

Engineering Education through Assistive Game Development: Supporting Speech Patterns and Verbal Productivity in Children with Mild Intellectual Disabilities

A. Astuty, H. Herpindo, F. Farikah, Sukron Mazid

Universitas Tidar, Magelang, Indonesia
astuty@untidar.ac.id

Abstract—This study develops and evaluates a probing-based assistive game to support speech patterns and verbal productivity in children with mild intellectual disabilities (MIID) from an engineering education perspective. The study employed a research and development approach using the ADDIE model, consisting of analysis, design, development, implementation, and evaluation. Initial analysis identified limitations in vocabulary, phrase and sentence development, speaking productivity, and pragmatic communication. Based on these needs, a game application integrating gradual probing questions was developed using the Unity engine through a human-centered and iterative design process. The application was validated by content and media experts, followed by limited testing and classroom implementation. The findings indicate that probing-supported interaction enabled children with MIID to produce more varied vocabulary, longer utterances, more complete sentence structures, and emerging pragmatic expressions compared with their initial responses. The game also enabled active participation in language learning activities. From an engineering education perspective, the study demonstrates how assistive technology, instructional design, and iterative game development can be integrated to meet specific learning and communication needs. The findings support the development of inclusive educational technologies that connect engineering-based design solutions with special-needs education.

Keywords—assistive technology, engineering education, game-based learning, mild intellectual disabilities, probing questions, verbal productivity.

I. INTRODUCTION

Language development is closely related to children's cognitive, social, and communicative functioning.

Language enables children not only to express needs and ideas but also to participate in learning and social interaction. For children with intellectual disabilities, limitations in communication may influence academic participation, social relationships, independence, and everyday interaction. Functional communication is therefore an important component of special-needs education and requires learning approaches adapted to individual cognitive and linguistic characteristics (Gupta et al., 2023; Kalland & Linnavalli, 2023; Akmaral et al., 2025).

Children with mild intellectual disabilities (MIID) commonly experience difficulties in language processing and functional communication. Previous studies have identified limitations in vocabulary, literacy, syntactic development, and communication performance among children with intellectual disabilities (Sajewicz-Radtke et al., 2025; Koizumi et al., 2026). Communication difficulties may also affect participation in group activities and interactions with teachers and peers (Wallin et al., 2024; Hofmann & Müller, 2022). These characteristics suggest that assessment should not only consider what children can do independently, but also what they can do with appropriate support in the form of instruction.

The language performance of children with MIID should not be considered as completely fixed. They may develop their responses in learning environments that offer structured assistance, repeated opportunities, and appropriate linguistic stimulation. In this regard, scaffolding is pertinent, as assistance can help learners progress from actual to potential performance. The theoretical relationship between scaffolding and the zone of proximal development provides a basis for examining differences between independent performance and performance achieved with instructional support (Xi & Lantolf, 2021).

One type of linguistic scaffolding is asking probing questions. Probing asks a series of leading questions that draw out the learner to clarify, extend, or elaborate on the responses given, without the teacher supplying the answer directly. Structured questioning can stimulate verbal participation and support more elaborated responses when adapted to learners' abilities (Karousiou et al., 2026). For children with MIID, gradual probing can therefore provide a practical means of revealing language abilities that may not be evident from spontaneous speech alone.

Digital and game-based learning provides an opportunity to operationalize this scaffolding in an interactive environment. Game-based digital media can support active participation and higher-order learning when integrated appropriately into instructional activities (Ayustyaningtias et al., 2025). Digital gaming interventions have shown potential for supporting language-related skills among

students with intellectual disabilities (Kumaş et al., 2025). Technology-supported communication activities have also been used to improve communication skills among students with MIID (Elkot et al., 2025). In the Indonesian context, the integration of technology and innovation has similarly been identified as an important direction for language education.

Developments in special-needs education further indicate that technology should be integrated with appropriate pedagogical strategies. Baxtiyor and Sardor (2024) highlighted the potential of information technology for strengthening special and inclusive education. Baxtiyor and Sodikovna (2025) also showed that structured practical activities involving visual, multisensory, and game-based strategies can support communication, engagement, comprehension, and independent task performance among children with intellectual disabilities. These findings indicate that technological tools are most meaningful when their design responds directly to learners' functional needs.

This relationship between learner needs and technological solutions provides an important connection with engineering education. Engineering education can involve identifying problems, translating user needs into design requirements, developing technological solutions, and evaluating them through systematic and iterative research processes (Susilawati et al., 2025). In this study, the learning problem is limited verbal communication among children with MIID, while the engineering-oriented solution is an assistive game designed around structured probing, interaction, feedback, and user accessibility. Thus, the game-development process provides an educational context in which engineering design principles are applied to a specific special-needs learning problem.

From this perspective, assistive game development can connect engineering education with human-centered design. The learner becomes a central consideration in defining system requirements, including interface simplicity, response mechanisms, gradual difficulty, feedback, and accessibility. The ADDIE-based development process used in this study also provides a systematic sequence from needs analysis to design, development, implementation, and evaluation. The present study follows these stages through validation, limited trials, revision, and implementation to refine the developed game.

Such an approach is particularly relevant to inclusive engineering education because technological success should not be evaluated only by whether a system functions technically. Its effectiveness, to a great extent, hinges on how the technology can respond to individual differences and create positive learning results. For kids with MIID, taking into account aspects of cognitive processing, language production, reaction speed, interface accessibility, and how much help they receive in a task are essential. That is why the creation of assistive technology really is a great case of how engineering-oriented design methods can adapt to human requirements diversely. Nonetheless, most current investigations separately consider language shortcomings, teachers' questioning, digital interventions, and technology

architecture. There are not enough studies, at least until now, that merge those components in a combined development strategy and focus specifically on the development of Indonesian language among children with MIID. Most prior studies focused primarily on language deficits of the children, as it was the most readily recognizable factor, rather than paying attention to the development that was possible after the children had been helped by a structured form of support.

This shortfall creates challenges not only for teaching methods but also for the creation of learning tools. To teach a child, one must use vocabulary, phrases, sentences, speaking skills, and the ability to express and communicate their thought or their way of communicating. On the education engineering side, these features should be turned into actual functions and interfaces of the learning tool accessible to the user. A game with a questioning-based method could be the answer here since it includes orderly questioning in interaction between the learner and the game repeatedly, real-time feedback, and enhancement of language output gradually, all taking place in the digital space.

Accordingly, this study aims to develop and evaluate a probing-based assistive game and examine how structured probing supports verbal performance in children with MIID. The study analyzes actual and potential speaking performance in vocabulary use, phrase and sentence structure, utterance length, speech functions, and politeness expressions. In addition to its contribution to language and special-needs education, the study contributes to engineering education by demonstrating how human-centered design, assistive technology, and iterative game development can be applied to transform identified learner needs into an inclusive technological solution.

II. LITERATURE REVIEW

A. Speech Patterns and Communication Characteristics

Children with neurodevelopmental conditions may show differences in social interaction, verbal communication, gesture use, and responses to sensory stimuli. These characteristics are important when designing assistive learning media because communication difficulties can influence how children understand instructions, produce responses, and participate in learning activities. Figure 1 provides a visual overview of several communication and behavioral characteristics commonly discussed in relation to autism spectrum disorder. This figure is retained as contextual background and is not intended to equate autism with mild intellectual disabilities (MIID).

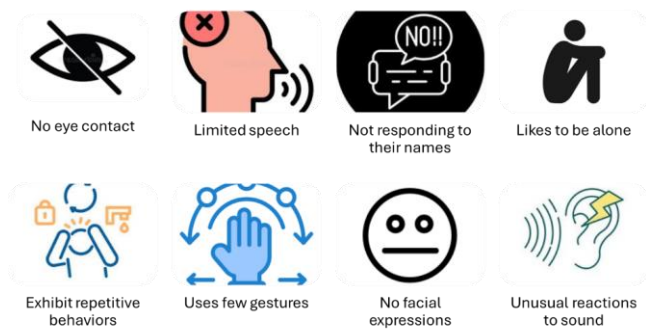


Fig. 1. Autism spectrum disorder (ASD).

Speech characteristics may also differ considerably among children with developmental conditions. Figure 2 illustrates several speech patterns associated with autism, including monotonic, sing-song, idiosyncratic, and cluttering speech. Although these patterns are not diagnostic characteristics of MIID, the figure provides useful background for understanding why speech assessment should consider not only the quantity of verbal production but also its form and communicative characteristics.



Fig. 2. Types of autism speech patterns.

For children with MIID, language limitations may appear in vocabulary, syntactic development, literacy, and functional communication. Vocabulary development is particularly important because structured instructional strategies can support more functional language use among learners with communication-related special needs (Kurniawati, 2022). Previous research has reported difficulties in language processing and communication among children with intellectual disabilities (Sajewicz-Radtke et al., 2025; Koizumi et al., 2026; Wallin et al., 2024; Hofmann & Müller, 2022). These difficulties may influence both classroom participation and everyday social interaction.

B. Mild Intellectual Disabilities and Learning Needs

MIID involves limitations that can affect academic, social, personal, and functional performance. Figure 3 provides a broader neurodevelopmental context for intellectual disability, while Figure 4 summarizes major areas of difficulty associated with mild intellectual disability. These visual frameworks emphasize that learning needs should be understood multidimensionally rather than only through academic performance.

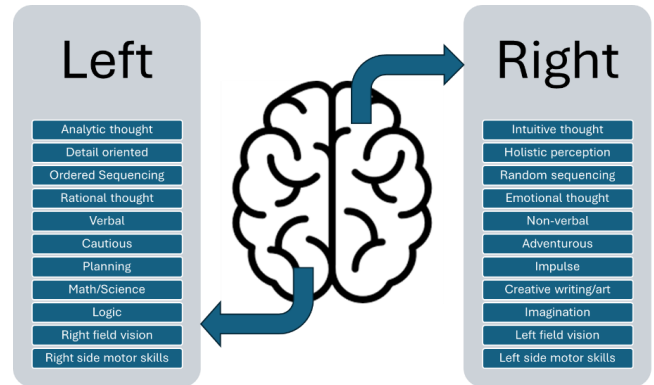


Fig. 3. Conceptual illustration of cognitive processing differences relevant to neurodevelopmental learning needs.

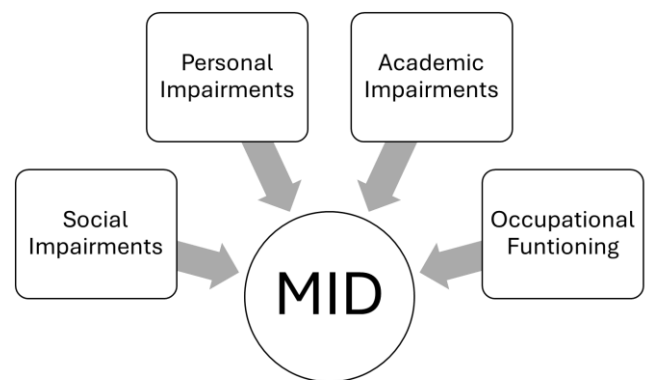


Fig. 4. Major areas of difficulty associated with mild intellectual disability.

Assessment is important for identifying individual strengths, limitations, and educational needs. Figure 5 presents a general sequence from developmental screening and surveillance to more formal cognitive assessment. In the present study, existing school psychological assessments were used to identify children who had already been classified as having MIID before participation in the game-based intervention.

From an engineering education perspective, these individual differences are important because assistive technology should be designed according to actual user requirements. Cognitive processing, communication ability, response speed, visual accessibility, and level of assistance therefore become design considerations when developing an educational game for children with MIID.

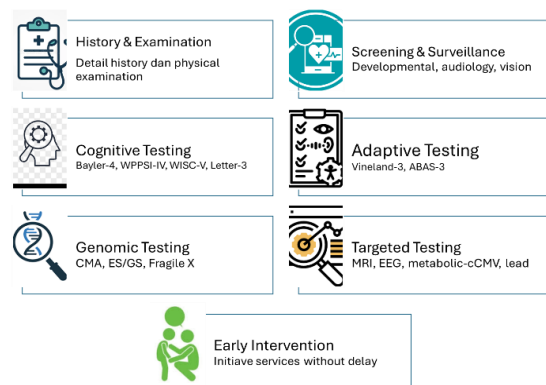


Fig. 5. Diagnostic evaluation of intellectual disability.

C. Probing Questions as Linguistic Scaffolding

Scaffolding provides structured assistance that can help learners move from independent performance toward more advanced performance. The relationship between scaffolding and the zone of proximal development provides a theoretical basis for distinguishing actual ability from potential ability (Xi & Lantolf, 2021).

Probing questions represent one form of linguistic scaffolding. Rather than providing the answer directly, probing questions encourage learners to clarify, extend, or elaborate an initial response. Structured questioning can support verbal participation and more elaborated responses when adapted to learners' abilities (Karousiou et al., 2026).

The studies in Table I show that probing has been used to investigate prior knowledge, learning difficulties, speaking, and learning performance. In the present study, probing is adapted specifically for children with MIID through short, gradual, and contextually familiar questions. This design allows the game to stimulate language production without directly determining the content of the response.

TABLE I
PREVIOUS STUDIES ON PROBING AND PROMPTING APPROACHES.

No.	Study	Reference
1	Cognitive and affective probing: A tutorial and review of active learning for neuroadaptive technology	Krol et al. (2020)
2	The learner's prior knowledge: A critical review of techniques for probing its organization	Sutton (1980)
3	The effect of applying the probing-prompting learning model based on a scientific approach to student learning outcomes in social arithmetic mathematics learning	Rosada (2023)
4	Probing-prompting learning in teaching speaking	Fajar (2020)

D. Technology-Based Learning for Intellectual Disabilities

Technology can provide repeated practice, visual support, structured interaction, and immediate feedback for children with intellectual disabilities. Digital gaming has shown potential for supporting phonological awareness among students with intellectual disabilities (Kumaş et al., 2025), while technology-supported communication has also been applied to students with MIID (Elkot et al., 2025).

Research from special-needs education also supports the use of structured technology. Baxtiyor and Sardor (2024) emphasized the role of information technology in special and inclusive education, while Baxtiyor and Sodiqovna (2025) reported that visual, multisensory, and game-based activities can support communication, comprehension, engagement, and independent task performance among children with intellectual disabilities.

Table II shows that assistive technologies have been used for academic skills, cognitive development, daily living, independence, and self-management. These findings support the development of technology that is adapted to individual

abilities rather than merely transferring conventional learning materials into a digital format.

TABLE II
PREVIOUS STUDIES ON TECHNOLOGY-BASED LEARNING AND DAILY FUNCTIONING FOR INDIVIDUALS WITH INTELLECTUAL DISABILITIES.

No.	Study	Reference
1	Review of twenty-first-century portable electronic devices for persons with moderate intellectual disabilities and autism spectrum disorders	Mechling (2011)
2	Developing technology-supported instructional activities in a class of middle school students with intellectual disability	Özgüç & Cavkaytar (2016)
3	Multimedia applications in special education: New opportunities for developing cognitive processes of children with intellectual disabilities	Derbissalova et al. (2024)
4	Using smartphone technology to improve daily living skills for individuals with intellectual disabilities	Stierle et al. (2023)
5	Teaching students with moderate intellectual disability to solve word problems	Browder et al. (2018)
6	Self-controlled technologies to support skill attainment in persons with autism spectrum disorder and/or intellectual disability	den Brok & Sterkenburg (2015)
7	The effectiveness of Multimedia in Education for Special Education to improve reading ability and memorizing for children with intellectual disability	Munir et al. (2018)
8	Assistive technology as a self-management tool for prompting students with intellectual disabilities to initiate and complete daily tasks	Mechling (2007)

E. Engineering Education and Game-Based Assistive Technology

From an engineering education perspective, assistive game development involves identifying a learning problem, defining user requirements, designing a technological solution, testing its functionality, and revising the product based on evaluation. In this study, limitations in verbal communication represent the user problem, while gradual probing, simple interaction, immediate feedback, and repeated practice become design requirements.

Figure 6 presents the conceptual relationship among assistive technology, learners, learning objectives, rules, community, and the roles of individuals involved in the learning environment. The framework illustrates that assistive learning technology functions as part of an interconnected system rather than as an isolated digital product.

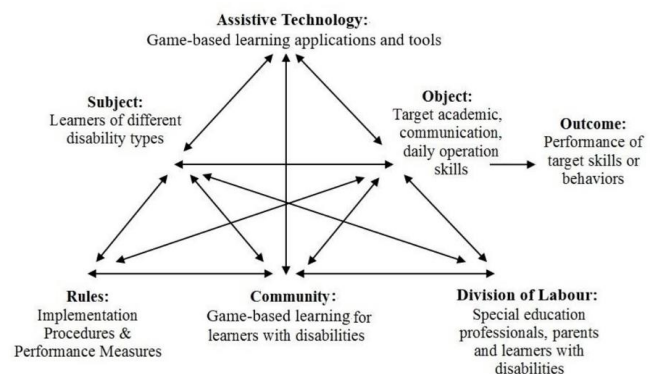


Fig. 6. Framework of game-based assistive technology for learners with disabilities.

This framework provides an engineering education basis for the present study because the probing game is developed as a human-centered technological solution. Its effectiveness depends on the alignment among learner characteristics, pedagogical objectives, interface design, game logic, feedback, and implementation context. Accessible digital learning environments should also be designed around learners' specific sensory and functional needs rather than technological features alone (Musayroh et al., 2023). Engineering education is therefore positioned here as the application of systematic and iterative design principles to an inclusive learning problem.

III. METHOD

A. Research Design

This study employed a research and development approach using the ADDIE model: analysis, design, development, implementation, and evaluation. The model was used as an iterative engineering education framework in which learner needs were identified, translated into game-design requirements, developed into an assistive application, tested, and refined through evaluation. The analysis phase used a descriptive qualitative cross-sectional approach. The purpose was to identify the characteristics, speech patterns, and verbal productivity of children with MIID in Indonesian language learning. The analysis focused on language phenomena and differences between actual and potential performance rather than statistical hypothesis testing.

B. Analysis and Design

During the analysis phase, verbal performance was examined in terms of vocabulary, phrase construction, sentence structure, verbal productivity, and pragmatic communication. Actual performance referred to responses produced independently, whereas potential performance referred to responses produced after structured probing. The results of this needs analysis were then translated into game-design requirements. The design phase included interface planning, game flow, probing patterns, coding structure, evaluation procedures, and assessment components. Gradual questions were designed to move from simple identification toward more elaborated verbal responses.

C. Development and Validation

The probing game was developed using the Unity engine. Development included the preparation of game interfaces, questions, response logic, feedback mechanisms, and progression between game stages. The content validation was limited to checking the learning materials as well as the probing questions, while media validation was mainly aimed at interface, presentation, and usability. A minor version of the product was then tested by five children with MIID, after which the product was improved according to the validator and user inputs. If seen from the perspective of engineering education, the said process of validation would correspond

to the production of the prototype and the simultaneous assessment that involves the evaluation of technical performance and educational relevance, and in this case both factors are taken into consideration at the same time and not one after the other.

D. Participants and Implementation

The game was actually used to educate fifth-grade children with MIID at the Semarang State Elementary School for Children with Special Needs, Central Java, Indonesia. Existing school psychological assessments were used to identify MIID, with the study referring to an intelligence-score range of 50–70. The participant criteria were: (i) an existing MIID diagnosis from an authorized institution, (ii) basic speaking ability, (iii) no severe hearing or visual disability, and (iv) willingness to participate in the research activities. Participant identities were protected using specific identification codes.

E. Data Collection and Analysis

The main data sources were spoken responses of children with MIID to Indonesian language-learning activities. The way the responses were collected included questions that were naturally integrated into the game scenario, short stories, and simple dialogues. Supporting data were collected from various sources, including classroom teachers, teachers' notes of the lessons, classroom materials, and field observation. Data gathering took place in two situations: free speaking and speaking with a helper. The vocabulary use, phrase-making, sentence structure, and verbal productivity features (e.g., mean utterance length) were covered in a linguistic analysis. Pragmatic analysis concerned speech functions and the use of politeness strategies. The difference between what was actually done at the surface and what was potentially possible had been characterized as descriptive and qualitative. Changes were interpreted through observable differences in response length, vocabulary variation, structural complexity, speech functions, and politeness rather than inferential statistical testing.

F. Evaluation

Evaluation took place during the various stages of ADDIE development. Results of the initial analysis were a basis for designing the game. Validation from content and media helped shape the revisions made in the development phase, where limited testing also highlighted usability and appropriateness issues. The implementation phase was put to good use to evaluate how the developed game supported probing-based interaction with children with MIID.

In the context of engineering education, this repeated cycle aligns with user-needs analysis, human-centered design, prototype development/validation, testing, implementation, and the evaluation of an inclusive assistive learning technology.

IV. RESULTS AND DISCUSSION

A. Development of the Probing-Based Assistive Game

This part is a description or explanation of the findings of the study, which can also be viewed as the main findings or key results to be reported in research. Movement from the initial step (need) of the design to the second stage (solution) in engineering education means that the design is being changed from the user requirements at hand into design specifications or requirements of technology.

The main aim of such an inquiry or probing system was to be a three-level questioning system as well. Simple questions aimed at triggering the child's verbal responses, whereas medium-level ones required the child to relate or to add something that the child knows from his/her experiences, while the advanced-level ones led to the expansion of ideas as well as reasoning of a very simple kind. Examples of the probing structure are presented in Table III.

TABLE III PROBING QUESTIONS ARE A MAJOR PART OF THE GAME'S INTERACTIVITY.		
Probing level	Example	Function
Basic	What do you see?	Trigger a verbal response
Medium	Where do you see it?	Add contextual information
Advanced	How does it happen?	Stimulate elaboration and reasoning

The gradual linguistic structure in Table III was meant to offer linguistic scaffolding without directly giving the right answers to the learners. This strategy coincides with the notion of probing that is structured and facilitates learners in further elaborating their own thoughts (Karousiou et al., 2026). It has also been used to justify the difference between current performance and potential performance that learners could achieve through the zone of proximal development (Xi & Lantolf, 2021).

In the same way, the interaction sequence was visualized as the game flow, presented in Figure 7. The illustration links initial responses to visual stimuli with probing, feedback, and various other game elements. Besides that, Figure 7 clearly reveals how educational goals were mapped into the game logic. The system is such that it is not just showing the children learning content passively; instead, it involves them in responding verbally. Moreover, when the child seems to elaborate the answers only a little, more guidance is given. From the viewpoint of engineering education, such a design shows how instructional requirements are seamlessly integrated with interaction and the system.

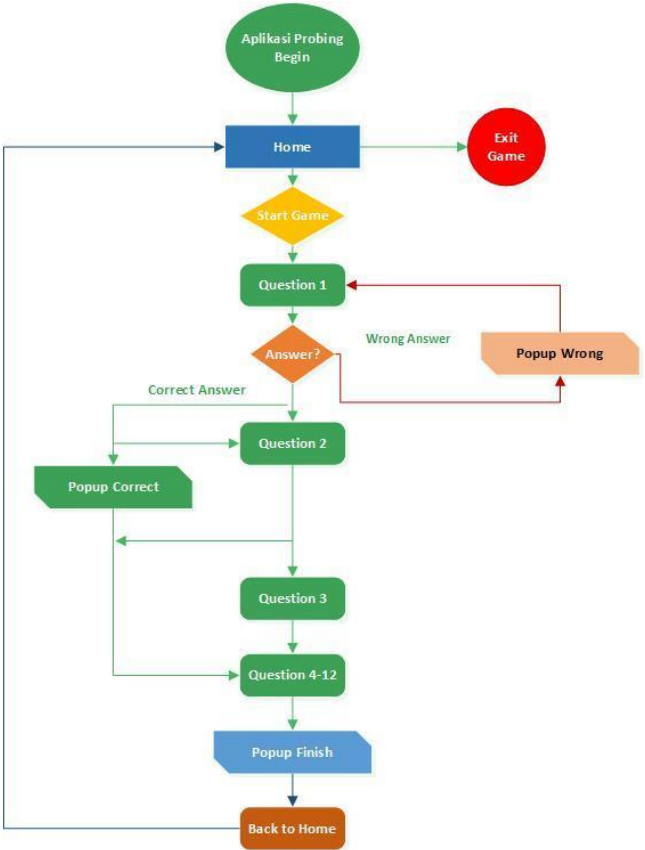


Fig. 7. Description of flowchart that shows the overall process of a developed probing-based assistive game.

B. Game Programming and Interface Development

The designed probing structure was implemented using the Unity engine. The programming stage connected questions, visual stimuli, interaction sequences, and feedback within the application. Figure 8 presents the script used to implement the probing mechanism.

```
using UnityEngine;
}

public class GameManager:
MonoBehaviour
{
    public GameObject home;
    public GameObject[] questions; // Drag Question1-Question12
    public GameObject popupCorrect;
    public GameObject popupWrong;
    public GameObject popupFinish;

    private int currentIndex = 0;

    void Start()
    {
        ShowHome();
    }

    public void StartGame()
    {
        home.SetActive(false);
        currentIndex = 0;
        ShowQuestion(currentIndex);
    }

    void ShowQuestion(int index)
    {
        HideAllQuestions();
        questions[index].SetActive(true);
    }

    void HideAllQuestions()
    {
        foreach (GameObject q in questions)
        {
            q.SetActive(false);
        }
    }

    // Calling if True
    public void AnswerCorrect()
    {
        popupCorrect.SetActive(true);
    }

    // Calling if false
    public void AnswerWrong()
    {
        popupWrong.SetActive(true);
    }

    public void NextQuestion()
    {
        popupCorrect.SetActive(false);
        currentIndex++;
        if (currentIndex < questions.Length)
        {
            ShowQuestion(currentIndex);
        }
    }

    public void RetryQuestion()
    {
        popupWrong.SetActive(false);
        ShowQuestion(currentIndex);
    }

    void FinishGame()
    {
        HideAllQuestions();
        popupFinish.SetActive(true);
    }

    public void BackToHome()
    {
        popupFinish.SetActive(false);
        ShowHome();
    }

    void ShowHome()
    {
        home.SetActive(true);
        HideAllQuestions();
    }
}
```

Fig. 8. Script used in the development of the probing-based game.

The script in Figure 8 represents the technical implementation of the instructional design. The development process therefore connected pedagogical decisions with software implementation, which is an important engineering education aspect of the study. The learning objective was first identified, converted into an

interaction requirement, and subsequently implemented as game functionality.

The application interface was designed to provide simple navigation and accessible choices. Figure 9 shows the game icon, home page, and location-selection interface.

The interface was kept relatively simple because children with MIID may require clear visual information and manageable interaction sequences. This reflects a human-centered design approach in which interface decisions are based on user characteristics rather than technological complexity alone. Such an approach is consistent with special-needs educational technology, where accessibility and learner requirements are central to system development (Baxtiyor & Sardor, 2024; Baxtiyor & Sodiqovna, 2025).

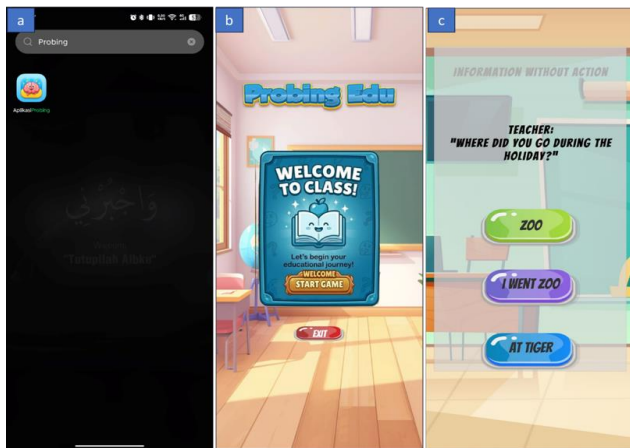


Fig. 9. Game icon, home page, and location-selection interface of the probing-based assistive game.

The assessment and interaction screens are presented in Figure 10. These components provide the environment in which children interact with visual material and respond to the probing questions.

Figures 8–10 show the progression from programming to user interface and assessment functions. Together, these components demonstrate an iterative engineering process in which instructional requirements are translated into software functions and subsequently presented through an accessible interface.

C. Validation and Limited Testing

The developed application was evaluated by content and media experts before classroom implementation. Content validation focused on the suitability of the learning materials and probing questions for children with MIID, whereas media validation considered appearance, font, interface elements, and usability. The expert review indicated that the application was suitable for further use after minor revisions. Adjustments were made to several icons and interface elements based on the feedback. Numerical validation scores were not available; therefore, the validation results were interpreted qualitatively rather than as quantitative evidence.



Fig. 10. Assessment and interaction screens of the developed probing-based assistive game.

A limited trial involving five children with MIID was subsequently conducted. The trial provided information about the accessibility of the game, the children's ability to follow the interaction sequence, and the suitability of the probing questions. The feedback obtained during validation and limited testing was used to revise the application before implementation. This validation–testing–revision sequence is important from an engineering education perspective because the developed technology was treated as an iterative prototype rather than a finished product at the first development stage. User and expert feedback therefore became part of the design cycle.

D. Development of Speech Patterns

The implementation results showed differences between children's initial verbal responses and responses produced after probing support. The observed changes occurred at the word, phrase, and sentence levels, as summarized in Table 4. Independent responses tended to involve relatively simple linguistic forms. After probing, the children demonstrated a broader range of verbal forms, including additional word classes, more varied phrases, and more complete sentence structures. These observations suggest that structured questions helped children elaborate responses that were not consistently produced during unaided speaking.

The difference should not be interpreted as evidence that probing permanently changed the children's language competence. Rather, it indicates that supported interaction revealed potential verbal performance beyond what was observed in initial independent responses. This interpretation is consistent with scaffolding and the distinction between actual and potential performance (Xi & Lantolf, 2021).

TABLE IV
ACTUAL AND POTENTIAL SPEECH PATTERNS OF CHILDREN WITH MILD INTELLECTUAL DISABILITIES.

Linguistic level	Actual performance	Potential performance
Word	Concrete nouns and basic verbs	Simple adverbs and adjectives began to appear
Phrase	Simple nominal phrases	More varied nominal and verbal phrases
Sentence	Simple single sentences and elliptical forms	More complete single sentences and simple compound sentences

E. Verbal Productivity

In addition to changes in linguistic structure, differences were observed in the length of children’s responses. Table V summarizes the comparison between actual and potential verbal productivity.

The results in Table V show that unaided responses were generally short, whereas probing-supported responses were longer and contained more information. This pattern suggests that gradual questioning provided additional opportunities for children to retrieve vocabulary, organize information, and extend their utterances.

The result is consistent with the intended function of the probing game. Basic questions initiate speech, while subsequent questions encourage additional contextual and explanatory information. Thus, the game does not simply increase the number of questions presented to children but structures those questions to progressively stimulate verbal production.

TABLE V
ACTUAL AND POTENTIAL VERBAL PRODUCTIVITY OF CHILDREN WITH MILD INTELLECTUAL DISABILITIES.

Aspect	Actual performance	Potential performance
Utterance length	Short responses consisting of one to two words or phrases	Longer responses consisting of one to two simple sentences

These findings are also consistent with previous research showing that digital and structured learning environments can support language-related activities among individuals with intellectual disabilities (Kumaş et al., 2025; Elkot et al., 2025). However, because the present analysis is descriptive and qualitative, the results demonstrate observed differences between unaided and supported responses rather than statistically established intervention effects.

F. Pragmatic Communication

The analysis also identified changes in pragmatic aspects of communication. These observations included direct speech, the emergence of politeness expressions, and the consistency of their use. The results are summarized in Table 6. Pragmatic development was less consistent than changes in vocabulary and sentence production. Politeness expressions began to emerge during probing-supported interaction, but their use remained variable. This finding is important because functional communication involves not

only producing longer utterances but also using language appropriately within social interaction.

TABLE VI
ACTUAL AND POTENTIAL PRAGMATIC COMMUNICATION OF CHILDREN WITH MILD INTELLECTUAL DISABILITIES.

Aspect	Actual performance	Potential performance
Direct speaking	Dominant	Began to decrease
Politeness expressions	Present only briefly	Began to emerge more clearly
Consistency	Low	Still fluctuated

The results therefore indicate different levels of development across linguistic and pragmatic dimensions. Improvements in supported verbal production were more clearly observable, whereas pragmatic consistency remained limited. This suggests that repeated interaction and longer-term practice may be necessary to strengthen socially appropriate language use.

G. Implications for Engineering Education

The findings demonstrate that the contribution of the study extends beyond the use of a digital game as a learning medium. The development process connected a specific human problem, limited verbal communication among children with MIID, with systematic technological design. Learner characteristics were translated into requirements for simple navigation, gradual questioning, visual interaction, immediate feedback, and repeated verbal practice.

This process provides a relevant example of engineering education through human-centered assistive technology development. Engineering design is applied not only to produce a technically functional application but also to create a solution that responds to the abilities and limitations of its intended users. The ADDIE stages further supported an iterative sequence of needs analysis, design, development, validation, testing, revision, and implementation.

The findings also reinforce the importance of connecting engineering education with inclusive design. Technologies developed for education should consider diversity in cognitive, linguistic, sensory, and functional characteristics. In this context, assistive game development provides an interdisciplinary connection among engineering education, educational technology, language learning, and special-needs education.

Overall, the study shows that the probing-based game provided a structured environment in which children with MIID could produce more elaborated verbal responses with assistance. The main contribution is therefore not a claim of statistically proven effectiveness, but the development and classroom application of a human-centered assistive technology that connects structured linguistic scaffolding with an iterative engineering design process.

CONCLUSION

This study developed and evaluated a probing-based assistive game to support speech patterns and verbal productivity in children with mild intellectual disabilities

(MIID). The game integrated gradual probing questions, visual interaction, and immediate feedback within an accessible digital environment. The findings showed that probing-supported interaction enabled children to produce more varied vocabulary, more developed phrases and sentences, and longer utterances than those observed during unaided speaking. Politeness expressions also began to emerge, although their use remained inconsistent. From an engineering education perspective, this study demonstrates how learner needs can be translated into technological design requirements through a human-centered and iterative development process. The integration of needs analysis, game design, software development, validation, testing, and evaluation illustrates the application of engineering design principles to an inclusive educational problem. Thus, the study connects engineering education, assistive technology, language learning, and special-needs education. Further research should involve larger samples and quantitative measures to evaluate the effectiveness and broader applicability of the developed game.

ACKNOWLEDGMENT

The authors would like to acknowledge Universitas Tidar and the participating special education school for their support during the development and implementation of this study. The authors also thank the teachers, experts, and participants who contributed to the validation and testing of the probing-based assistive game.

REFERENCES

- Akmaral, A., Kyalbek, A., Guldina, K., Abdikerim, M., Khalima, K., & Yerzhan, Y. (2025). Communication development in children with intellectual disabilities: Implications for education and psychology. *Journal of Intellectual Disability Diagnosis and Treatment*, 13(2), 96–107.
- Ayustyaningtias, R., Alinuridin, E., & Wahyudin, A. (2025). Improving students' critical thinking through blended learning media learning game word wall. *ASEAN Journal of Educational Research and Technology*, 4(1), 51–58.
- Baxtiyor, A. S., & Sardor, E. D. (2024). Transforming special and inclusive education: Leveraging information technologies for enhanced learning. *ASEAN Journal of Community and Special Needs Education*, 3(2), 95–104.
- Baxtiyor, A. S., & Sodiqovna, N. A. (2025). Organizing subject-practical activities to support the development of hearing-impaired children with intellectual disabilities. *ASEAN Journal of Community and Special Needs Education*, 4(1), 45–52.
- Browder, D. M., Spooner, F., Lo, Y. Y., Saunders, A. F., Root, J. R., Ley Davis, L., & Brosh, C. R. (2018). Teaching students with moderate intellectual disability to solve word problems. *The Journal of Special Education*, 51(4), 222–235.
- den Brok, W. L., & Sterkenburg, P. S. (2015). Self-controlled technologies to support skill attainment in persons with an autism spectrum disorder and/or an intellectual disability: A systematic literature review. *Disability and Rehabilitation: Assistive Technology*, 10(1), 1–10.
- Derbissalova, G., Shayakhmetova, A., Avagimyan, A., & Pyanova, E. (2024). Multimedia applications in special education: New opportunities for the developing of cognitive processes of children with intellectual disabilities. *Multimedia Tools and Applications*, 83(16), 49707–49721.
- Elkot, M. A., Youssif, E., Hago Elmahdi, O. E., AbdAlgane, M., & Ali, R. (2025). Generative conversational AI: Active practices for fostering students with mild intellectual disabilities to improve English communication skills. *Contemporary Educational Technology*, 17(1), ep549.
- Fajar, R. F. (2020). Probing-prompting learning in teaching speaking. *Expo Jurnal Pendidikan Bahasa Inggris*, 9(1), 86–95.
- Gupta, A., Nair, M., George, B., & M. L. (2023). Behavioural profile, linguistic skills, adaptive behaviours and intellectual functioning of school aged children with history of early language delay. *Journal of Nepal Paediatric Society*, 43(1), 9–14.
- Hofmann, V., & Müller, C. M. (2022). Challenging behaviour in students with intellectual disabilities: The role of individual and classmates' communication skills. *Journal of Intellectual Disability Research*, 66(4), 353–367.
- Kalland, M., & Linnavalli, T. (2023). Associations between social-emotional and language development in preschool children. Results from a study testing the rationale for an intervention. *Scandinavian Journal of Educational Research*, 67(5), 791–804.
- Karousiou, C., Evagorou, M., & Vrikki, M. (2026). Enhancing university students' questioning techniques in dialogic and argumentative practices. *Higher Education Quarterly*, 80(1), e70102.
- Koizumi, M., Kobayashi, W., Ogawa, S., & Kojima, M. (2026). Vocabulary and syntactic development in Japanese children with autism spectrum disorder and down syndrome accompanied by intellectual disability. *Journal of Intellectual Disability Research*, 70(2), 171–179.
- Krol, L. R., Haselager, P., & Zander, T. O. (2020). Cognitive and affective probing: A tutorial and review of active learning for neuroadaptive technology. *Journal of Neural Engineering*, 17(1), 012001.
- Kumaş, Ö. A., Dada, Ş. D., & Dodur, H. M. S. (2025). Enhancing phonological awareness skills in students with intellectual disability through digital gaming intervention. *Journal of Computer Assisted Learning*, 41(3), 1–16.
- Kurniawati, K. (2022). Efforts to improve the vocabulary of Indonesian language for 1st-grade elementary students with hearing impairment through the application of mnemonic. *ASEAN Journal of*

- Community and Special Needs Education*, 1(2), 81–88.
- Mechling, L. C. (2007). Assistive technology as a self-management tool for prompting students with intellectual disabilities to initiate and complete daily tasks: A literature review. *Education and Training in Developmental Disabilities*, 42(3), 252–269.
- Mechling, L. C. (2011). Review of twenty-first century portable electronic devices for persons with moderate intellectual disabilities and autism spectrum disorders. *Education and Training in Autism and Developmental Disabilities*, 46(4), 479–498.
- Munir, M., Setiawan, W., Nugroho, E. P., Kusnendar, J., & Wibawa, A. P. (2018). The effectiveness of multimedia in education for special education (MESE) to improve reading ability and memorizing for children with intellectual disability. *International Journal of Emerging Technologies in Learning*, 13(8), 254.
- Musayaroh, S., Asmiati, N., Utami, Y. T., Mulia, D., Sidik, S. A., Abadi, R. F., Pratama, T. Y., Maslahah, S., & Pramudyo, A. S. (2023). A digital accessibility and inclusive design-based e-module in higher education: Does it work in a classroom with a deaf student? *ASEAN Journal of Community and Special Needs Education*, 2(1), 55–60.
- Özgüç, C. S., & Cavkaytar, A. (2016). Developing technology supported instructional activities in a class of middle school students with intellectual disability. *Education and Science*, 41(188), 197–226.
- Rosada, A. (2023). The effect of applying the probing prompting learning model based on a scientific approach to student learning outcomes in social arithmetic mathematics learning. *Indonesian Journal of Education Research (IJoER)*, 4(3), 49–53.
- Sajewicz-Radtke, U., Łada-Maśko, A. B., Jurek, P., Olech, M., & Radtke, B. M. (2025). Reading and writing abilities in students with mild nonspecific intellectual disability: A multivariate examination of literacy and cognitive processing abilities. *Journal of Intelligence*, 13(12), 161.
- Stierle, J., Ryan, J. B., Katsiyannis, A., Mims, P., Carlson, A., & Allen, A. (2023). Using smart phone technology to improve daily living skills for individuals with intellectual disabilities. *Journal of Applied Research in Intellectual Disabilities*, 36(5), 1169–1178.
- Susilawati, A., Nandiyanti, S. R., Siddik, N. A. C., & Nandiyanto, A. B. D. (2025). How to do research in science and engineering education: A methodological framework with lessons learned from common research failures, bibliometric analysis, and practical insights. *ASEAN Journal of Educational Research and Technology*, 4(3), 507–522.
- Sutton, C. R. (1980). The learner's prior knowledge: A critical review of techniques for probing its organization. *European Journal of Science Education*, 2(2), 107–120.
- Wallin, S., Hemmingsson, H., Thunberg, G., & Wilder, J. (2024). Turn-taking and communication modes of students and staff in group activities at non-inclusive schools for students with intellectual disability. *Augmentative and Alternative Communication*, 40(1), 19–30.
- Xi, J., & Lantolf, J. P. (2021). Scaffolding and the zone of proximal development: A problematic relationship. *Journal for the Theory of Social Behaviour*, 51(1), 25–48.