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UP-Think in UDL MAthematics: Student Participation and Thinking Analysis

[1*]Indah Rahayu Panglipur, [2]Septi Triayani
[1]Faculty of Teacher Training and Education, PGRI Argopuro University, Jember, Indonesia
[2]Faculty of Teacher Training and Education, Sebelas Maret University, Surakarta, Indonesia
*Corresponding Author e-mail: indahmath89@gmail.com

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Abstract

This study evaluates the implementation of Universal Design for Learning (UDL) in mathematics instruction witha focus on students with visual impairments, a context that has not been sufficiently explored in higher education. Although UDL has been widely recognized as an inclusive approach, previous studies have primarily concentrated on general or primary–secondary education, leaving a gap in empirical evidence regarding its application in higher education mathematics. This research introduces the UP-Think (Understanding Participation and Thinking) framework as a novel contribution that integrates two essential dimensions: active student participation and higher-order thinking ability. Participation (asking, responding, collaborating); Thinking (conceptual, critical, creative) measured by easured by observation rubrics, a student-engagement questionnaire, pre–post concept-understanding tests, and a critical/creative thinking rubric with established reliability. Using a mixed-method descriptive evaluative design, data were collected from observations, questionnaires, pre–post tests, and interviews involving students of the Special Education Study Program. The results indicate a substantial increase in participation, with 79% (22/28) of visually impaired students more actively asking questions, 85% (26/28) responding and justifying answers, and 85% (26/28) engaging in group collaboration. In terms of thinking ability, 68% (19/28)achieved notable gains in conceptual understanding, 86% demonstrated consistent critical reasoning, and 78% displayed creative problem-solving strategies. These findings imply that accessible assessment design and lecturer training are essential for sustaining the benefits of UDL. Institutions should invest in systematic professional development and adaptive technology provision so that inclusive mathematics instruction can be implemented consistently and equitably across courses.

Keywords: Universal Design for Learning (UDL); Mathematics Instruction; Visual Impairment; Student Participation; Thinking Ability; UP-Think

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INTRODUCTION

Universal Design for Learning (UDL) in mathematics education has been widely studied and explored in recent years. However, its implementation, particularly in mathematics instruction for students with visual impairments, has not yet been fully optimized. Therefore, it is essential to conduct research on the application of UDL in mathematics learning for visually impaired students, with the aim of evaluating their participation and thinking abilities. The novelty of this study lies in its specific focus on the implementation of Universal Design for Learning (UDL) in mathematics instruction for students with visual impairments, an area that has not been optimally explored. Unlike previous research that mainly emphasizes accessibility or instructional design, this study introduces the concept of UP-Think (Understanding Participation and Thinking) to evaluate both student participation and thinking abilities. Although UDL has been widely recognized, empirical indicator-level evaluations of its effects on participation and thinking in higher-education mathematics for visually impaired learners remain scarce. Existing UDL rubrics do not explicitly integrate participation and thinking outcomes. This framework provides a fresh theoretical contribution and practical implications for developing more inclusive and effective mathematics learning. Learning mathematics in higher education presents significant challenges for students of the Special Education Study Program (PLB), especially due to the diversity of student characteristics that include visual impairments, learning disabilities, motor disabilities, and information processing disorders. Mathematics as a discipline is highly abstract and symbolic, with an emphasis on formal logic, numerical manipulation, and visual representations such as graphs and diagrams (Ince-Muslu & Erduran, 2020). This makes it difficult for PLB students, especially those with sensory or cognitive challenges, to access, understand and express mathematical concepts optimally. Many of them have difficulty in following mathematics learning that is delivered linearly and one-dimensionally without alternative media that supports their learning style (Rao et al., 2014). This difficulty is further exacerbated by the conventional learning model in higher education, which has minimal differentiation. In general, lecturers rely on lectures as the main method of delivering material, with little variation in media or learning approaches. Additionally, the format of learning evaluation is usually inflexible, such as written exams based on numbers or symbols, without considering the different expressive abilities of students with special needs (Tzivinikou & Papoutsaki, 2016). Students with disabilities have their own uniqueness in their learning activities, and this must be understood (Panglipur et al., 2024). As a result, PLB students are often unable to demonstrate their understanding of concepts to their full potential due to non-inclusive evaluation (Coyne et al., 2010). Limited access to assistive technology and adaptive media such as screen reader software, braille media, or concrete manipulatives are additional barriers to meaningful math learning.

Most lecturers have not been provided with systematic training on inclusive learning strategies based on Universal Design for Learning (UDL) principles, even though UDL has been proven as an effective approach to accommodate different learning needs through providing various ways of representation, expression, and engagement (Hartmann, 2015; Al-Azawei et al., 2016). Without the application of these principles, PLB students are vulnerable to experiencing barriers to access to materials, low participation in class, and low confidence in learning mathematics. (Anna et al., 2024).In the face of these challenges, the Universal Design for Learning (UDL) approach offers a powerful solution to create a learning system that is more inclusive, equitable, and responsive to the needs of students with diverse conditions (Lintangsari & Emaliana, 2020). UDL is developed based on the principle that learning barriers do not lie with the individual, but with learning designs that are inflexible and unable to accommodate differences in learning styles, backgrounds, and abilities of learners. Through its main principles of multiple means of representation, multiple means of action and expression, and multiple means of engagement, UDL is able to support students' learning (Darrow, 2018). UDL encourages educators to present material in a variety of formats, provide choices of how students express understanding, and create a variety of strategies to maintain motivation and learning engagement.

In the context of mathematics learning, UDL can be applied by providing visual materials, concrete manipulatives, interactive simulations, or audio explanations for students who have difficulty accessing text or mathematical symbols (Shin et al., 2025). Evaluation can also be designed more flexibly by providing alternatives such as oral presentations, contextualized projects, or learning portfolios, instead of just conventional written tests. This approach is particularly relevant for EE students who may have barriers in accessing standardized evaluation formats. In addition, UDL emphasizes the importance of building intrinsic motivation through the choice of relevant activities, emotional support, and positive reinforcement, things that are often overlooked in conventional mathematics learning that is rigid and too focused on the end result (Mirriam Matshidiso Moleko, 2018). Empirical evidence shows that the application of UDL principles can significantly improve accessibility, participation and academic achievement of learners with special needs at various levels of education (Rao et al., 2014; Jatiningsih et al., 2021)). In the context of higher education, the application of UDL not only provides equity in access to learning, but also empowers PLB students as active subjects in the learning process. Thus, UDL is not just a technical approach, but also an educational philosophy that emphasizes fairness, flexibility, and respect for diversity in the classroom. Therefore, evaluating the implementation of UDL in mathematics learning in inclusive classrooms is a strategic step to ensure that the learning rights of PLB students are fulfilled thoroughly.

Although Universal Design for Learning (UDL) has been widely recognized in the literature as an inclusive and adaptive learning approach, empirical studies examining its application in the context of higher education, particularly in mathematics courses for PLB students, are still very limited. Most UDL studies focus on primary and secondary education, and are more studied in the context of general education than special education(Anna et al., 2024). Even in the realm of higher education, research on UDL tends to be conceptual or descriptive, not many have systematically evaluated the effectiveness of UDL implementation in improving learning outcomes or participation of students with special needs. In other words, there is a significant research gap related to evaluating the actual impact of UDL implementation in the context of inclusive classrooms in higher education, especially in subjects with high complexity such as mathematics (Darrow, 2018).

In fact, the effectiveness of a learning approach should not only be measured by its design feasibility or theoretical potential, but also by the extent to which it is able to bring about real changes in learning processes and outcomes. In this case, it is important to know whether the UDL principles are consistently applied in mathematics teaching practices and whether the application has a positive impact on the active engagement and concept understanding of PLB students. Without strong empirical data, higher education institutions risk continuing conventional learning practices that systemically discriminate against students with special needs. Furthermore, evaluating UDL implementation is a strategic step in supporting an inclusive higher education agenda, in line with global commitments through Sustainable Development Goals (SDG) 4 on quality and inclusive education for all (Veytia Bucheli et al., 2024; Martin et al., 2019). This evaluation is also an important basis for data-driven policy-making, development of professional training for lecturers, and refinement of curricula and teaching tools that are more adaptive. In other words, evaluating the effectiveness and real impact of UDL implementation is not only an academic necessity, but also an ethical and pedagogical responsibility in ensuring equal learning rights for all students, including those with special needs.

This framework illustrates the relationship between the characteristics of EE students and their learning needs with Universal Design for Learning (UDL) based learning design, which is implemented through three main principles: multiple means of representation, multiple means of action and expression, and multiple means of engagement. The implementation of UDL-based learning is then evaluated to see the extent to which these principles are effectively applied in the process of teaching mathematics in inclusive classrooms. The evaluation is directed to measure two main impacts, namely the increase of PLB students' active participation in learning and the improvement of their understanding of mathematical concepts. This framework emphasizes that the success of inclusive learning is not only determined by the initial design, but also by the consistency of implementation and concrete results in student engagement and learning outcomes (Figure 1).

Previous studies on the implementation of Universal Design for Learning (UDL) in higher-education mathematics have mostly focused on providing access or media adaptations for students with disabilities in general. However, systematic investigations that measure the effects of UDL on specific indicators of participation and thinking skills among students with visual impairments are still very limited. In addition, existing evaluation frameworks largely consist of generic UDL rubrics that do not directly link UDL practices with students' cognitive outcomes. This study introduces the UP-Think framework as its main novelty—an evaluative lens that explicitly maps the relationship between UDL implementation, active participation, and the development of students' thinking abilities. UP-Think differs from existing UDL rubrics because it integrates participation and thinking indicators and provides an operationalized measurement approach. The purpose of this study is to evaluate the implementation of UDL principles in mathematics instruction for higher-education students with visual impairments by using the UP-Think framework, and to examine its impact on students' active participation and thinking abilities. Based on this framework, the study proposes the following hypotheses: (H1) implementing UDL will increase participation indicators among students with visual impairments; (H2) implementing UDL will improve conceptual understanding as well as critical and creative thinking skills; and (H3) increased participation mediates improvements in thinking abilities.

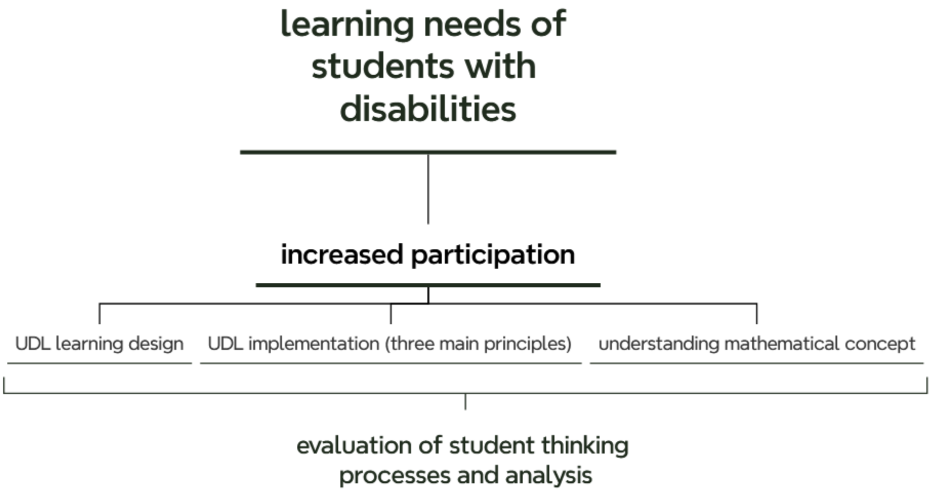

Figure 1. UDL Learning Framework For Students With Disabilities In Inclusive Classrooms

Based on the background and framework that have been described, this study aims to evaluate the extent to which the principles of Universal Design for Learning (UDL) have been applied in learning mathematics in inclusive classes in the Special Education study program. The main focus of the problem formulation is how the UDL implementation process is carried out by lecturers in delivering mathematics materials, as well as how PLB students respond to the learning strategies applied. In addition, this research also formulates problems related to the form of active participation of students in the learning process, as well as the extent to which they can understand mathematical concepts after participating in UDL-based learning. Equally important, this research also wants to reveal the obstacles and supporting factors that arise in the process of implementing UDL, both in terms of lecturers, students, and the learning environment. In line with the problem formulation, the purpose of this study is to comprehensively describe the implementation of UDL principles in mathematics learning in inclusive classrooms, as well as evaluate its impact on active participation and concept understanding of PLB students. This research also aims to identify various forms of student involvement during the learning process, both in the form of discussion activities, responses to tasks, and expression of understanding through various media. In addition, this research is expected to reveal various challenges faced in the implementation of UDL as well as factors that support its successful implementation, so that the results of this research can contribute to the development of mathematics learning strategies that are more inclusive, equitable, and adaptive for students with special needs.

METHOD

Determination of Respondents

The subjects of this study were active students of the Special Education Study Program at a university in Jember Regency, East Java Province, who had completed the Basic Mathematics course. The selection of subjects was conducted purposively with initial criteria that they were active students with disabilities, willing to participate as respondents, and had diverse learning needs. Out of 126 students enrolled in the Special Education Study Program, 40 met these initial criteria. Furthermore, a more specific selection was carried out with additional criteria: the students had to be visually impaired and able to communicate effectively. Based on these specific criteria, 28 students were found to be eligible.

Research Design and Data Collection Procedures

This study employed a descriptive evaluative design with a mixed-methods approach. Data were collected during the "Mathematics and Science Learning" course in the Special Education Study Program in the even semester of the 2023/2024 academic year, across four weekly meetings. Pre–post assessments were conducted during the first and fourth meetings (Creswell, 2014; Creswell & Clark, 2011). Therefore, the study focused on students with visual impairments as the main respondents. This approach was chosen because it allows researchers to evaluate both the process and learning outcomes in depth based on empirical data and direct experience narratives from the research subjects. Data collection began from the initial observation stage, the implementation of UDL in learning, to the evaluation and reflection stage. The data collection techniques included direct classroom observation, questionnaire distribution, written tests, as well as online and offline interviews. For quantitative data analysis, descriptive statistics (mean, percentage, and pre-post scores) were used to observe changes in students' levels of understanding and participation. Meanwhile, qualitative data from observations and interviews were analyzed using data reduction, data presentation, and conclusion-drawing techniques (Miles & Huberman, 1994) to identify patterns of behavior, responses, and challenges in the implementation of UDL-based learning. Through this approach, the research findings are expected to provide a comprehensive picture of the successes or challenges in implementing UDL to support inclusive and diversity-oriented mathematics learning for Special Education students.

Research Instruments and Data Collection Tools

The instruments used in this study included observation sheets, student learning engagement questionnaires, mathematics concept understanding test items, and interview guidelines. The observation sheet was used to record classroom learning activities related to the implementation of UDL (Universal Design for Learning) principles, such as media variations, alternative expressions, and motivational strategies used by lecturers. Questionnaires were distributed to students to measure the level of active participation, perceptions of learning comfort, and the extent to which they felt the learning strategies met their needs. Meanwhile, tests were administered to measure students' understanding of mathematical concepts before and after the implementation of UDL. Semi-structured interviews were conducted with lecturers and selected students to gain more in-depth information regarding learning experiences, challenges, and the effectiveness of UDL implementation in inclusive classrooms.

Research and Data Analysis Flowchart

Figure 2 illustrates the flow of research methods and data analysis in an evaluative study of UDL implementation in mathematics learning for PLB students which includes the Research Approach using mixed methods (combined quantitative and qualitative) with descriptive evaluative Research Design, Research Subjects are students of the Special Education Study Program (PLB). To measure the implementation of UDL and the indicators of the UP-Think framework, four main instruments were employed. First, a UDL Implementation Observation Rubric was developed from the three UDL principles multiple means of representation, action and expression, and engagement and contained 12 indicators (four per principle). For example, one item reads “The lecturer provides alternative media (audio/tactile) for mathematical symbols.” Two independent raters scored each session, achieving an interrater reliability of κ = 0.82. Second, a Student Learning-Engagement Questionnaire assessed three participation indicators (asking questions, responding/providing explanations, and collaborating) using 15 Likert-type items (1 = strongly disagree to 5 = strongly agree). A sample item is “I feel comfortable asking questions during class,” and the internal consistency was α = 0.87.

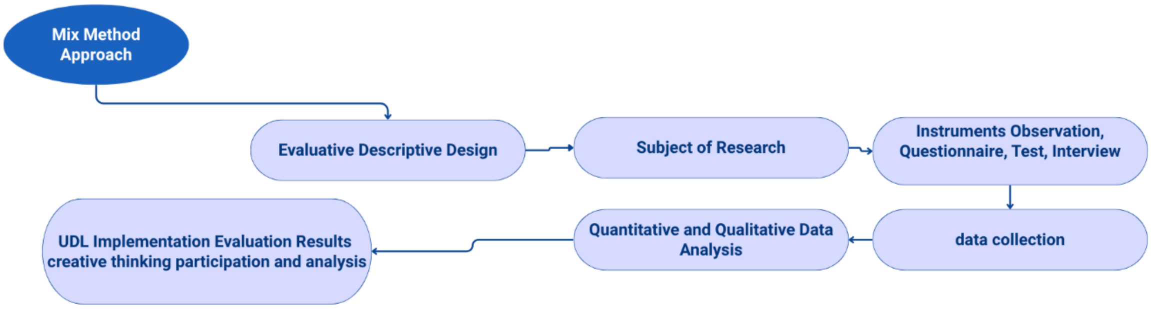

Figure 2. Research and Data Analysis Flowchart

Third, a Mathematics Concept-Understanding Test consisting of 20 items (15 multiple-choice and five open-ended) measured students’ understanding of core mathematical concepts before and after the intervention; scores ranged from 0 to 100 and the test showed a KR-20 reliability of 0.81 based on a pilot with a comparable cohort. Fourth, a Critical and Creative Thinking Rubric evaluated students’ ability to justify problem-solving steps (critical thinking) and propose alternative strategies (creative thinking) on a four-point scale. Two independent raters scored the products of tasks and pre/post tests with an inter-rater reliability of κ = 0.78. Finally, a SemiStructured Interview Guide was used to gather in-depth perceptions from lecturers and students; sample questions included “How did the availability of alternative formats influence your participation?” All instruments were adapted to be accessible for visually impaired students (e.g., screen-reader compatible formats, audio versions) and were reviewed by experts for content validity.

RESULTS AND DISCUSSION

This study aims to evaluate the implementation of Universal Design for Learning (UDL) in mathematics learning in inclusive classes for students of the Special Education Study Program (PLB), and analyze its impact on participation and understanding of mathematical concepts. The results were obtained through triangulation of quantitative (questionnaire and test) and qualitative (observation and interview) data. The following is a description of the results and discussion based on the thematic categories generated in the study.

Implementation of UDL Principles in Mathematics Learning

Qualitative Result (Observation & Interview)

Based on four classroom observations analyzed using the UDL rubric, lecturers implemented UDL principles with the following average scores: multiple means of representation (M = 3.4 out of 4, SD = 0.5), multiple means of action and expression (M = 3.1 out of 4, SD = 0.6), and multiple means of engagement (M = 3.6 out of 4, SD = 0.4). Although audio support was provided, braille or tactile materials were only partially available, meaning accessibility for visually impaired students was not fully optimal. From the observations across four sessions, lecturers had applied UDL principles. For the principle of representation, they used various presentation formats such as visual presentations (PowerPoint with large fonts and high-contrast colors), pre-recorded audio explanations, and concrete aids like interactive graphics. Visually impaired students were supported with audio explanations, although braille or tactile versions were not fully available.

In the principle of action and expression, lecturers allowed students to choose how to complete their tasks for example, answering written questions, giving audio-recorded explanations, or doing group presentations. Some special education (PLB) students preferred to explain their understanding orally because it felt more comfortable than writing. Meanwhile, under the principle of engagement, lecturers offered various activity options such as interactive quizzes, logic-based games, and project-based learning. From the interviews, students reported feeling more comfortable and enthusiastic about participating because they could choose learning methods that suited their strengths. One student said, "I never liked math, but when I was assigned a group presentation using pictures, I understood and enjoyed it."

Quantitative Results (Lecturer & Student Questionnaires)

Out of 28 visually impaired students who completed both pre- and post-tests, the proportion actively asking questions increased from 10/28 (36%) to 22/28 (79%) (McNemar $p = .01$, $r = .40$). Responding/providing explanations rose from 12/28 (43%) to 26/28 (85%) ($p < .001$), and group collaboration from 13/28 (46%) to 26/28 (85%) ($p < .001$). Figure 3 presents these changes with n values on each bar.

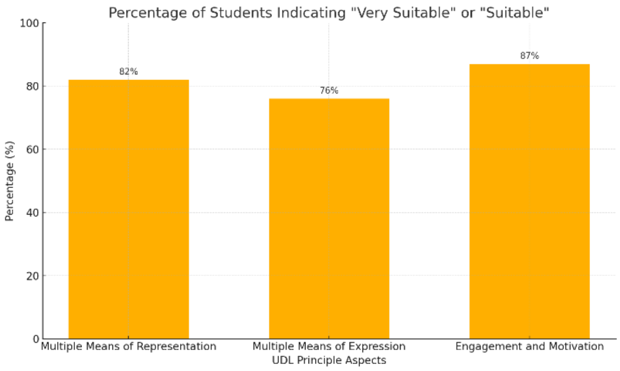

Figure 3. Results of Perception and Learning Engagement Questionnaire

This finding corroborates CAST's (2018) study that UDL can create wider access to learning through diversity of representation, expression and engagement. The implementation of UDL in mathematics learning that is adapted to the learning styles of PLB students encourages an increase in their cognitive and affective responses. However, barriers in providing specialized media such as braille indicate that institutional readiness in technical aspects is still a challenge. Therefore, lecturer training and provision of adaptive resources are important needs so that UDL principles do not stop at the concept level, but become a comprehensive real practice. It showed that the participation of PLB students increased significantly after the implementation of UDL. Students were more active in asking questions, discussing, and completing tasks. This result is in line with research (Sewell et al., 2022) which states that when learners are given choices in how to learn and express themselves, they will feel more engaged and motivated. In this context, UDL acts as a facilitator of participation by removing structural barriers to learning. The active involvement of PLB students also reflects the formation of a learning environment that respects differences, increasing the sense of ownership of the learning process. However, this success is also largely determined by the openness of lecturers in responding to student needs and the flexibility of the curriculum. The pre-test and post-test results showed a substantial in mathematical concept understanding scores. This was reinforced by interviews which showed that students felt they understood the material better when given various forms of representation and real contexts.

The increase in concept understanding shows that UDL is not only effective in increasing motivation, but also has a real cognitive impact. UDL allows PLB students to build understanding gradually, according to their respective developmental zones. The multiple representation approach and experiential learning are very helpful in visualizing abstract mathematical concepts. This also reinforces Vygotsky's view that the right learning environment can help learners reach higher levels of development through appropriate scaffolding (Raynaudo & Peralta, 2017; Bray et al., 2024). The results show that although there are many positive aspects of UDL implementation, there are obstacles in the availability of adaptive media, lecturer readiness, and material preparation time. However, supporting factors such as lecturers' enthusiasm and collaboration between students helped the implementation go well. These results reflect that the success of UDL is highly dependent on the readiness of the system and human resources. Barriers such as limited assistive technology and lack of lecturer training hinder the optimization of UDL (Mackey et al., 2023; Cash, 2019). However, key factors such as lecturers' positive attitudes and social support in the classroom can be important starting points. UDL implementation requires the involvement of all stakeholders, from policy makers, lecturers, to students, for the learning strategy to be truly inclusive and sustainable (Rao et al., 2014).

Thinking Outcomes (Quantitative)

Students' mean conceptual understanding scores increased from 48.2 ± 12.4 to 79.6 ± 10.3 ($t(27) = 10.21$, $p < .001$, $d = 1.93$). Critical thinking rubric scores improved from 2.1 ± 0.5 to 3.4 ± 0.4 ($p < .001$, $d = 2.5$), and creative thinking from 2.0 ± 0.6 to 3.1 ± 0.5 ($p < .001$, $d = 1.9$). Figure 5 displays these gains. Inter-rater reliability for rubric scoring was $\kappa = 0.78$.

Integration/UP-Think

Correlation analyses showed that increases in participation were positively associated with gains in conceptual understanding ($r = .52$, $p = .004$) and critical thinking ($r = .47$, $p = .009$), supporting the UP-Think framework's premise that enhanced participation mediates improvements in thinking abilities.

Participation and Thinking Ability of Students with Visual Impairments

Qualitative & Quantitative Synthesis

Out of a total of 126 Special Education (PLB) students who participated as respondents, 28 students with visual impairments were the focus of the analysis on participation and thinking ability. Following the implementation of UDL in mathematics lectures, the active participation of visually impaired students increased across three main indicators: asking questions, responding/expressing opinions, and collaborating/discussing. Specifically, 22 out of 28 subjects (79%) showed an increase in the frequency of asking questions, 26 out of 28 subjects (85%) more frequently responded to questions or provided explanations, and 26 out of 28 subjects (85%) actively engaged in group work through oral contributions or audio recordings. This pattern is consistent with the availability of flexible modes of expression (oral, audio, presentations), which reduced structural barriers (e.g., purely visual media) and enhanced emotional engagement. These findings confirm that access and a sense of agency are fostered when visually impaired students are able to choose modes of participation that align with their functional profiles.

Regarding thinking ability, pre–post tests and qualitative evidence indicated meaningful improvements in (i) conceptual understanding, (ii) critical thinking, and (iii) creative thinking. Overall, 68% of students improved by at least 40 points on the conceptual understanding test; 86% consistently provided reasoning/justifications for the procedures they selected (critical thinking indicator); and 78% were able to present alternative strategies based on tactile or concrete experiences (creative thinking indicator). Interviews further emphasized that diverse representations (audio, tactile manipulatives, contextual examples) helped bridge the abstraction of mathematical symbols into accessible experiences, thereby facilitating UP-Think (Understanding Participation and Thinking) simultaneously enhancing participation and strengthening thinking quality.

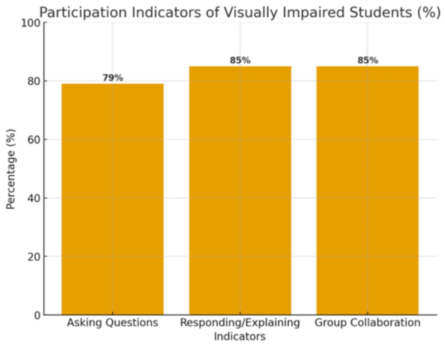

Figure 4. Participation Indicators of Visually Impaired Students (%)

The figure 4 illustrates the impact of UDL implementation on the active participation of visually impaired students in mathematics lectures. Three main indicators of participation were analyzed: asking questions, responding or providing explanations, and group collaboration. The data show that 79% of the students demonstrated an increase in the frequency of asking questions, 85% more actively responded or explained their reasoning during discussions, and 85% actively participated in group collaboration through oral contributions or audio recordings. These results indicate that UDL strategies effectively reduce barriers to classroom participation. The availability of multiple modes of expression—such as oral explanations, audio recordings, and group presentations—provided opportunities for visually impaired students to engage in ways that align with their strengths. This flexibility not only enhanced their comfort in participating but also fostered a stronger sense of inclusion and belonging in the learning process. The high percentages in responding and collaboration suggest that students felt more confident in expressing their ideas when given options beyond conventional written formats. This aligns with UDL's principle of providing multiple means of action and expression, which is crucial for learners with disabilities. The findings reinforce that when structural barriers are minimized, students with visual impairments can engage as active participants, demonstrating both agency and motivation in mathematics learning.

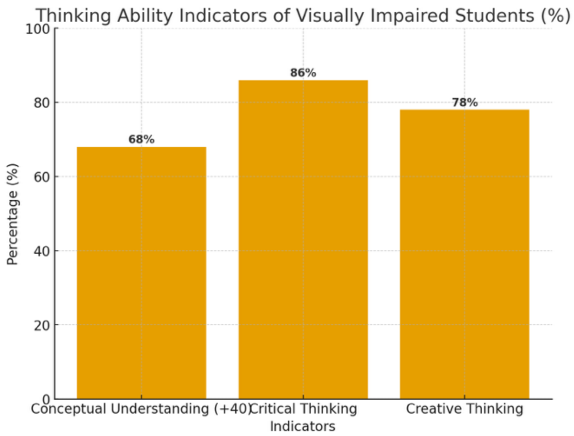

Figure 5. Thinking Ability Indicators of Visually Impaired Students (%)

The figure 5 presents the improvements in students' cognitive outcomes following the implementation of UDL in mathematics lectures. Three key dimensions of thinking ability were examined: conceptual understanding, critical thinking, and creative thinking. The results reveal that 68% of the students achieved at least a 40-point increase in conceptual understanding scores, 86% consistently provided logical reasoning or justifications for their chosen procedures (critical thinking), and 78% were able to propose alternative problem-solving strategies based on tactile or concrete experiences (creative thinking). These findings demonstrate that UDL fosters not only access to learning materials but also the development of higher-order thinking skills. The significant improvement in conceptual understanding indicates that multiple means of representation such as audio explanations, tactile manipulatives, and contextual examples helped students bridge abstract mathematical symbols with accessible experiences. The high percentage in critical thinking reflects that UDL encouraged students to justify and evaluate their problem-solving steps, while the creative thinking indicator highlights their ability to generate alternative solutions, even if grounded in tangible and contextual experiences. Overall, the data suggest that UDL provides an enabling framework for strengthening both the depth and flexibility of mathematical reasoning among visually impaired students. By reducing cognitive barriers and offering varied pathways to engage with mathematical concepts, UDL supports the dual goals of UP-Think (Understanding Participation and Thinking)**:** fostering active involvement and enhancing quality of thought.

The findings provide strong evidence that the implementation of Universal Design for Learning (UDL) in mathematics instruction significantly enhanced both participation and thinking abilities among visually impaired students. From the total respondents (28), 18 visually impaired students (≈64%) were the main focus of the analysis. Their participation was evaluated through three indicators: asking questions, responding or providing explanations, and collaboration in group activities. The data revealed that 79% of the students showed a marked improvement in asking questions, 85% became more engaged in responding or justifying answers, and 85% actively contributed to group collaboration through oral communication or audio recordings. These patterns highlight that UDL strategies particularly the flexibility to use multiple modes of expression enabled students to participate in ways that matched their functional profiles. The reduction of structural barriers such as reliance on purely visual media fostered both emotional engagement and a stronger sense of belonging in the classroom.

In addition to participation, the results also revealed substantial progress in thinking abilities. Three cognitive dimensions were examined: conceptual understanding, critical thinking, and creative thinking. The data indicated that 68% of the students achieved at least a 40-point improvement in conceptual understanding scores, 86% consistently provided logical reasoning or justification for their chosen problem-solving procedures (critical thinking), and 78% were able to generate alternative strategies grounded in tactile or concrete experiences (creative thinking). These outcomes demonstrate that UDL principles not only enhance access to learning but also stimulate higher-order thinking skills. By offering diverse means of representation such as audio explanations, tactile manipulatives, and contextual examples, UDL helped students bridge abstract mathematical symbols with tangible experiences, thereby deepening their comprehension. The alignment between increased participation and strengthened thinking abilities supports the UP-Think (Understanding Participation and Thinking) framework proposed in this study. This framework underscores the interdependence of affective engagement and cognitive development, suggesting that inclusive participation is a critical precondition for fostering advanced thinking. The findings further corroborate prior research emphasizing that when students are provided with multiple pathways for representation, action, and engagement, they not only feel more motivated but are also more capable of demonstrating reasoning and creativity in mathematics.

Overall, this study reinforces the pedagogical value of UDL in inclusive higher education. By accommodating the diverse needs of visually impaired students, UDL transforms potential barriers into opportunities for engagement and learning. Participation becomes more meaningful, while thinking processes become richer and more flexible. Thus, the findings position UP-Think as both an evaluative lens and a practical framework for assessing the success of inclusive mathematics instruction, moving beyond access to ensure equity in both learning opportunities and outcomes.

CONCLUSION

This study demonstrates that implementing Universal Design for Learning (UDL) in higher-education mathematics courses can markedly enhance the participation and thinking abilities of visually impaired students. When lecturers consistently applied multiple means of representation, action and expression, and engagement, students showed substantial increases in asking questions, responding, and collaborating, alongside significant gains in conceptual understanding, critical reasoning, and creative problem-solving. These results support the UP-Think framework, which integrates participation and higher-order thinking as dual indicators of inclusive learning effectiveness. Nevertheless, the findings should be interpreted in light of the study’s limitations: a relatively small and purposively selected sample, partial provision of braille/tactile materials, and a short-term pre–post design without long-term follow-up. Despite these constraints, the evidence highlights the transformative potential of UDL when adapted thoughtfully for learners with visual impairments.

RECOMMENDATION

Building on these findings and considering the study’s limitations, it is recommended that universities strengthen systematic lecturer training on UDL principles, with a particular focus on designing flexible assessments and offering multiple modes of representation to ensure consistent implementation across courses. At the same time, institutions should invest in improving accessibility infrastructure by developing reliable supply chains for braille and tactile materials, providing screen-reader-friendly resources, and integrating adaptive technologies so that partial access does not moderate learning outcomes. Future research should expand to larger and more diverse samples of students with different disabilities, adopt longitudinal or quasi-experimental designs to examine sustained impacts, and formally test the mediation pathways posited in the UP-Think framework. Finally, embedding UDL indicators into curriculum design, lecturer appraisal, and institutional quality assurance processes will help move inclusive mathematics instruction from isolated initiatives to a sustainable, system-level practice.

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AUTHOR CONTRIBUTIONS STATEMENT

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Indah Rahayu Panglipur	✓	✓	✓	✓	✓	✓		✓	✓	✓			✓	✓
Septi Triayani	✓					✓	✓	✓		✓	✓	✓		✓

CONFLICT OF INTEREST STATEMENT

The authors declare that there is no conflict of interest regarding the publication of this paper. No financial, personal, academic, or other relationships that could inappropriately influence or bias the content of this manuscript have been declared by the authors.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study. All participants were informed about the objectives, procedures, and voluntary nature of their participation. They were also assured of the confidentiality and anonymity of their personal information. Participation was entirely voluntary, and participants could withdraw from the study at any time without any consequences.

ETHICAL APPROVAL

Ethical approval for this study was granted by the institutional ethics committee of the Special Education Study Program, Universitas PGRI Argopuro Jember. All participants provided written informed consent, and their privacy and anonymity were safeguarded throughout the research process.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, I.R., upon reasonable request. The dataset includes observation rubrics, engagement questionnaires, pre–post concept-understanding test scores, and interview transcripts involving visually impaired students. Due to ethical considerations and privacy protection, the raw data are not publicly available. However, de-identified summary data and coding frameworks used in the analysis can be shared upon request.

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