Development of a UDL-Based Learning Management System by Including the Voice of Deaf and Autistic Students

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ABSTRACT

Learning management system (LMS) is one of the learning spaces that can be used flexibly and independently in inclusive classes. This study described the steps in developing Semester Learning Plan (SLP) and LMS through 5 stages of design thinking: Empathize, Define, Ideate, Prototype, and Test. This study involved 3 deaf students, 1 autistic student, and 29 non-disabled students as respondents and experts to assess and provide input on the development of SLP and LMS. The results of the LMS development showed an increase in students' assessment of LMS accessibility with a moderate positive effect. The LMS was categorized as good in terms of its fulfilment of UDL principles, accessibility of learning tools, pedagogical feasibility, and ease of use. Further improvements are needed to advance the accessibility of the LMS.

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1. INTRODUCTION

Higher education institutions still face numerous challenges in upholding the educational rights of people with disabilities, encompassing aspects of substance, structure, and culture (Amnesti et al., 2023), including appropriate curriculum accommodations. Yet, government regulations allowing students with various disabilities to participate in higher education, leading to an increasing number of university enrolments.

With the increasing diversity of students entering higher education, appropriate learning accommodations are needed that address their characteristics and learning needs. A learning environment accessible to students independently is becoming increasingly important. An LMS is one learning space that can be used flexibly and inclusively (Kontio, 2025). Research from the Center for the Study of Individuals with Special Needs on students with disabilities at Sanata Dharma University indicates that deaf students find the comprehensive information available in the LMS helpful, but not all LMSs are equipped with accessible materials. Furthermore, deaf students reported that some LMS content is difficult to understand due to language barriers (Kurniastuti et al., 2025). Therefore, it is

necessary to develop an LMS that fulfills the diverse needs of students, particularly students with disabilities.

Although research (Mujiono et al., 2018) has begun incorporating the universal design for learning (UDL) approach for inclusive classes, many studies related to LMS have not yet incorporated the UDL principles (Almayeni & Marlina, 2023; Anggara et al., 2024). However, a research review (Lomellini et al., 2025; Masitoh et al., 2022; Saini et al., 2024; Utami et al., 2025) on online learning in higher education recommends the use of UDL principles for flexible learning that accommodate diverse student needs. LMSs should be developed to provide multiple means of engagement, representation, and action and expression, so students, including those with disabilities, can access materials in various formats according to their needs.

A structured and comprehensive planning that includes UDL principles (Maslahah et al., 2023) is required because students with disabilities still have problems in using LMS in inclusive classes (Kusumastuti et al., 2022) The novelty of this research is developing an inclusive LMS that integrates UDL principles and based on input from regular students, autistic students, and deaf students using five design thinking steps.

Inclusive LMS Model

Based on literature reviews, the implementation of UDL as a tool for creating inclusive learning will remain relevant for the next decade (Fovet, 2020). UDL principles can be an alternative in developing an inclusive LMS. The general principles of UDL for reducing learning barriers and obstacles, according to Center for Applied Special Technology in (Dalton, 2017), are as follows:

1. Multiple Means of Representation, a variety of flexible methods of presenting content and information are used to support the learning process.
2. Multiple Means of Action and Expression, a variety of flexible methods of action and expression are integrated into lessons to support strategic learning.
3. Multiple Means of Engagement, a variety of flexible options for engaging in the learning process are used to support affective learning.

In addition to fulfilling UDL principles, accessibility to the LMS is also required. In LMS development, when learning materials are provided in video format, for example for deaf students, subtitles and closed captions (CC) are required. The video's narrative uses sentence structures with the following criteria: using commonly used words, avoiding technical and academic terms, using active voice and simple sentences (consisting of a subject, predicate, and object) (MD et al., 2021). Multimedia is developed in the form of animated videos equipped with sign language, narrative text, visual images, and subtitles (Astuti et al., 2022).

Adjustments for students with autism require attention to the following: Adapting learning materials and methods to individual learning styles; The LMS's appearance should be consistent and organized, avoiding excessive changes to the template, as autistic students are sensitive to change and uncertainty; Learning media should be tailored to student needs; audio should be present, but not excessively loud or noisy; and the LMS should be designed to be sensory-friendly, such as simple in appearance and easy to navigate with color coding or charts (Tholkapiyan et al., 2025).

The development of a UDL-based LMS conducted in this study was supported by the journal "How LMS Shapes Inclusive Education" (Julien, 2024). When an LMS integrates UDL, it must accommodate various learning styles and accessibility needs, such as alternative text for images, subtitles for videos, and voice-based navigation. Multiple means of representation, engagement, and expression must be implemented so students can learn at their own pace. Furthermore, the LMS needs to be personalized and adaptive, supporting learning that can be tailored to student needs, such as video speed control, customizable text, and multimodal input options. The LMS should also integrate assistive technologies like artificial intelligence (AI) where appropriate. The LMS should also provide a collaborative and interactive environment. Discussion forums, chat rooms, and video conferencing features that are inclusive of all students, including those with sensory or mobility limitations, should be provided.

2. METHODS

This research follows the five-step design thinking process proposed by the Hasso-Plattner Institute of Design at Stanford (Deepa, 2020). In its development, the researcher incorporated a problem statement, which served as a benchmark for developing a UDL-based SLP and LMS. The subjects of this study were 29 regular students, 1 autistic student, and 3 deaf students. The instruments used were validated based on content validity. The study was conducted from February to July 2025. This study involved 5 validators capable of assessing the designed product.

Table 1. Problem Statement Explanation Steps

Steps	Description
Empathize	Identifying the problems students faced in using LMS and accessing teaching materials from lecturers, conducting studies related to the needs of inclusive classrooms, considering the presence of students with disabilities.
Define	Collecting data by interviews, questionnaires, and analysing the existing SLP and LMS.
Ideate	Synthesizing the data collected and the theoretical basis studied, developing various alternative solutions for developing LMS and teaching materials suitable for inclusive classes.
Prototype	Developing an LMS that could be accessed by regular, deaf, and autistic students based on UDL principles.
Testing	A team of inclusive experts is asked to provide assessments and feedback on the developed product. Assessments are also conducted by regular, deaf, and autistic students as LMS users.

3. FINDINGS AND DISCUSSION

The following is the explanation of each step of design thinking in developing the SLP and LMS summarized from data collected from students taking the Indonesian Contemporary History course, as well as autistic and deaf students at Sanata Dharma University.

Step 1: Empathize (identify user needs)

Non-disabled students: Most students did not experience significant obstacles when accessing the LMS. The most common issues were internet connection issues and occasional server downtime. However, they needed several things such as dark mode feature, a customizable display, multilingual features, a more responsive notification system, videos with subtitles, a more user-friendly interface, a chart-like display of course sequences, and feedback from lecturers.

Deaf Students: The three deaf students found the LMS helpful because they could access materials, PowerPoint presentations, journals, and videos with subtitles and CC. The problem was that not all lecturers uploaded complete materials. Furthermore, not all uploaded videos have subtitles and CC. They also expressed difficulty understanding relatively long passages with many new terms, especially texts in English. A summarized material, created as a PowerPoint presentation, provided explanations of difficult terms, or provided a translated version in Indonesian, would be significantly helpful for them. In addition, presenting materials in the form of diagrams, animations, or recorded lecturers' explanations would also be very helpful in learning. A question-and-answer feature between lecturers and students would significantly aid comprehension.

Autistic Student: An autistic student expressed a need for a simple LMS interface. He often struggles with lengthy instructions or introductions. It is easier if step-by-step information and illustrations in the form of pictures or charts is provided. It will be better to include a dictionary of difficult terms and illustrations explaining the context of the material in LMS. Practice questions should

be provided to aid comprehension through automatic feedback. Autistic students are often afraid and shy to speak in class or in unfamiliar groups, so a discussion forum with familiar people in LMS would be very helpful for assignments. Furthermore, due to their language limitations, lecturers should consider allowing extended time for completing assignments. While not all videos uploaded to the LMS have subtitles, autistic students find it more helpful to understand if they have subtitles. A text-to-speech feature could also be added for further understanding. To understand instructions, it is better to use simple language, along with clear illustrations and short sentences. An open-book method for evaluating lectures for autistic students will be very helpful in completing assignments. A question-and-answer feature or chat with lecturers feature on WhatsApp would be very helpful, as autistic students are less likely to ask direct questions and are afraid of processing emotions, such as being overly sensitive to angry tones.

Step 2: Define (State user needs and problems)

The needs and problems of LMS users and the development of the SLP were as follows:

1. Ease of access

   Most students complained about slow server access. Therefore, it is important to consider selecting LMS content that requires lower internet bandwidth and easily accessible despite network limitations.

2. Simple Interface and Easy Navigation

   Both regular and autistic students want an LMS interface that is simple, user-friendly, and customizable (e.g., dark mode, step-by-step displays, display proper visual graphics/charts, and minimal information distractions).

3. Language Options for Various Needs

   There should be language options in Indonesian and English with a variety of difficulty levels, such as translations of foreign terms, a dictionary or glossary, material summaries, and supporting visual formats such as pictures, diagrams, and illustrations.

4. Video and Audio Features

   Subtitles and CC are required for all learning videos. Text-to-speech and screen reader features are also needed.

5. Interactive Communication System

   All student groups require flexible interaction between students and lecturers. However, asynchronous discussion forums are still needed, especially for autistic students. WhatsApp groups are also needed for direct communication. If available in the LMS, notification features should be activated for assignments, responses, and assignment submissions.

6. Learning Support Independent

   All students need practicing problems with automatic feedback to check their understanding. Autistic students with language limitations suggested an open-book evaluation model. Deaf students suggested presenting material with visual illustrations to explain difficult concepts.

7. Need for Emotional Comfort

   Autistic students feel more comfortable working in familiar groups. The LMS should facilitate interactions that do not trigger social anxiety. For example, discussions should not always take place in person in class, but rather through discussion forums in the LMS or WhatsApp groups.

Step 3: Ideate

Based on gathering various assumptions and theories, synthesizing, and developing various development ideas from students, the main idea for developing the SLP and LMS is based on the UDL approach, which includes Multiple Means of Representation, Multiple Means of Action and Expression, Multiple Means of Engagement, providing a learning environment, and adaptive formative and summative assessment.
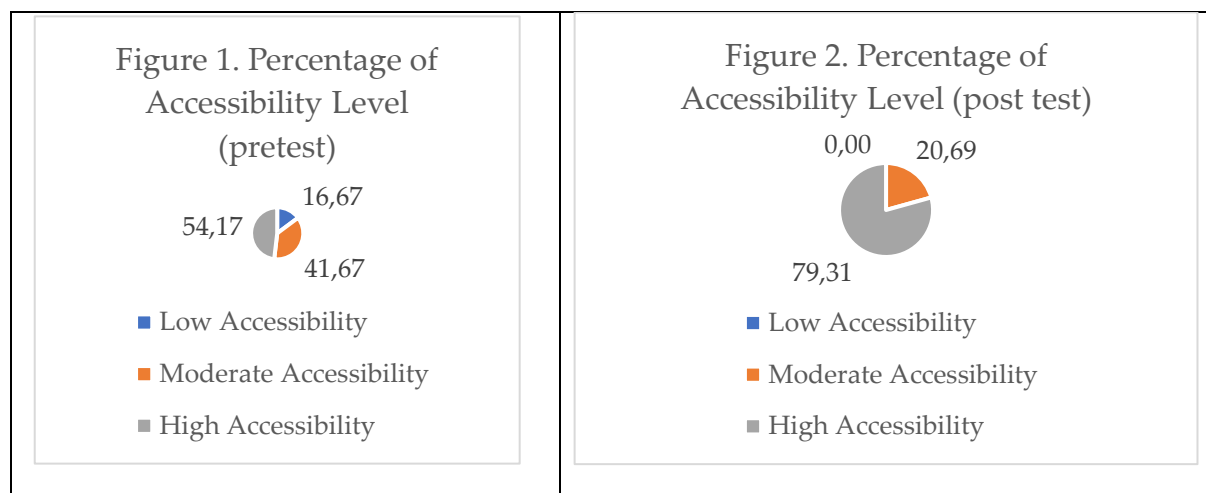
Step 4: Prototype (Creating an Initial Model of an Inclusive LMS)

Results preparation of products in the form of SLP along with learning tools and preparation of an inclusive LMS can be accessed at learning management system provided by campus.

Step 5: Testing (Trial and Evaluation of the Inclusive LMS)

Students were asked to assess the SLP and LMS twice: before and after improvements and development efforts. They were given a questionnaire that revealed how the LMS development met the UDL principles and accessibility.

A paired-samples t-test was conducted to examine whether there was a significant difference between participants' pretest and posttest scores. The analysis revealed a statistically significant increase from the pretest (M = 60.25, SD = 15.40) to the posttest (M = 74.30, SD = 14.80), $t(19) = -2.18$, $p = .042$, $d = 0.49$, indicating a medium effect size.

Figure 1. Percentage of Accessibility Level (pretest)

16,67
54,17
41,67

- Low Accessibility
- Moderate Accessibility
- High Accessibility

Figure 2. Percentage of Accessibility Level (post test)

0,00   20,69
79,31

- Low Accessibility
- Moderate Accessibility
- High Accessibility

The study also conducted questionnaires with five validators to assess the developed SLP and LMS. Each assessor provided an assessment related to the fulfilment of UDL principles, accessibility of learning tools, pedagogical feasibility, and ease of use as shown at table 3.

Table 3. Validator Assessment and Feedback

Aspects of UDL	Validator's comments	Recommendation
Multiple means of representation	The material is already diverse (video, text, audio) but needs adjustments for various disabilities: videos need sign language and Indonesian subtitles, the reading is still too dense, the font needs to be dyslexia-friendly, audio needs to support screen readers, infographics are more recommended.	Add Indonesian subtitles, sign language, infographics, and simplified text versions; use dyslexia-friendly fonts (e.g., OpenDyslexic); ensure formatting is compatible with screen readers.
Multiple Means of Action & Expression	The methods used to help students express their understanding are varied, but alternatives are needed for deaf and autistic students. Online discussions or LMSs can be used for students who have difficulty communicating in person.	Provide alternative presentation formats (visual, written, video), and online discussion spaces; use consistent assessment terms.

Multiple Means of Engagement	The teaching strategies used are good. However, they need to ensure inclusivity for all. The videos provided need to be contextual, the quizzes should be engaging, and quick communication via chat is helpful.	Use videos that are relevant to students' lives, create interactive quizzes, and provide quick communication channels with lecturers.
Accessibility	Most of the features are adequate, but not all videos have subtitles/JBI, and there's no audio support for text-to-speech. The LMS interface is considered simple and autistic-friendly, but it needs clear instructions and simpler materials.	Add subtitles and JBI; provide text-to-speech features; create a clean interface, with step-by-step guides and simple illustrations.
Multiple Means of Engagement	Assignments vary, but simplification of certain tasks and an open-book approach are recommended. Features like help chat, summaries, and glossaries are also included.	Add simple assignment options, encourage open book methods, and maintain the help chat and summary/keywords features.
Pedagogical Feasibility and Ease of Use in Inclusive Classrooms	The structure is clear, but task analysis is needed to make it easier for students with learning difficulties to follow. Some instructions are still unclear.	Use structured steps and task analysis-based task guides.
Curriculum adjustments and individual support	The curriculum is appropriate but needs clarity regarding the criteria for modifications (whether only those with a diagnosis are eligible). Students also requested flexibility in time and peer support.	Explain the criteria for receiving modifications, provide flexible options (time, level of difficulty), and facilitate peer support or mentoring.

The results of the pretest and post-test on student use of the LMS showed an increase in accessibility. This indicates that students input in the development of the sections is indeed aligned with their needs. However, despite the various input and comments from students, there are still areas that have not been adequately addressed, including students with disabilities.

In this study, deaf students expressed their appreciation for the LMS development, which provided additional options for studying Indonesian Contemporary History. The History course material is characterized by reading lengthy texts, including texts in English (the deaf students' native language: Indonesian). Therefore, considering the limited language proficiency of deaf students, the LMS design included translated readings, summaries of the readings, and a glossary of difficult terms. Furthermore, it included self-administered quizzes with automatic feedback to check student understanding. This finding is supported by research by Musayaroh et al., who developed an interactive module for deaf students (Musayaroh et al., 2022).

Figure 3. Reading Text Selection Menu with Various Levels of Understanding

One feature needed by autistic students and regular students who are uncomfortable expressing their opinions verbally, whether in small or large groups, is a discussion forum feature. History classes typically include discussions involving the discussion and analysis of historical texts and artifacts. The discussion forum feature provided in the LMS is very helpful for students with limited social participation.

Autistic students need programs that support social inclusion. Students with autism often have limitations in social participation. Educators need to provide emotional support and create a supportive environment so that autistic students can participate in classroom and community activities, taking into account each student's unique routines (Shaham et al., 2025). However, in certain circumstances, students sometimes prefer to express their opinions in writing rather than verbally. Students are given the freedom to choose whether to express their opinions orally or in writing, provided both learning modes are available.

Figure 4. Discussion Forum Feature in LMS

Based on qualitative feedback provided by students during the needs analysis, they desired a feature that could adjust the screen display. Apparently, students were still unaware that the Moodle LMS already has a feature that can adjust the display of letter size, screen brightness, and font for students with dyslexia or reading disorders. This feature can automatically be adjusted by students themselves.

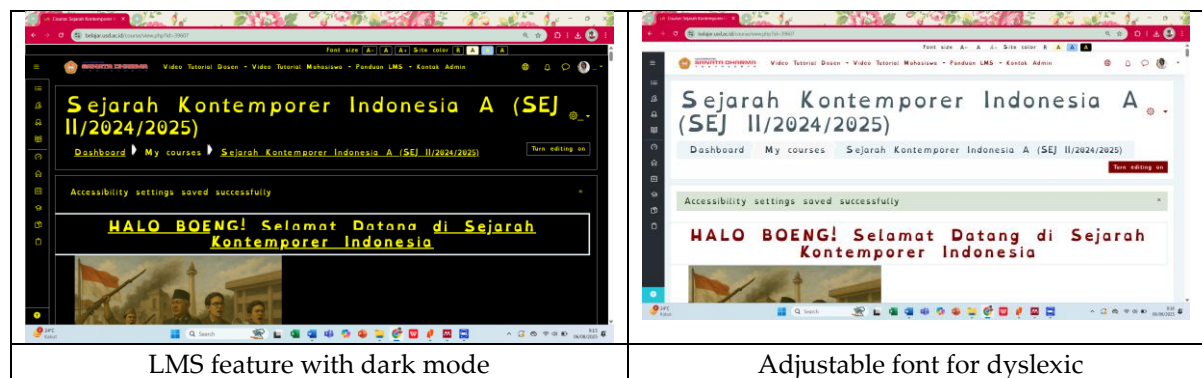| LMS feature with dark mode | Adjustable font for dyslexic |

Figure 5. Accessibility setting for background and fonts

Selecting the right font type and size, foreground and background colors, line spacing, sentence length, and text difficulty play a significant role in text readability. A black and white color combination is considered one of the best for achieving optimal text readability and legibility (Zorko et al., 2017). In this study, the use of a dark mode with high contrast was reported to improve readability. Furthermore, students with visual impairments, such as low vision, can choose between black-and-white or full-color learning options (Yuwono et al., 2023).

Accommodating the diverse learning needs of students is challenging, and technological assistance is necessary (Soliyev, 2023). Similarly, in this LMS development research, various efforts have been made to accommodate the learning needs of all students. Technology plays a crucial role in assisting lecturers in preparing LMS content. Technology assists in providing text translations, summaries, and illustrations. Artificial intelligence (AI) technology is also used to create various tests or quizzes with automated feedback to aid student understanding. This is also the case in LMS development at various universities. AI can be used to assist in creating quiz questions and integrating them with the LMS (Zain, 2024).

A limitation of this study is the lack of support for sign language interpreters (SLI), although input was provided in the needs analysis and expert comments. This is due to the limited availability of SLI. Therefore, to help deaf students better understand the material, we need to develop comprehensive LMS materials and content. It is hoped that modified teaching materials, such as simplified language, a glossary of difficult words, visual illustrations, and videos with subtitles and CC, will help deaf students understand the material.

The results of the SLP and LMS development in this study demonstrated positive results, but there is still room for improvement. One of the findings was the low Krippendorff's alpha value, -0.149 (SE = 0.030; 95% CI [-0.205, -0.095]). This value indicates significant disagreement between assessors and is far below the minimum acceptable reliability threshold, which is 0.667 for initial decisions and 0.800 for final decisions (Marzi et al., 2024). Most errors in calculating reliability are caused by the number of raters and the measurement scale of the relevant variables. Failure to consider these factors will result in unrealistic reliability calculations (Shabankhani, 2020). This is likely the reason for the low-quality assessment of the LMS and SLP development in this study. The assessors for this research product consisted of three inclusive education experts and two other assessors, considered experts due to their disabilities and deemed capable of providing insights from their experiences, were one autistic student and one deaf student. Disagreements between the ratings given by the raters were indeed evident among the professional expert group and the group of students with disabilities. What seems appropriate to an expert assessor without a disability may be a significant concern for an assessor with a disability. Another possibility could be a different perception or understanding of the instrument used.

The research findings and explanations above indicate that in developing inclusive learning, we need to consider the perspectives and voices of people with disabilities, even though we have attempted to develop products in accordance with existing research and theory. A fundamental key to developing inclusive pedagogy is understanding. Lecturers can ask their students how they can help

them and trust them to make informed choices regarding their own learning. Furthermore, it is crucial to recognize students' personal interests, assess their prior knowledge, and provide relevant programs and information at the beginning of the course. For students with disabilities, prior access to materials is crucial for understanding explanations and assimilating information, as well as prior planning for organizing their assignments. Lecturers need to utilize methodological diversity that addresses diverse learning styles, motivations, interests, and capacities. The foundation of inclusive pedagogy is ensuring student success through their participation in class, while recognizing their individual differences (Carballo et al., 2021).

This research demonstrates that the task of lecturers becomes challenging when accommodating diverse student populations in inclusive classrooms. The educators cannot struggle alone in implementing inclusive education and developing a curriculum that addresses all students' needs. Educators' lack of understanding of the conceptual framework for curriculum development also impacts curriculum implementation. Furthermore, educators with a strong background or experience in inclusive education tend, consciously or unconsciously, to implement learning principles that support the needs of all students. A policy that ensures every educator has knowledge and effective implementation of an inclusive curriculum is needed (Mosito et al., 2025).

Indeed, not all lecturers are able to accommodate the needs of inclusive students and develop an adequate LMS. This was also reflected in student comments, which indicated that not all lecturers developed a comprehensive and accessible LMS. It is possible that lecturers' lack of LMS development is also due to limited knowledge of the inclusive education paradigm. However, it is true that there has not been much publicity regarding inclusive education at the university level. In this regard, the task of providing information to lecturers should not be solely the responsibility of higher education. All of teachers and lecturers are primarily responsible for implementation, and the challenge often lies in a lack of resources and training (Bourke et al., 2025). Teacher training can positively impact teacher attitudes toward inclusive education, teaching strategies, and knowledge about disabilities. Teacher training on inclusive education can be provided during pre-service and in-service training. Commitment from various stakeholders is needed to create policies that support inclusive education (Mendoza & Heymann, 2024; Mitchell, 2023). Improving teaching practices for students with disabilities will positively impact teaching and learning for all students (Fernández-Batanero et al., 2022). UDL is expected to be able to provide perspective to society so that they can accept diversity (Anggraini & Subasno, 2024). It also expands attention beyond LMS development and classroom learning to include the provision of facilities and infrastructure (Harahap et al., 2019).

There is no "magic solution" that can address accessibility and inclusion issues for students with disabilities who choose to study both online and offline (Edwards, 2022). Cultural change must be driven by institutional policies and practices. Effective strategies from policymakers and educational leaders are still needed (Lomellini et al., 2022; Umeshkumar Sharma, 2024). Also public awareness is needed so that universities can better understand how to implement inclusivity in educational institutions: availability, accessibility, acceptability, and adaptability (Kirno & Premchaiporn, 2022). One way to achieve this is by developing an inclusive LMS that is more accessible to all students, including those with disabilities. Apart from that, this research also reminds us about the importance of technological support to realize inclusive education (Veytia Bucheli et al., 2024).

4. CONCLUSION

The development of this LMS and SLP followed the five steps of design thinking: (1) Empathize, (2) Define, (3) Ideate, (4) Prototype, and (5) Test. The development steps obtained input from students, including deaf and autistic students, which became the basis for efforts to develop UDL-based SLP and LMS. The developed product has a relatively good level of accessibility, as seen from its compliance with UDL principles, accessibility of learning tools, pedagogical feasibility, and ease of use, although it has not yet shown consistency between raters. Future research is expected to conduct more accessible developments based on input from experts and students with disabilities.

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