

The Utilization of Understanding by Design in Mathematics Learning: A Literature Review

Ivo Apristi¹, Molli Wahyuni²

- 1 Universitas Pahlawan Tuanku Tambusai;
ivoapristi9@gmail.com
- 2 Universitas Pahlawan Tuanku Tambusai ;
whykpr@gmail.com

ABSTRACT

This study aims to examine the application of Understanding by Design (UbD) in mathematics learning. UbD is an instructional planning approach that focuses on conceptual understanding as the primary goal. The method used is the literature study method. The data analysis technique uses deductive qualitative analysis. The results obtained are that UbD learning can be used as a reference in preparing learning implementation plans that are oriented towards learning goals. This review compiles various literature related to UbD and its implementation in mathematics learning to understand its impact on student learning outcomes. Based on findings from various studies, UbD can enhance students' deep understanding, critical thinking skills, and problem-solving abilities in mathematics. This article also discusses challenges in implementing UbD and recommendations for optimizing its use in mathematics classrooms.

ARTICLE INFO

Keywords:

Understanding by Design;
Mathematics Learning ;
Conceptual
Understanding;
Instructional Planning 4

Article history:

Received :

Revised :

Accepted:



This is an open access article under the [CC BY-NC-SA](https://creativecommons.org/licenses/by-nc-sa/4.0/) license.

Corresponding Author:

First name Last name

Affiliation 1; e-mail@e-mail.com

1. INTRODUCTION

Mathematics is a discipline that requires a deep understanding of concepts for students to apply them in various contexts (Kilpatrick, Swafford, & Findell, 2001). However, in practice, mathematics learning is often procedural without emphasizing deep understanding (Hiebert et al., 1997). To address this challenge, the Understanding by Design (UbD) approach has been introduced as an alternative in designing more structured and understanding-oriented learning (Wiggins & McTighe, 2005; Anderson, 2017).

Mathematics teachers adapt questions to be simpler for students with special needs, ensuring their participation in class activities. Special accompanying teachers provide guidance and support to help these students engage and respond to the teacher's questions. During the core learning stages, mathematics teachers utilize various strategies, instructional media, and learning resources to enhance the teaching process. They actively involve both regular students and those with special needs by assigning tasks, posing questions, and encouraging verbal responses. There is no distinction in treatment between the two groups, fostering an inclusive learning environment. Collaboration between math teachers, special accompanying teachers, and students is encouraged to promote interaction. In the closing stage, the mathematics teacher summarizes the lesson for all students, while special accompanying teachers assist students with special needs in creating summaries. The final phase of the learning process includes evaluation and follow-up to assess student understanding and progress (I. W. Widana et-al, 2023). At this stage, mathematics teachers plan follow-up activities such as remedial lessons, enrichment programs, and counseling support for both regular students and those with special needs. Inclusive mathematics learning ensures that all students receive equal opportunities without distinction. However, teachers often struggle with developing effective assessment methods. Understanding by Design (UbD) introduces a fresh perspective on learning evaluation, focusing on deep comprehension rather than surface-level knowledge. This approach encourages teachers to go beyond simply covering topics, ensuring that students develop a thorough and meaningful understanding of mathematical concepts and their broader connections (Kuntari, F.R et-all, 2019).

Understanding by Design (UbD) is a curriculum design theory that helps teachers create learning activities, assessments, and instruction. The goal of UbD is to help students develop a deep understanding of the subject matter. UbD emphasizes the teacher's role as a designer of student learning. It helps teachers: Clarify learning goals, Create assessments that reveal student understanding, and Create engaging learning activities (Kuntari, F. R., Rondonuwu, F. S., & Sudjito, D. N., 2019). UbD emphasizes instructional design that begins with the desired learning outcomes (backward design), aiming to help students achieve better conceptual understanding through systematic and goal-oriented planning (McTighe & Curtis, 2018; Reynolds & Miller, 2020). This article reviews various studies on the application of UbD in mathematics learning and how this approach can improve learning quality.

2. METHODS

This study employs a literature review method by collecting and analyzing various academic sources, including research journals, reference books, and conference reports discussing UbD in mathematics learning (Boote & Beile, 2005; Fink, 2019). A literature review contains theories relevant to the challenges researchers address in their research. The purpose of the literature review is to establish theoretical aspects as well as practical benefits (Padilla et al., 2020).

3. FINDINGS AND DISCUSSION

Understanding by Design (UbD) is a framework that emphasizes backward design in curriculum planning, ensuring that learning experiences are purposefully structured to achieve meaningful student outcomes. In mathematics education, UbD provides a systematic approach that prioritizes deep conceptual understanding, critical thinking, and problem-solving over rote memorization. By focusing on essential questions and real-world applications, UbD helps students make meaningful connections between mathematical concepts and their practical use. This section explores the fundamental principles of UbD in mathematics

learning, its impact on student achievement and teacher effectiveness, as well as the challenges faced in its implementation.

2.1. Understanding By Design

Fundamental Principles of UbD in Mathematics Learning

UbD consists of three main stages (Wiggins & McTighe, 2005)

1. Identifying desired results: Determining the core understanding students should achieve, ensuring alignment with curriculum standards and learning objectives (Tomlinson & McTighe, 2006).
2. Determining assessment evidence: Designing assessments that effectively measure students' understanding through formative and summative evaluations, including performance-based assessments and problem-solving tasks (Roberts, 2016).
3. Planning learning experiences: Developing structured learning activities that facilitate deep conceptual understanding, encouraging active student engagement through real-world applications and inquiry-based approaches (Boaler, 2016).

Impact of UbD Implementation in Mathematics Learning

Several studies indicate that UbD positively impacts:

1. Students' conceptual understanding: By focusing on essential questions and big ideas, students develop a deeper grasp of mathematical concepts rather than merely memorizing formulas (Bransford, Brown, & Cocking, 2000).
2. Critical thinking and problem-solving skills: UbD fosters analytical reasoning by integrating authentic problem-solving tasks and encouraging metacognitive reflection (Wiggins and McTighe, 2005).
3. Motivation and engagement: Students find learning more meaningful and relevant when they understand the purpose behind their studies, increasing intrinsic motivation (Deci & Ryan, 2000).
4. Teacher effectiveness: Teachers who adopt UbD report improvements in lesson coherence and alignment with learning goals, leading to better instructional outcomes (Guskey, 2007; Peterson & James, 2023).

Challenges in Implementing UbD

Despite its advantages, UbD implementation faces several challenges, including:

1. Time constraints: Designing UbD-based lessons requires significant planning time, which may be challenging for teachers with heavy workloads
2. Lack of professional development: Effective UbD implementation requires adequate training for educators to master backward design principles and apply them effectively (Reynolds, 2023).
3. Institutional resistance: Traditional teaching practices and standardized testing pressures may hinder the widespread adoption of UbD, necessitating systemic support and policy adjustments (Cuban, 2013).
4. Assessment alignment: Ensuring that assessments accurately measure deep understanding rather than rote memorization remains a key challenge in UbD-based instruction (McTighe, J., & Wiggins, G. : 2018 ; Gregory, G. H., & Kuzmich, L ; 2011).

The UbD approach encourages teachers to think critically and creatively, part of the process also requires them to reflect on their plans. While planning their units, they engage asking themselves these Socratic questions: what is the goal? what content and resources should I be using and what should I be assessing to know how my students are doing against the goal? what should I be doing instructionally that facilitates meaningful learning and transfer? These teachers exactly know where they want to end up. Subsequently, they also 'reflect' on what is working for them and what is not working for them, and how can they strategize to make it work next time. These Socratic questions encourage them to find meaning in every activity they do in the classroom. In this chapter, authors introduce the three stages of Backward Design processes :

1. 'Identify Desired Results' by keeping the long-term goals in view
2. 'Determine Acceptable Evidences' by getting the blend of content and performance right
3. 'Plan learning experiences and instructions' Better engage learners

2.2. Figures depicts the three steps of Backward Design

Figure 1. Backward Design Stages as mentioned by Uluçınar (2021)

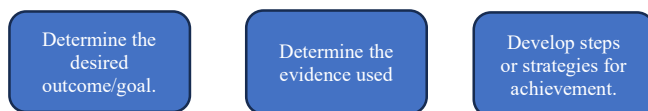


Figure 1. Backward design in UbD is divided into three stages: establishing the results and objectives, determining the evidence to be used, and strategizing to achieve the intended objectives. This stage directs the learning design to focus on the goals to be attained. Setting goals early and clearly will improve learning and focus on obtaining desired outcomes (Dack & Merlin-Knoblich, 2019).

Uluçınar (2021) also expresses this, stating that adopting the UbD strategy with a backward framework can assist teachers in developing plans tailored to the aims and needs of the students being taught. Ria et al. (2019) state that UbD can increase students' critical and creative thinking skills. Using UbD phases can help focus learning on the targeted learning outcomes and improve the efficacy of developing learning processes and activities.

Table 1. Analyse of Data Literature

No	Author	Jounal Name (Tahun, Vol, No, Hal)	Title of Article	Methods	Result of research
1.	I Wayan Sumandya ¹ , I Wayan Widana ¹ , I Putu Pasek Suryawan ² , I Gusti Agung Handayan ³ , Amirul	<i>Edelweiss Applied Science and Technology</i> (2023, 7, 2, 124-135)	Analysis of understanding by design concept of teachers' independence and creativity in developing evaluations of mathematics learning in	Quantitativ e and qualitative approaches	The understanding of mathematics teachers in inclusive schools of the concept of Understanding by Design (UbD) influences the independence and creativity of teachers in developing evaluations of learning mathematics in inclusive schools. The teacher's independence and creativity in developing Understanding

	Mukminin ⁴		inclusion schools		by Design (UbD)-based mathematics learning evaluations are categorized as sufficient.
2.	Kuntari, F. R. Rondonu wu, F. S.and. Sudjito, D. N.	<i>Journal of Physics Research and Applications</i> (2019, 9, 1, 32-43)	Understanding by design (UbD) for the physics learning about parabolic motion.	literature review or literature study	In conclusion, the UbD strategy provides a structured and goal-oriented approach to learning that effectively addresses 21st-century challenges. By focusing on backward design, UbD ensures that learning objectives, assessments, and activities are well-aligned to promote deep understanding. This strategy not only enhances students' ability to think critically, apply knowledge, and develop essential skills but also supports teachers in designing meaningful and engaging learning experiences. With creativity and innovation, teachers can maximize the benefits of UbD, making learning more purposeful and impactful for students.
3.	Ertaş, G.	<i>Empowering Education: Research, Theory And Practice</i> , (2021, 285-297)	The Investigation of the Impact of UbD-Based Learning Enrichment Activities on Students' Mathematics Achievement.	Quantitative and qualitative approaches	The experimental group participated in UbD-based enrichment activities, while the control group received traditional mathematics instruction. Quantitative analysis revealed a significant improvement in mathematics achievement for the experimental group compared to the control group. Qualitative feedback indicated that students exposed to UbD-based activities displayed increased interest, active participation, and enjoyment during lessons. The study concludes that integrating UbD-based enrichment activities can effectively enhance students' mathematical performance and engagement.
4.	Taiyabi, F	<i>International Journal of Innovation, Creativity and Change.</i> , (2021, 15(4), 1142–1152)	Understanding by Design (UbD) "Curriculum Innovation and Instructional Development."		UbD is a powerful and effective framework for curriculum planning and achieving learning outcomes, but its implementation can be challenging due to the knowledge and skills

required. To ensure success, educators should start with a few key units and collaborate in teams to refine their plans through data analysis and feedback. The alignment of learning goals, assessments, and pedagogical strategies creates a strong and engaging curriculum that enhances student learning and performance. Additionally, UbD supports continuous professional growth for teachers, helping them refine their instructional practices and improve overall educational effectiveness.

5.	Wulandari ¹ Saleh Hidayat ² , Eka Wulandari ³	<i>Biosfer: Jurnal Tadris Biologi</i> (2023, 14, 2, 169-179)	The Understanding by Design Strategy in 21st-Century Education	the literature study method	UbD strategy enables learners to explain, interpret, apply, viewpoint, empathize, and have self-awareness. Teachers play an important role in UbD. The teacher's responsibility is to create learning activities aimed at obtaining results and objectives and to implement the design and direct the learning activities that will be carried out. Teachers must be creative, imaginative, and capable of making learning more meaningful to attain objectives.
----	--	--	--	-----------------------------	--

¹Tables of Literature Data Analyse

UbD strategy enables learners to explain, interpret, apply, viewpoint, empathize, and have self-awareness. Teachers play an important role in UbD. The teacher's responsibility is to create learning activities aimed at obtaining results and objectives and to implement the design and direct the learning activities that will be carried out. Teachers must be creative, imaginative, and capable of making learning more meaningful to attain objectives. In the UbD framework, teachers take on the role of facilitators, guiding students through meaningful learning experiences to enhance their understanding and make learning more engaging. Their responsibilities include designing instructional plans that align with learning objectives and cater to students' needs (Tshering, 2022). To effectively implement UbD, teachers must develop clear learning goals, design assessments that accurately measure progress, and create engaging activities suited to their students' characteristics. As Uluçınar (2021) emphasizes, the teacher's role in UbD is to support and direct students throughout the learning process, ensuring a deeper and more effective understanding of the material.

The UbD strategy offers a structured and effective approach to learning by aligning objectives, assessments, and activities to foster deep understanding. It enhances students' critical thinking, application of knowledge, and essential skills while supporting teachers in designing engaging lessons. Research findings show that UbD-based enrichment activities significantly improve students' mathematics achievement, increase their interest, and promote

active participation. Overall, implementing UbD can make learning more meaningful, impactful, and engaging for students.

In discussing the impact of Understanding by Design (UbD) on mathematics learning, it is crucial to analyze the findings in relation to the initial research objectives and previous studies. The results indicate that UbD provides a structured, goal-oriented approach that enhances students' conceptual understanding, critical thinking, and engagement. Scientifically, this aligns with the principles of backward design, where clear objectives, aligned assessments, and meaningful learning activities contribute to improved academic performance. The findings are consistent with previous research showing that UbD-based enrichment activities significantly enhance students' mathematics achievement and participation. However, variations may exist depending on implementation factors such as teacher expertise, institutional support, and student adaptability. These insights highlight the broader implications of UbD in modern education and suggest future research directions, including exploring its long-term effects and integration with technology-enhanced learning. Overall, the study reinforces the effectiveness of UbD in fostering deep and meaningful learning experiences.

4. CONCLUSION

UbD is an approach that can enhance students' conceptual understanding in mathematics learning. With systematic and goal-oriented planning, students can better connect mathematical concepts with real-life applications. However, to ensure effective UbD implementation, teacher training, institutional support, and strategies to overcome implementation challenges are necessary.

Based on the literature review, Understanding by Design (UbD) emerges as an effective framework for structuring learning experiences that promote deep understanding, critical thinking, and meaningful engagement. Studies indicate that UbD enhances student achievement, particularly in mathematics and science education, by aligning learning goals, assessments, and instructional strategies. Additionally, UbD fosters teacher independence, creativity, and continuous professional development. However, challenges such as the complexity of implementation, time constraints, and the need for professional training highlight the necessity for gradual adoption and collaborative efforts among educators. Overall, the literature supports UbD as a valuable approach for improving instructional effectiveness and student learning outcomes in 21st-century education.

UbD is a powerful approach that enhances conceptual understanding in mathematics learning. Through systematic and goal-oriented planning, students can connect mathematical concepts to real-life applications, fostering deeper comprehension and problem-solving abilities (Wiggins & McTighe, 2005; Kim & Dawson, 2023). However, for UbD to be effectively implemented, the following recommendations should be considered:

1. Comprehensive teacher training: Schools and educational institutions should invest in professional development programs to equip teachers with the necessary skills to implement UbD effectively
2. Collaborative lesson planning: Encouraging teacher collaboration in designing UbD-based lessons can reduce workload burdens and enhance instructional quality
3. Integration with existing curricula: UbD should be aligned with national and international curriculum standards to facilitate seamless adoption
4. Ongoing research and evaluation: Further studies are needed to refine UbD strategies, explore best practices, and measure long-term impacts on student achievement in mathematics.

By addressing these challenges and leveraging the strengths of UbD, mathematics education can become more meaningful, engaging, and effective in nurturing students' understanding and lifelong learning skills. Further research is needed to explore the best strategies for integrating UbD with other instructional methods to improve the effectiveness of mathematics learning at various educational levels.

REFERENCES

- Anderson, R., & Wright, K. (2023). *Innovative Teaching Strategies for Conceptual Understanding*. Educational Journal.
- Boaler, J. (2016). *Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages and Innovative Teaching*. Jossey-Bass.
- Boote, D.N. & Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher*, 34(6), 3-15.
- Cuban, L. (2013). *Inside the black box of classroom practice: Change without reform in American education*. Harvard Education Press.
- Dack, H., & Merlin-Knoblich, C. (2019). Improving Classroom Guidance Curriculum With Understanding by Design. *The Professional Counselor*, 9(2), 80–99. <https://doi.org/10.15241/hd.9.2.80>
- Deci, E. L., & Ryan, R. M. (2000). The “what” and “why” of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry*, 11(4), 227–268. https://doi.org/10.1207/S15327965PLI1104_01
- Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181–199.
- Ertas, G. (2021). The Investigation of the Impact of UbD-Based Learning Enrichment Activities on Students' Mathematics Achievement. *Empowering Education: Research, Theory And Practice*, 285-297, <https://www.scopus.com/inward/record.uri?partnerID=HzOxMe3b&scp=85107458817&origin=inward>
- Fink, A. (2019). *Conducting Research Literature Reviews: From the Internet to Paper*. Sage Publications.
- Gregory, G. H., & Kuzmich, L. (2011). *Data driven differentiation in the standards-based classroom*. Corwin Press.
- Guskey, T. R. (2007). Professional development and teacher change. *Teachers and Teaching: Theory and Practice*, 13(1), 37-52. <https://doi.org/10.1080/13540600601173897>
- Kilpatrick, J., Swafford, J., & Findell, B. (Eds.). (2001). *Adding it Up: Helping Children Learn Mathematics*. Washington, DC: National Academy Press.
- Kuntari, F. R. Rondonuwu, F. S. and Sudjito, D. N. (2019). Understanding by design (UbD) for the physics learning about parabolic motion. *Journal of Physics Research and Applications*, vol. 9, no. 1, pp. 32-43.
- Lai, Y.H. (2024). Learning efficacy of understanding by design-Internet of Things (UbD-IoT) education integrated with design thinking and computational thinking. *Library Hi Tech*, 42(2), 730-747, ISSN 0737-8831, <https://doi.org/10.1108/LHT-01-2023-0002>
- McTighe, J., & Curtis, R. (2018). *Leading Modern Learning: A Blueprint for Vision-Driven Schools*. ASCD.
- McTighe, J., & Wiggins, G. (2018). *Understanding by Design: White Paper*. Retrieved from

<https://jaymctighe.com/wp-content/uploads/2018/06/UbD-White-Paper.pdf>

- Padilla-Rivera, A., Russo-Garrido, S., & Merveille, N. (2020). Addressing the social aspects of a circular economy: A systematic literature review. *Sustainability (Switzerland)*, 12(19), 1–17. <https://doi.org/10.3390/SU12197912>
- Peterson, K., & James, L. (2023). Effective teaching strategies: Implementing Understanding by Design in schools. *Educational Research Journal*, 45(2), 112-129.
- Reynolds, D., & Miller, G. (2020). *Effective Teaching and Learning Strategies in Mathematics Education*. Cambridge University Press.
- Reynolds Community College. (2023). *Professional development policy*. Retrieved from https://www.reynolds.edu/policy/human_resources/3-18-professional-development.html
- Roberts, J. (2016). *Writing for Strategic Communication Industries*. Ohio: Pressbook
- Sumandya, I. W., Widana, I. W., Suryawan, I. P. P., & Handayani, I. G. A. (2023). Analysis of understanding by design concept of teachers' independence and creativity in developing evaluations of mathematics learning in inclusion schools. *Edelweiss Applied Science and Technology*. 7(2), 124–135. <https://doi.org/10.55214/25768484.v7i2.382>
- Taiyabi, F. (2021). Understanding by Design (UbD) "Curriculum Innovation and Instructional Development." *International Journal of Innovation, Creativity and Change.*, 15(4), 1142–1152.
- Tshering, S. (2022). The Impact of Using Understanding by Design (UbD) Model on Class 10 Student's Achievement in Chemistry. *IJCER (International Journal of Chemistry Education Research)*, 6(April), 29–33. <https://doi.org/10.20885/ijcer.vol6.iss1.art4>
- Uluçınar, U. (2021). Findings of qualitative studies on Understanding by Design: A meta-synthesis. *Uluslararası Eğitim Programları ve Öğretim Çalışmaları Dergisi*, 11(2), 167–194. <https://doi.org/10.31704/ijocis.2021.009>
- Widana, I. W., Sumandya, I. W., and Citrawan, I. W. (2023). The special education teachers' ability to develop an integrated learning evaluation of Pancasila student profiles based on local wisdom for special needs students in Indonesia. *Kasetsart Journal of Social Sciences*, vol. 44, no. 2, pp. 527–536.
- Wiggins, G., & McTighe, J. (2005). *Understanding by Design*. ASCD.