	9	45%	16	80%	7	35%
2.	MAM	12	60%	14	70%	2	10%
3.	ANF	9	45%	13	65%	4	20%
Amount		30	150%	43	215%	13	65%
Average		3	50%	14.3	71.7%	4.3	21.7%

The results of the effectiveness test for the development of the Project-Based Learning Model Assisted by the Orientation and Mobility Techniques Application (ATOM), conducted through testing, indicate an improvement in the comprehension scores of students with hearing impairments regarding sighted guide techniques in the mobility orientation course, as shown in Table 2. All three students who participated in the effectiveness test showed an increase in their post-test scores compared to their pre-test scores. The highest score improvement was recorded by subject RA, with a 35% increase, while the lowest improvement was observed in subject MAM, with a 10% increase. The average score improvement across the three students was 21.7%. Overall, the post-test scores of all three students were higher than their pre-test scores, indicating that the Project-Based Learning Model Assisted by ATOM is effective in enhancing the comprehension of sighted guide techniques among students with hearing impairments.

3.2 Discussion

The use of the Project-Based Learning (PjBL) model assisted by the Orientation and Mobility Techniques Application (ATOM) has demonstrated effectiveness in improving the understanding of sighted guide techniques among students with hearing impairments. This model is designed to address the learning needs of students with hearing impairments, who often struggle with verbally delivered material. By integrating technology into project-based learning, ATOM serves as a tool that provides a more visual, interactive, and contextual learning experience. The presence of sign language interpreters in the application content aligns with the findings of Yuwono et al. (2022), which indicate that students with hearing impairments require sign language interpreters to access information optimally during lectures. Similar findings were reported by Utomo, Rapisa, and Susanti (2023), who demonstrated that sign language videos presented by sign language interpreters effectively support the comprehension of technical terms among deaf students. While features such as application navigation, user interface design, and accessibility are important, the primary focus should be on how these features facilitate students' understanding and application of sighted guide techniques. Therefore, a more in-depth analysis of ATOM's impact on the learning process remains a critical aspect that should be further strengthened in this research.

One of the main limitations of this study is the small sample size, involving only three students with hearing impairments. With such a limited number of participants, generalizing the findings to a broader population becomes challenging. To ensure that these results can be applied in a wider context, further research with a larger and more diverse participant pool is needed. Additionally, a longitudinal study could be conducted to assess the long-term impact of the ATOM-assisted PjBL model on students' skills.

The research findings indicate variations in students' comprehension improvement after implementing this learning model. One student, RA, showed the highest score increase of 35%, while MAM experienced only a 10% increase. This difference suggests that, although the model is generally effective, individual factors influence learning outcomes. Some factors to consider include students' level of engagement in the project, prior academic experience, and their readiness to use technology as a learning medium.

In the PjBL model, active student engagement is a key element in the success of learning. Students who actively participate in discussions, collaborate, and practice the sighted guide techniques with

ATOM's guidance tend to achieve better comprehension. Conversely, students who are less engaged or face additional challenges in understanding the material may experience lower improvements. Therefore, it is crucial for lecturers to ensure that all students receive adequate support to maximize their participation in this project-based learning approach.

From a pedagogical perspective, Project-Based Learning (PjBL) offers significant advantages in enhancing practice-based learning experiences. Students not only understand the theory of guiding techniques but also directly apply these skills in real-life situations. Project-based learning also encourages students to develop social and communication skills, which are crucial when assisting individuals with visual impairments. In the context of students with hearing impairments, this model enables them to gain a more concrete learning experience through visualization and direct practice. The study conducted by Fiana, Relmasira, and Hardini (2019) demonstrated that learning using the Project-Based Learning model is superior to the Problem-Based Learning model. This is also supported by the findings of Irnawati, Sanjoto, and Sriyono (2019), which indicate that the Project-Based Learning model is more effective and suitable for teaching image interpretation compared to the Problem-Based Learning model, as stated by Slavin (2011) based on four indicators of learning effectiveness: instructional quality, appropriate level of instruction, incentive, and time.

To support the successful implementation of project-based learning models, Prasad et al. (2017) emphasize the need for adequate time and resource allocation, including technology, materials, and physical space. The practical implications of this study are extensive, particularly in developing inclusive learning models in higher education. The ATOM-assisted PjBL model can be adapted for students with other disabilities, such as visual impairments or motor disabilities. By adjusting application features and instructional syntax, ATOM can become a more flexible tool that is applicable in various educational contexts. Additionally, other universities can adopt a similar approach by integrating assistive technologies available within their institutions.

In addition to improving learning outcomes, this study also highlights the importance of collaboration between students with and without hearing impairments in the learning process. Through group work that involves students from diverse backgrounds, social interactions become more enriched, allowing students to learn from each other's experiences. This model not only enhances academic understanding but also fosters inclusivity and empathy within the higher education environment.

Feedback from research participants also provides valuable insights into their experiences using ATOM in the learning process. For instance, student RA stated that this learning model made the learning process more engaging and interactive. MAM highlighted that ATOM facilitated their understanding of how to assist individuals with visual impairments, while ANF assessed that the model was effective in helping them master the material. These testimonials complement the quantitative data obtained and demonstrate that qualitative aspects also play a crucial role in evaluating learning effectiveness. The positive aspects of the project-based learning model, as reported by students with and without disabilities, include fostering collaboration (Boardman & Hovland, 2024) and promoting cooperation between students, with the teacher acting only as a guide during the project (Greenier, 2020). The project-based learning model trains students to be more collaborative, work together, and show empathy towards others (Larmer, Mergendoller, & Boss, 2015; Martati, 2022). Three students with hearing impairments were involved in assessing the model, namely RA, MAM, and ANF. In addition to providing ratings in the form of scores, the three students also provided testimonials about the model that had been tested. RA stated, "*I find the learning activities interesting with the application of the ATOM-assisted PJBL Learning Model." Meanwhile, MAM expressed,* "ATOM and PJBL are great because they are helpful for the visually impaired," and ANF said, "It's already good."

In project-based learning, students' learning experiences are highly influenced by the quality of guidance provided by both instructors and peers. The implementation of ATOM as an assistive tool in the PjBL model must be accompanied by appropriate teaching strategies to ensure that students can maximize its benefits. The use of ATOM goes beyond merely being a supporting medium; it also serves as a catalyst in enhancing students' understanding and engagement in the learning process.

Although this model has proven effective in the context of this study, there is still room for improvement. One aspect that can be further developed is enhancing the accessibility of the ATOM application, such as by adding interactive features that allow students to receive real-time feedback during the implementation of guided practice techniques. Additionally, the integration of augmented reality (AR) or virtual reality (VR) technology could be considered to enhance the learning experience for students with hearing impairments.

The evaluation of this learning model also indicates that the effectiveness of ATOM largely depends on how the application is used in the learning process. Merely providing the application is not enough if it is not accompanied by appropriate teaching strategies. Therefore, the role of the instructor in facilitating the learning process is crucial to ensure that students can utilize this technology optimally and achieve the best learning outcomes.

Furthermore, further studies are needed to explore how the use of ATOM can be expanded to other courses that also require a practice-based approach. If this application proves to be beneficial in supporting the learning of guided practice techniques, there is potential to adapt and develop additional features relevant to other skills that need to be taught to students with special needs.

One aspect that also needs to be considered in future research is how students with hearing impairments adapt to the project-based learning model compared to the conventional model. Data on learning preferences and the challenges faced by students can provide deeper insights into optimizing a technology-based inclusive learning approach.

In addition, this research also opens up opportunities to explore how students with visual impairments can collaborate more effectively with students with hearing impairments in learning projects. By understanding the dynamics of group work involving students with various types of disabilities, educational institutions can develop more inclusive and adaptive teaching strategies that address the needs of students with special needs.

Overall, this research makes a valuable contribution to the development of inclusive learning models in higher education. By adapting technology in project-based learning, students with hearing impairments can gain better access to learning materials and a more meaningful learning experience. This finding is supported by Evenddy, Gailea, and Syharizal (2023), who state that through real-world project work, students gain a deeper understanding of concepts and learn how to apply their knowledge in meaningful ways. The success of this model in enhancing students' understanding of guided practice techniques also demonstrates that technology can play a crucial role in supporting the learning of students with special needs. Therefore, future research should examine how this model can be more broadly integrated into the inclusive education curriculum.

The ATOM-assisted Project-Based Learning model has proven effective in enhancing the understanding of students with hearing impairments regarding guided practice techniques. However, to strengthen the research findings, further studies with a larger sample and a more comprehensive research design are necessary. Additionally, improvements in the application's interactivity and learning support aspects could be a strategic step to ensure that ATOM can provide broader benefits in inclusive education in the future. Thus, this study not only contributes to the field of inclusive education but also paves the way for the development of more adaptive and innovative learning technologies.

4. CONCLUSION

Based on the findings, this research concludes that the Project-Based Learning (PjBL) model, supported by the Mobility Orientation Technique Application (ATOM), effectively aids students with hearing impairments in understanding guided practice techniques within mobility orientation courses. The integration of ATOM within the PjBL framework—grounded in assessment-driven customization—proved instrumental in addressing the specific learning needs of these students. Validation from both subject matter and media experts classified the model as highly feasible, while student assessments indicated its high practicality. Additionally, the improvement in students' post-

test scores compared to their pre-test results demonstrates a positive learning impact. However, this study is limited by its sample size and scope, which may affect the generalizability of the findings. Future research should consider broader participant demographics and explore the long-term effects of integrating ATOM in various educational settings for students with special needs.

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