Al-Ishlah: Jurnal Pendidikan
Vol.17, 3 (September, 2025), pp. 3952-3965
ISSN: 2087-9490 EISSN: 2597-940X, DOI: 10.35445/alishlah.v17i3.6893

Understanding by Design (UbD): An Effective Way to Design Elementary School Science Learning for the Competencies of Teacher Professional Education Students

Woro Sri Hastuti[1], Febrina Siska Widyaningtyas[2], Unik Ambar Wati[3], Sandy Abdi Kusumah[4]

[1] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; woro_srihastuti@uny.ac.id
[2] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; febrinawidyaningtyas@uny.ac.id
[3] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; unikpgsd@gmail.com
[4] Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; sandyabdikusumah@uny.ac.id

ARTICLE INFO

Keywords:

science learning;
understanding by design;
teacher professional education;
teacher competence

Article history:

Received 2025-01-11
Revised 2025-07-30
Accepted 2025-08-25

ABSTRACT

Many pre-service teachers in Teacher Professional Education (PPG) programs lack the competence to develop effective teaching materials aligned with curriculum goals. Understanding by Design (UbD) offers a structured approach to support this development through backward design. This study employed a quantitative research design using purposive sampling to select 116 PPG students as respondents. Data were collected via an online questionnaire distributed through Google Forms. The collected data were analyzed using descriptive statistical methods. Findings reveal that UbD effectively supports the development of Subject Specific Pedagogy (SSP) through its three core stages: identifying desired learning outcomes, designing appropriate assessments and tasks, and planning targeted learning activities. Respondents demonstrated increased competence in aligning instructional strategies with learning objectives through this framework. The results suggest that UbD provides a practical model for guiding teachers in curriculum-aligned material development. The structured approach helps educators better understand learning goals and translate them into classroom practice. UbD is an effective framework for improving PPG students' mastery of Subject Specific Pedagogy. It is recommended that teacher training programs integrate UbD principles into their instructional models. Teachers are also encouraged to continuously refine their teaching strategies in line with evolving curriculum demands.

***Corresponding Author:**
Febrina Siska Widyaningtyas
Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; febrinawidyaningtyas@uny.ac.id

1. INTRODUCTION

Education is one way to improve the quality of human resources. The goal of education is to create a nation that is capable, pious, highly knowledgeable, and has a broad friendship perspective, achieved through a series of activities arranged in the curriculum. The curriculum has developed over time to adjust education policies to the needs of the times so that national education goals can be achieved. Curriculum development directs the current curriculum to the expected educational goals because of various positive influences that come from outside or from within, with the hope that students can face their future well (Rosnaeni, 2022). This curriculum development needs to be supported by design in the learning process, one of which is the learning design approach, namely Understanding by Design (UbD). The completeness of the learning materials used includes students worksheet, teaching materials, learning media, and assessment tools (Natala, et al., 2023).

A teacher must prepare a learning design or learning plan before entering the classroom and provide open materials to students so that teachers can present the best learning for students in the form of optimal learning opportunities (Asari et al., 2018). Some important components in the learning process are learning objectives, learning stages, and evaluation. The third main component is the use of instructional strategies carried out by teachers to facilitate students in achieving learning objectives (Dagdalan &Tas, 2017). Competency achievement will be measured using assessment and evaluation instruments. Teachers generally only design learning stages based on teaching experience without looking at learning objectives and learning evaluations (Wiggins & McTighe, 2005). Therefore, TPE students are equipped to compile open materials using the UbD approach. The use of this approach will be implemented in TPE students to compile learning activities, especially science materials, in the independent curriculum currently being implemented in schools. This approach is expected to help improve the skills of TPE students in compiling teaching materials so that learning objectives and the curriculum being implemented can be achieved properly, and to equip TPE students with the skills to become professional educators.

There is a gap in research specifically evaluating the effectiveness of the UbD approach in the context of teachers participating in the Teacher Professional Education (PPG) in Indonesia, which is still very limited. In fact, PPG teachers are prospective professional educators who are in a crucial transition period from theory to field practice, thus requiring a systematic and in-depth understanding of learning planning approaches such as those offered by UbD. Furthermore, there is not much research that empirically measures the extent to which the UbD approach can support the improvement of PPG teachers' pedagogical competence, both in planning, implementation, and reflection on learning. There is also not enough data available regarding the perceptions, challenges, and readiness of PPG teachers in implementing UbD in the context of the national curriculum and the current demands for authentic assessment. Therefore, it is important to conduct research that focuses on the application and effectiveness of UbD in the PPG context. This kind of research is expected to make a real contribution to the development of more effective learning models for novice teachers in Indonesia.

Some of the problems that teachers often face related to UbD include difficulty in determining clear learning objectives. UbD begins the design process with clear objectives, namely the "end goal" that students want to achieve. However, for some teachers, determining objectives that not only measure outcomes but also lead to deep understanding can be very challenging. Lack of time for in-depth planning. The UbD approach requires more time in the planning stage, such as formulating learning objectives that focus on understanding, designing authentic assessments, and determining appropriate activities. Many teachers feel pressured by the limited time to design lessons according to UbD principles, especially if they also have to adjust to existing standards or curricula. Implementing UbD requires the ability to connect theory to practice, such as designing activities that encourage students to think critically and deeply. This can be difficult to do, especially if teachers are used to more traditional teaching methods or focus on content-based instruction.

Understanding by Design (UbD) has gained significant attention as an effective approach for improving the quality of learning through structured, goal-oriented instructional planning. Pertiwi et

al. (2019) emphasize that the three interrelated stages of Backward Design—identifying learning outcomes, designing assessments, and planning instruction—are not only theoretically sound but also applicable in real classroom settings. Almaseid (2017), in a study on 8th-grade science students, found that implementing the UbD model enhanced student achievement, particularly in science-related content. Similarly, Gloria and Sudarmin (2018) demonstrated that formative assessment, when integrated within the UbD stages, significantly contributes to prospective biology teachers' conceptual understanding by utilizing self-assessment, peer evaluation, and feedback.

UbD emphasizes the importance of clearly defined learning objectives from the outset, followed by designing assessments aligned with these objectives, and finally, planning learning activities that support goal attainment (As'Ari, 2014; Putra et al., 2023). Unlike traditional instructional models, UbD begins with the end in mind, ensuring that all learning activities are directly aligned with desired outcomes (Pertiwi et al., 2019). McTighe and Wiggins (2012) further elaborated on UbD's three-stage process: (a) identifying desired results that prioritize long-term understanding, (b) determining acceptable evidence through performance tasks such as projects and portfolios, and (c) planning learning experiences that guide instructional decisions, including teaching methods, sequencing, and material selection.

UbD also fosters deep understanding across six dimensions: the ability to explain, interpret, apply knowledge, show perspective, empathize, and demonstrate self-awareness (Setiyawati et al., 2023; Karamustafaoglu, Bayar, & Kaya, 2014). Bowen (2017) noted that UbD inherently promotes intentional instructional planning, offering a comprehensive framework for developing effective lessons, units, and courses.

Wiggins and McTighe (2005) identified seven core principles of UbD: (1) it serves as a curricular planning framework, (2) it aims to deepen student understanding, (3) understanding is revealed through independent transfer of knowledge, (4) it prioritizes long-term outcomes, (5) teachers act as coaches of understanding, (6) curriculum and instruction are continuously reviewed for quality, and (7) it embodies an ongoing improvement process. These principles support the notion that when UbD is effectively implemented, students not only grasp the "what" of learning but also the "why," ultimately enhancing learning outcomes (Pertiwi et al., 2019).

Given the increasing emphasis on professional standards in teacher education, it is critical that pre-service teachers—particularly those in Teacher Professional Education (PPG) programs—are equipped with the skills to design effective instruction. UbD offers a practical pathway for developing such competencies. However, despite substantial research on UbD's effectiveness in general educational contexts, limited studies focus specifically on its implementation within PPG programs. This gap highlights the need for research exploring how UbD can be applied to enhance the instructional planning and pedagogical skills of teacher candidates in the Indonesian context.

Therefore, this study aims to investigate how the Understanding by Design framework can be applied to improve the teaching competencies of students enrolled in Teacher Professional Education programs. The central research question is: *How can UbD be effectively applied to support the development of instructional planning skills among TPE students?*

2. METHOD

2.1 Research Design

This study employed a survey research design to collect factual and quantifiable data regarding the impact of the Understanding by Design (UbD) approach on the competencies of Teacher Professional Education (TPE) students, specifically in designing elementary science learning. The survey method was chosen to gain a broad overview of students' perceptions and experiences in applying the UbD framework within the context of their coursework.

2.2 Participants

The population in this study comprised all TPE students at Yogyakarta State University (UNY) in 2024. Participants were selected through purposive sampling to ensure alignment with the study's objectives. The sampling focused on TPE students—particularly those who had applied or were currently applying the UbD approach in their instructional planning. This selection criterion was essential, as not all TPE participants may have had relevant exposure to UbD practices. PPG students, in particular, were considered due to their unique training and engagement with pedagogical models not typically encountered by regular in-service teachers.

2.3 Instruments and Data Collection

The primary research instrument was a structured questionnaire designed to assess students' perceptions of the impact of the UbD model on their ability to design elementary science learning. The questionnaire included demographic information (name and study program) and targeted questions related to UbD implementation and its influence on instructional planning competencies. Data collection was conducted via a Google Form and distributed through a WhatsApp group after participants had completed related TPE coursework. This ensured that respondents had sufficient background to provide informed responses and that the entire target group had access to the survey link.

Table 1. Indicator of the instrumen questionnaire

No	Indicator
1	Understand the three main stages of UbD
2	Know the main objectives of UbD
3	Able to formulate understanding-based learning objectives
4	Develop assessments that align with learning objectives
5	Design learning activities according to the third stage of UbD
6	Implement UbD stages in the learning process
7	Assess that UbD increases student engagement
8	Perceives that UbD increases personal pedagogical competence
9	Perceives that UbD helps design meaningful learning

The instrument was validated by experts through group discussion forum activities. Comments and suggestions from experts led to the modification of the instrument so that it was authentic in terms of face validity and content validity. The reliability of the instrument is determined based on the Cronbach's alpha coefficient. The reliability of the questionnaire instrument is 0.82, while the reliability of the learning satisfaction questionnaire instrument is 0.85, thus, the reliability value of the instrument is in a high category. The assessment of each item on the questionnaire was carried out using a Likert scale containing 5 assessment scales, namely: Never 2 = Rarely 3 = Sometimes; 4 = Often and 5 = Always. Higher scores indicate the frequency of certain teaching practices/behaviors perceived by students, and vice versa. The total score summed up from each component of Understanding by Design (UbD) indicates the overall rating of the lecture conducted by the lecturer. Each questionnaire was prepared and adjusted to the competencies of TPE students.

The data were analyzed using descriptive statistics, including percentages and frequency counts, using IBM SPSS for Windows.

3. FINDINGS AND DISCUSSION

The results and discussion in this study are presented in the following picture.

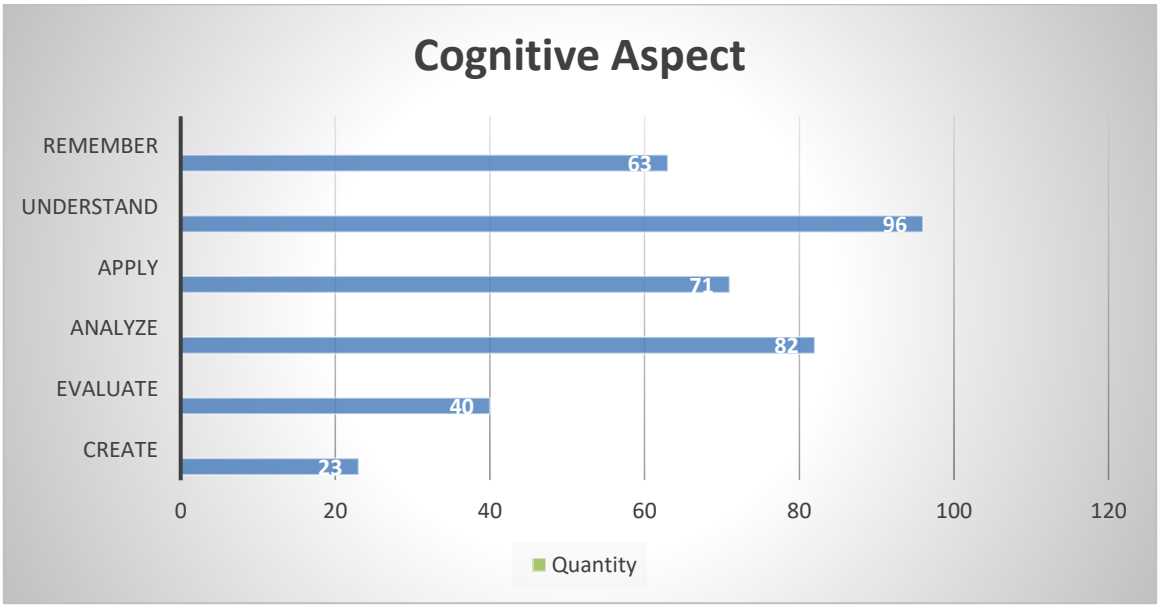

Figure 1. Cognitive aspect

Based on the data presented in Graph 1, responses were collected from 116 participants who completed the questionnaire. The learning objectives identified by respondents during the TPE predominantly focused on various cognitive levels. Specifically, 63 respondents (54.3%) selected objectives at the remembering level, 96 (82.8%) at the understanding level, 71 (61.2%) at the applying level, 82 (70.7%) at the analyzing level, 40 (34.5%) at the evaluating level, and 23 (19.8%) at the creating level. These results indicate that the majority of respondents prioritized learning objectives at the understanding level, while the fewest selected objectives at the creating level.

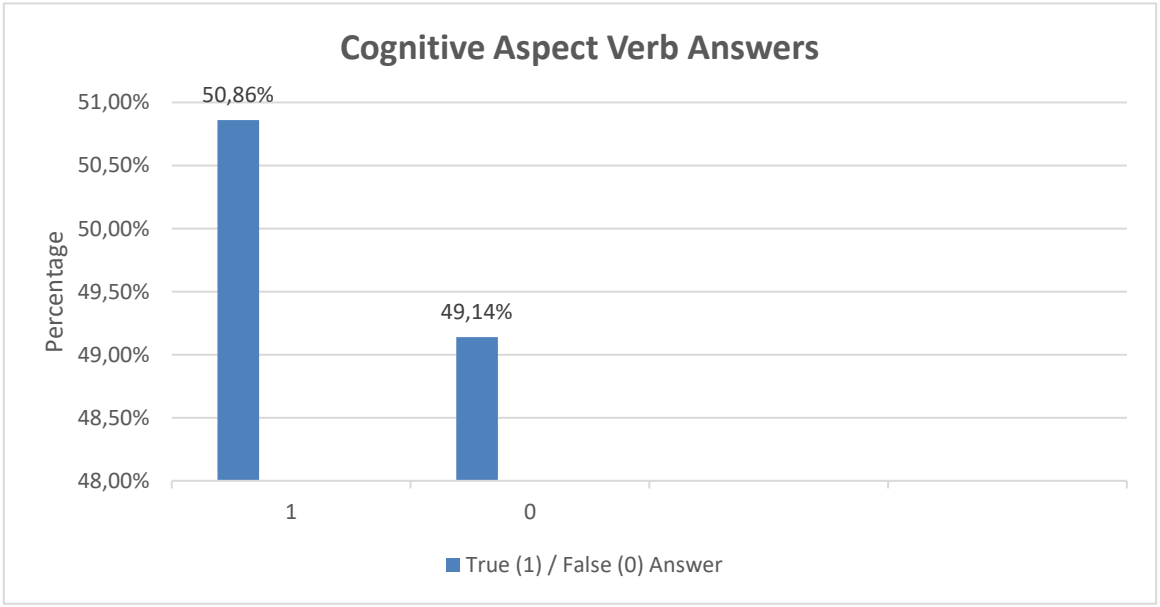

Figure 2. Cognitive Aspect Verb Answers

Based on Graph 2 above, the respective verbs used in the cognitive aspect show that 59 people (50.86%) answered correctly and the remaining 57 people (49.14%) answered incorrectly.

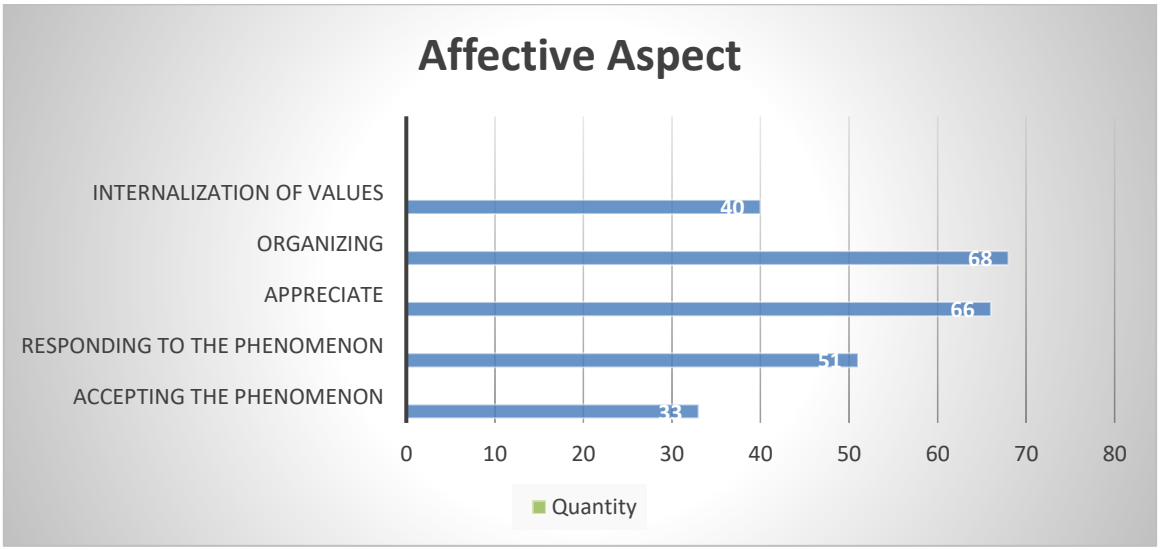

Figure 3. Affective aspect

Based on the data presented in Graph 3, a total of 116 respondents completed the questionnaire. The learning objectives set by participants during the TPE focused on various levels of the affective domain. Specifically, 33 respondents (28.4%) identified objectives at the level of accepting phenomena, 51 (44%) at the level of responding to phenomena, 66 (56.9%) at the level of appreciation, 68 (58.6%) at the level of organization, and 40 (34.5%) at the level of internalization of values. These findings indicate that the majority of respondents emphasized learning objectives at the organizational level of the affective domain, while the fewest selected objectives at the level of accepting phenomena.

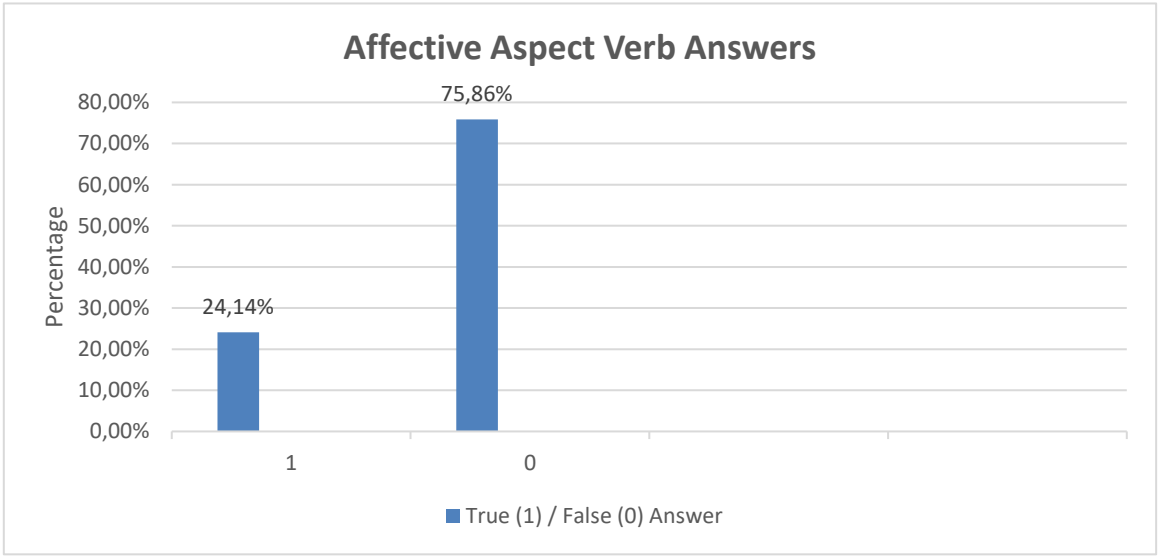

Figure 4. Affective Aspect Verb Answers

Based on Graph 4 above, the respective verbs used in the affective aspect show that 28 people (24.14%) answered correctly, and the remaining 88 people (75.86%) answered incorrectly.

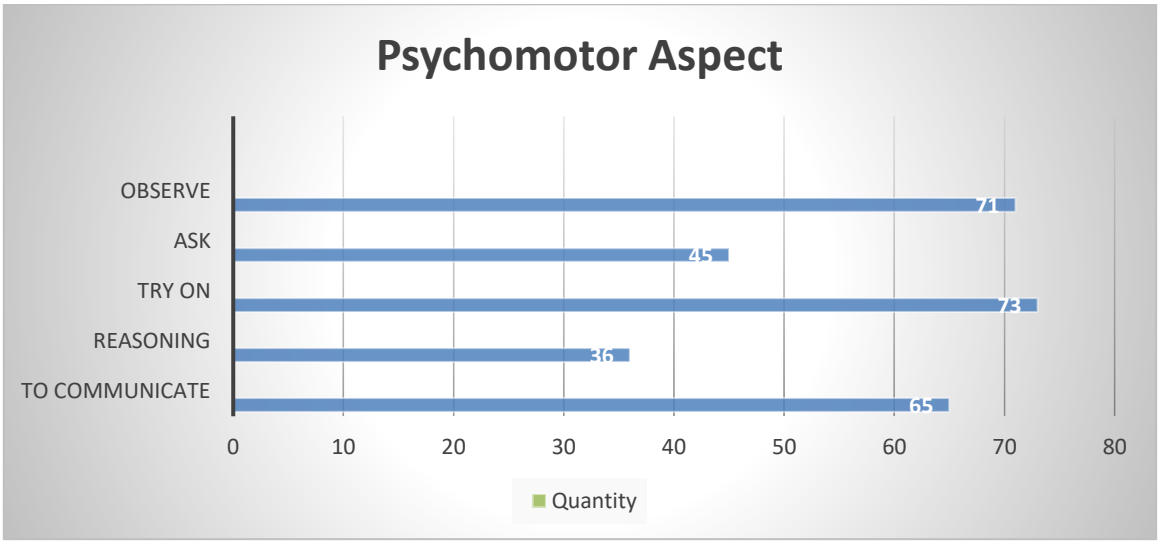

Figure 5. Psychomotor aspect

Based on the data presented in Graph 5, a total of 116 respondents completed the questionnaire. The learning objectives established by participants during the TPE addressed various levels of the psychomotor domain. Specifically, 71 respondents (61.2%) selected the observing level, 45 (38.8%) the questioning level, 73 (62.9%) the trying level, 36 (31%) the reasoning level, and 65 (56%) the communicating level. These results indicate that the majority of respondents prioritized learning objectives at the trying level, while the reasoning level was the least frequently selected.

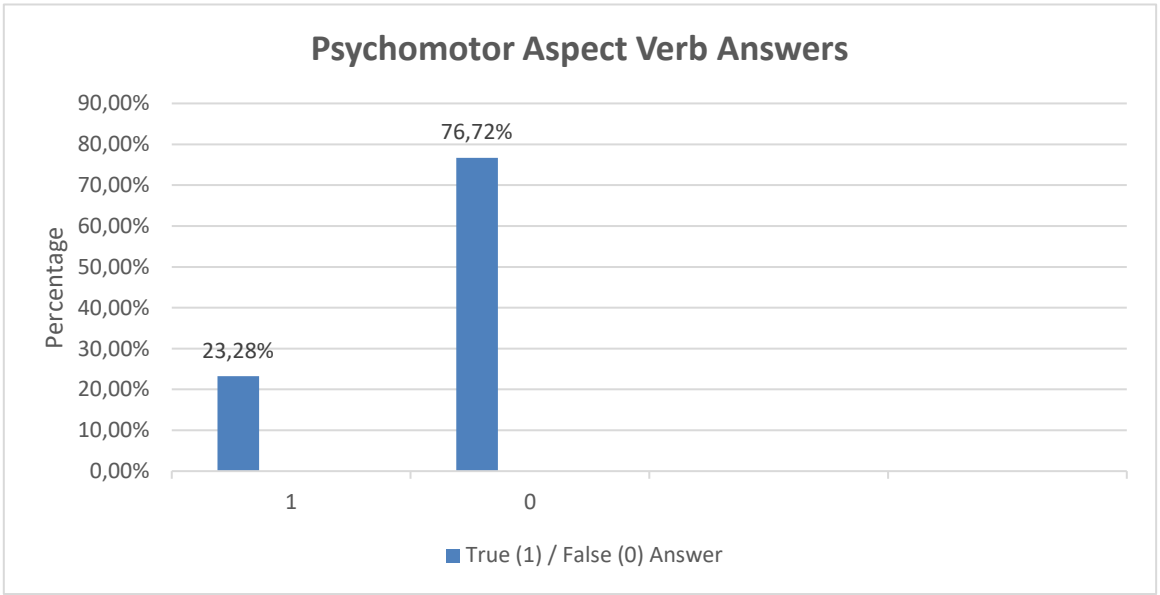

Figure 6. Psychomotor Aspect Verb Answers

Based on Graph 6 above, the respective verbs used in the affective aspect show that 27 people (23.28%) answered correctly and the remaining 89 people (76.72%) answered incorrectly.

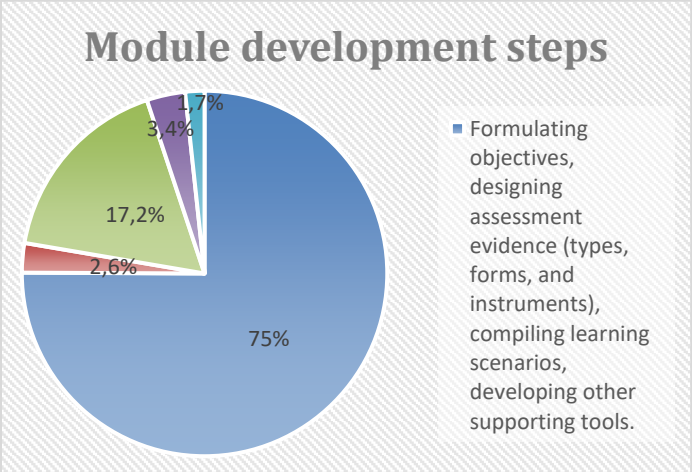

Figure 7. Module development steps

Based on Graph 7 above, it shows that the steps for developing teaching modules carried out by a number of respondents are namely by formulating objectives, designing assessment evidence (types, forms, and instruments), compiling learning scenarios, developing other supporting devices as much as 75% and the steps for developing teaching modules carried out by a number of respondents are by formulating objectives, developing other supporting devices, designing assessment evidence (types, forms, and instruments) as much as 17.2%.

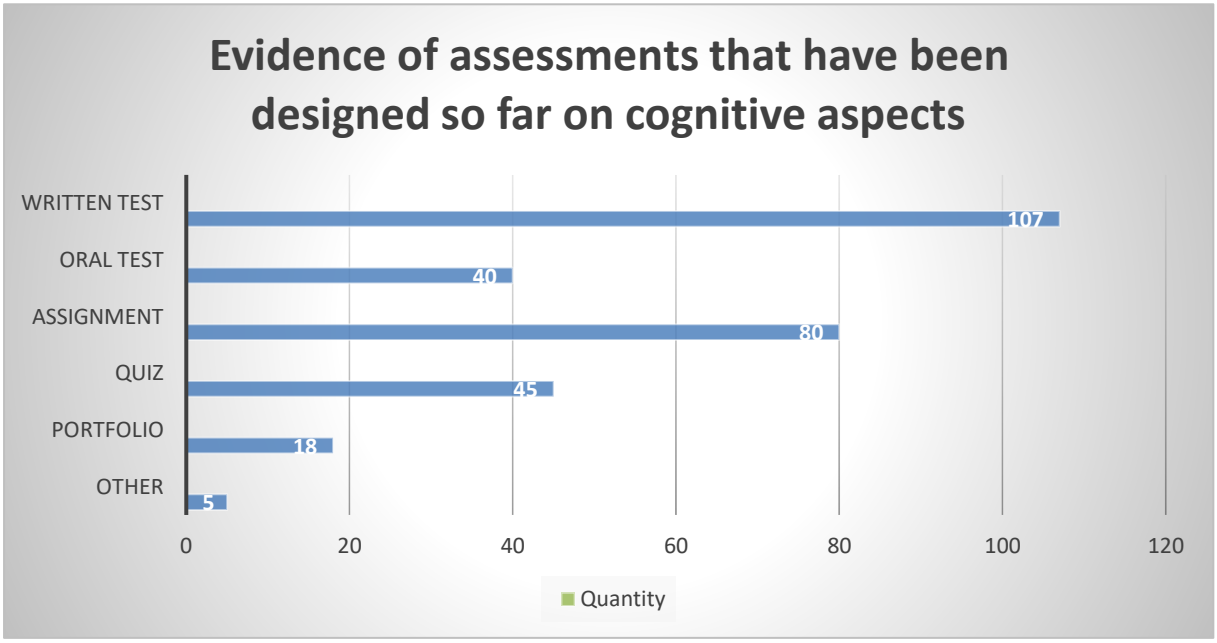

Figure 8. Assessment of cognitive aspects

Based on Graph 8, the assessment evidence designed for the cognitive aspect includes various formats: written tests were used by 107 respondents, oral tests by 40, assignments by 80, quizzes by 45, portfolios by 18, and other forms of assessment by 5 respondents.

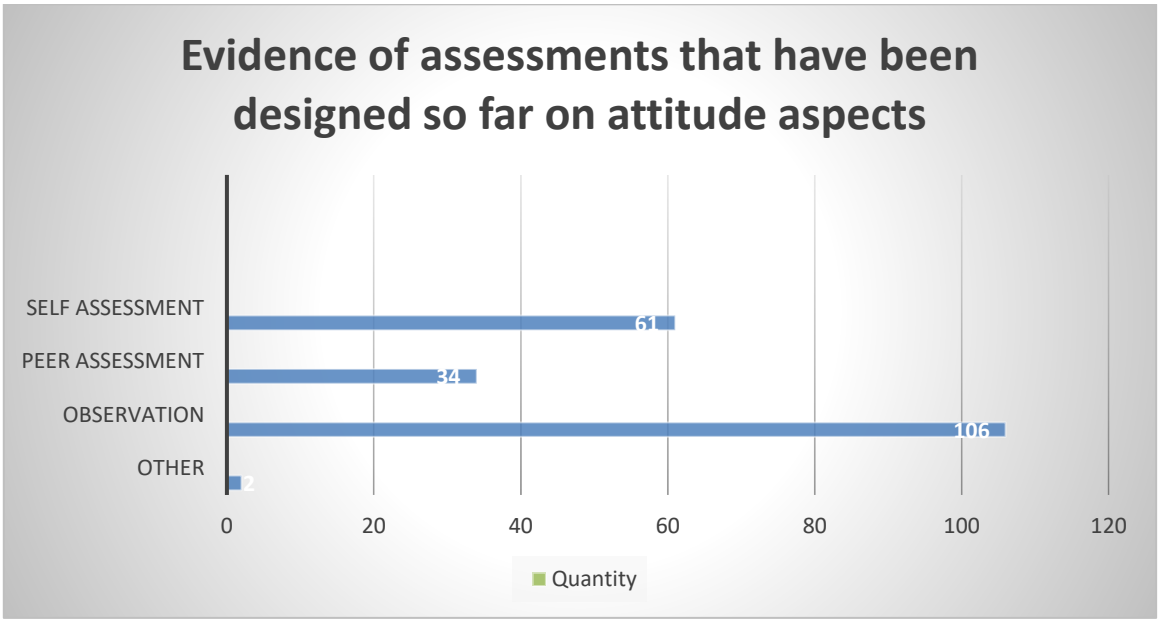

Figure 9. Assessment of evidence attitude aspects

Based on Graph 9, the assessment evidence designed to evaluate the attitude aspect includes self-assessment (61 respondents), peer assessment (34 respondents), observations (106 respondents), and other forms of assessment (2 respondents).

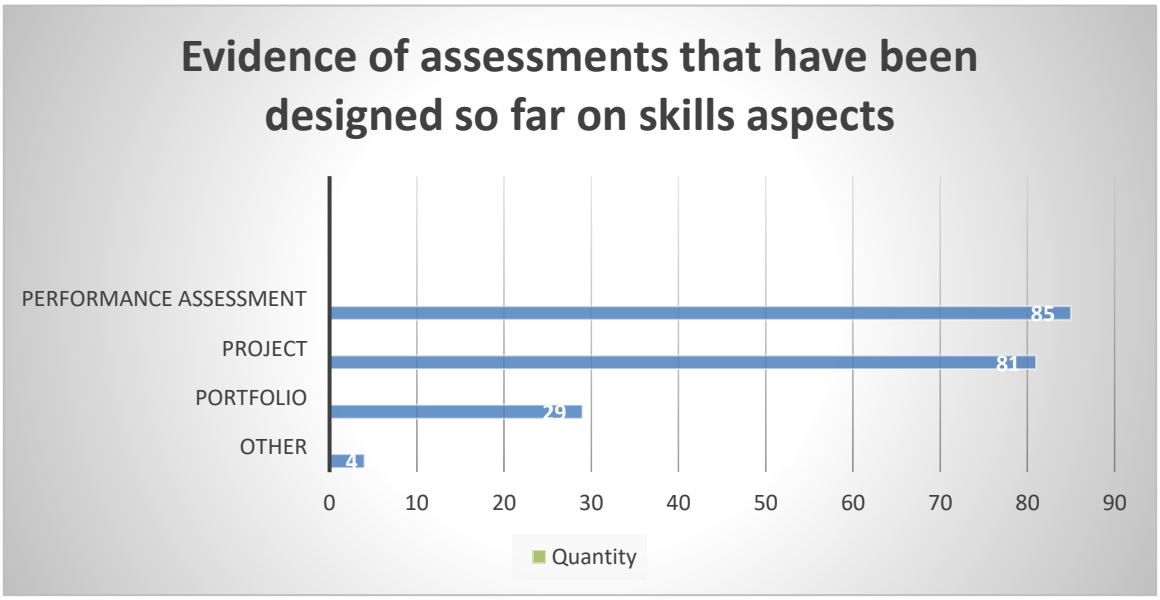

Figure 10. Assessment of the evidence skill aspect

Based on Graph 10, the assessment evidence designed to measure the skills aspect includes performance assessments (85 respondents), project-based assessments (81 respondents), portfolios (29 respondents), and other types of assessment (4 respondents).

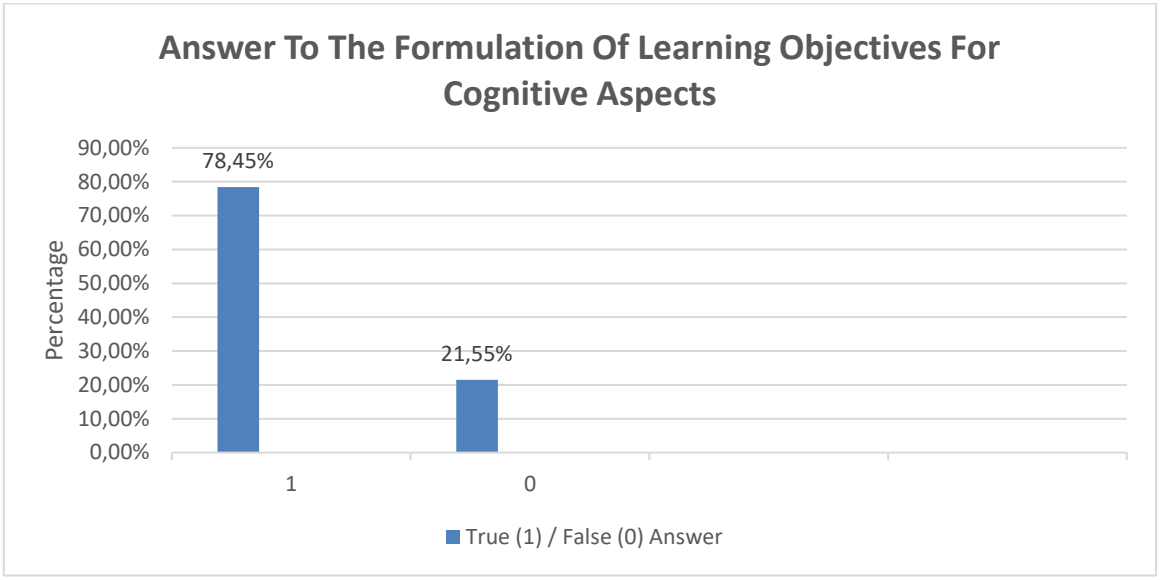

Figure 11. Answer to Learning Objectives Cognitive Aspect

Based on Graph 11 above, the respective verbs used in the cognitive aspect show that 78,45% people answered correctly and the remaining 21,55% people answered incorrectly.

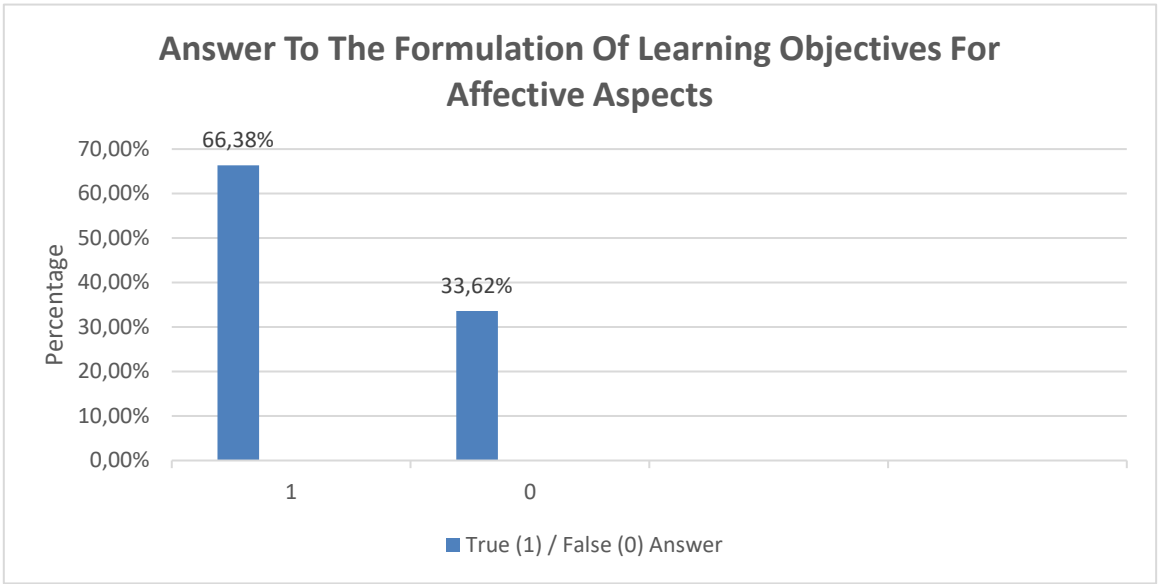

Figure 12. Answer to Learning Objectives for Affective Aspect

Based on the Graph 12 above, the formulation of the affective aspect learning objectives shows that 66,38% people answered correctly and the remaining 33.62% people answered incorrectly.

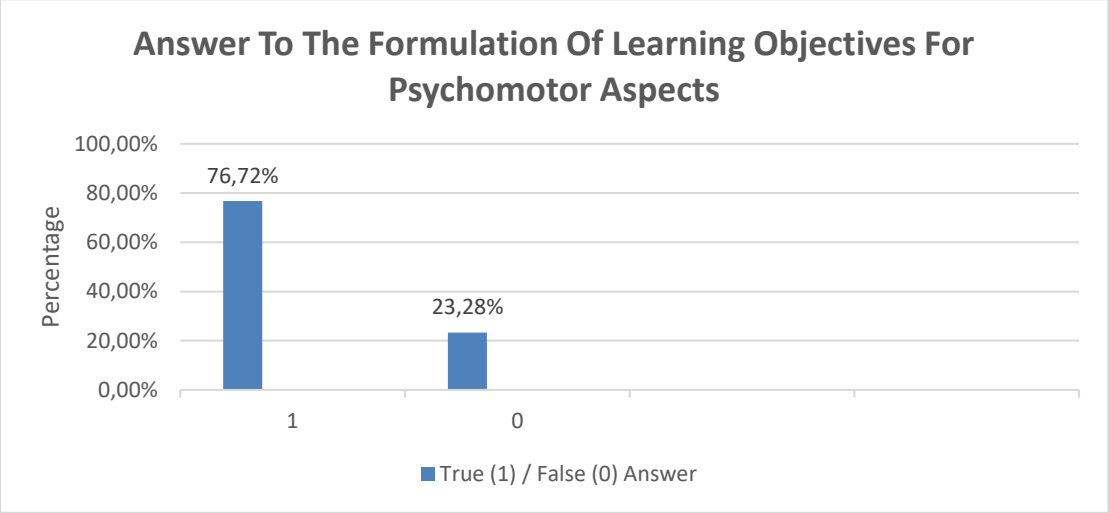

Figure 13. Answer to Learning Objectives for Psychomotor Aspect

Based on the Graph 13 above, the formulation of the learning objectives for the psychomotor aspect shows that 76.72% people answered correctly and the remaining 23.28% people answered incorrectly.

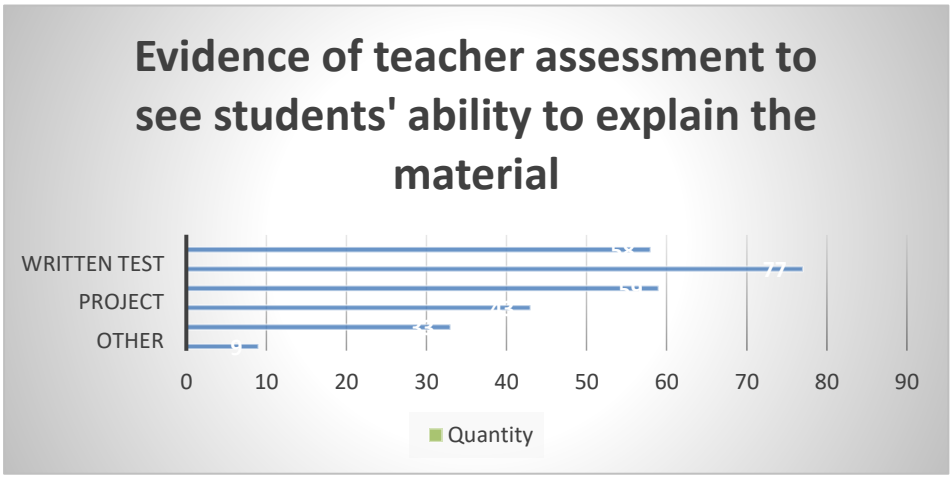

Figure 14. Evidence of teacher assessment to see students' ability to explain the material

Based on the Graph 14 above, it shows that the assessment evidence that teachers can do if they want to see students' ability in explaining the material being taught is through performance tests for 58 people (50%), through written tests for 77 people (66.4%), observations for 59 people (50.9%), projects for 43 people (37.1%), quizzes for 33 people (28.4%), and others through presentations, oral tests, portfolios, and LKPD for nine people.

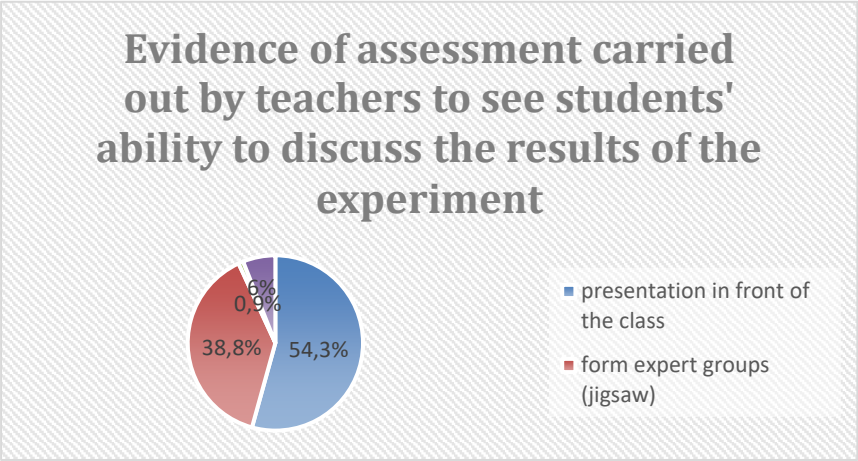

Figure 15. Evidence of assessment carried out by teachers to see students' ability to presentation

Based on the Graph 15 above, it shows that the assessment evidence that teachers can carry out if they want to see students' abilities in demonstrating results is through performance assessments for 82 people (70.7%), projects for 85 people (73.3%), portfolios for 43 people (37.1%), and others such as observations for three people (2.6%).

Discussion

The findings of this study highlight the effectiveness of the Understanding by Design (UbD) framework in strengthening the teaching competencies of prospective elementary science educators. Utilizing a structured backward design model, participants demonstrated improved abilities in aligning learning objectives with appropriate assessments and instructional activities. Data collected through questionnaires revealed that TPE students were able to design lesson plans that comprehensively addressed the cognitive, affective, and psychomotor domains of learning.

In the cognitive domain, participants effectively formulated learning goals across various levels, including understanding, application, and analysis. Within the affective domain, they demonstrated competency in integrating values and fostering students' emotional and ethical development. For the psychomotor aspect, students successfully incorporated activities such as observation, experimentation, and reasoning—skills essential in science education (Natala et al., 2023). These results are consistent with McTighe and Willis (2019), who emphasized that UbD's backward design process enables educators to plan learning units that focus on desired understandings and performance tasks requiring knowledge transfer.

The implementation of UbD begins with defining clear learning goals, followed by identifying evidence of learning through assessments, and finally designing relevant learning experiences (As'Ari, 2014). Unlike conventional models, UbD reverses the instructional planning sequence, prioritizing learning outcomes from the outset (Pertiwi et al., 2019). This reverse planning model fosters deeper understanding by guiding students through six facets of learning: the ability to explain, interpret, apply, empathize, adopt multiple perspectives, and develop self-awareness (Setiyawati, 2023).

Moreover, the analysis suggests that UbD promotes intentionality in lesson design, allowing teachers to plan instruction that is purposeful, cohesive, and aligned with long-term educational goals. This results-oriented approach empowers future educators to create meaningful and engaging learning experiences, which can enhance student motivation and academic achievement. As Yurtseven and Altun (2017) note, UbD encourages continuous reflection and refinement of instructional strategies to stay aligned with evolving curriculum demands.

UbD's positive impact is particularly relevant to the development of 21st-century teaching competencies. By placing student understanding at the core of curriculum design, UbD equips future educators with the tools to implement active learning strategies rooted in constructivist theory. This

approach promotes the development of critical thinking, problem-solving, and collaborative skills, all essential in modern science education (Arslan Buyruk et al., 2018).

Science education plays a central role in developing interdisciplinary knowledge and preparing students for future challenges. Previous efforts to enhance science learning at the elementary level have often fallen short due to the lack of structured pedagogical models. In contrast, the UbD framework has shown consistent promise in improving science achievement by fostering deep, transferable understanding and encouraging student-centered learning environments (Dagdalan & Tas, 2017). This study underscores the importance of integrating UbD into teacher education programs, as its application not only enhances instructional quality but also supports the development of skilled, reflective, and adaptive science educators.

4. CONCLUSION

This study concludes that the Understanding by Design (UbD) approach is effective in enhancing the pedagogical competencies of teacher candidates, particularly in elementary science education. The structured UbD framework—beginning with the identification of desired learning outcomes, followed by the development of assessments and the design of targeted learning activities—proves to support meaningful curriculum planning aligned with long-term educational goals. Findings indicate that UbD not only fosters deeper student understanding but also equips pre-service teachers with the ability to design instructional plans that address cognitive, affective, and psychomotor learning domains. However, the research is limited by its exclusive use of a questionnaire for data collection, which restricted the ability to gain rich insights into participants' lived experiences, challenges, and perceptions regarding UbD implementation. To address this limitation, future research should consider adopting qualitative or mixed-methods approaches to explore the practical application of UbD in greater depth. Longitudinal studies are also recommended to assess the long-term impact and sustainability of UbD in teaching practices post-PPG. Additionally, further research could focus on the development of UbD-based training models tailored to the Indonesian educational context. It is also recommended that teacher education programs promote the integration of UbD stages into instructional models to foster intentional, outcome-oriented teaching practices.

Acknowledgments: The researchers would like to express their sincere gratitude to Universitas Negeri Yogyakarta for providing the necessary funding and resources to support this research. Special thanks to the respondents, particularly the TPE students, who participated and contributed their valuable time and perspectives. Lastly, we acknowledge the collaborative efforts of our research team, whose dedication and hard work were essential to the realization of this project.

Conflicts of Interest: The authors report no conflicts of interest.

REFERENCES

Almasaeid, T. F. (2014). The effect of using blended learning strategy on achievement and attitudes in teaching science among 9th grade students. *European Scientific Journal*, *10*(31). 1-15

Arslan Buyruk, A., Erdogan, P., Cavusoglu Deveci, C., &Yucel Toy, B. (2018). The effects of understanding by design (UbD) model enriched with model of motivational design on the students' speaking skills and motivation in English: A design based research. *Journal of Higher Education and Science, 8*(1), 82-94

Asari, A. R. (2014). Penggunaan Backward Design Dalam Merancang Pembelajaran Matematika Yang Bernuansa Observation-Based Learning. Makalah disajikan dalam Seminar Jurusan Matematika FMIPA. Universitas Negeri Malang.23-31

Bowen, R. S. (2017). *Understanding by design*. Vanderbilt University Center for Teaching.

Dagdalan, G., &Tas, E. (2017). Effect of simulation-based science teaching on students' achievement and attitudes towards computer-basedscienceteaching. *Journal of Science Teaching, 5*(2), 160-172

Gloria, R. Y., & Sudarmin, S. (2018). Kontribusi Asesmen Formatif dalam Tahapan Understanding by Design terhadap Pemahaman Mahasiswa Calon Guru Biologi. *Peer Review Jurnal Ilmiah. Bioedukatia, 6*(2).

Hosseini, H., Chalak , A., & Biria, R. (2019). Impact of Backward Design on Improving Iranian Advanced Learners' Writting Ability: Teachers' Practices and Beliefs. *International Journal of Instruction, 12*(2), 33- 50.

Karamustafaoglu, O., Bayar, A., & Kaya, M. (2014). An investigation of science teachers' teaching methods and techniques: Amasya case. *Journal of Theoretical Educational Science*, 7(4), 436-462.

McTighe, J., & Wiggins, G. (2012). *Understanding by design framework. Alexandria*, VA: Association for Supervision and Curriculum Development.

Natala, V. E. D., Vanalita, M., Pratama, A. O., & Astuti, M. D. (2023). Implementasi Understanding by Design dalam Kegiatan Pembelajaran: *Literature Review. In Prosiding Seminar Nasional Ilmu Pendidikan* (Vol. 2, No. 1).

Pertiwi, S., Sudjito, D. N., & Rondonuwu, F. S.,(2019). Perancangan Pembelajaran Fisika tentang Rangkaian Seri dan Paralel untuk Resistor Menggunakan Understanding by Design (UbD). *Jurnal Sains dan Edukasi Sains, 2*(1), 1-7

Putra, Z. R. I. A., Pratama, C. E., Pramudito, M. S., & Fauziyah, N. (2023). Pengembangan Modul Ajar Matematika Berdiferensiasi Berbasis Understanding by Design (UbD). *Postulat: Jurnal Inovasi Pendidikan Matematika, 4*(1), 128-139.

Rosnaeni, R., Sukiman, S., Muzayanati, A., & Pratiwi, Y. (2022). Model-Model Pengembangan Kurikulum di Sekolah. *Edukatif: Jurnal Ilmu Pendidikan,* 4(1), 467-473.

Setiyawati, N., Milianti, M., Septiani, U. R., & Titin, T. (2023). Analisis Pengembangan Rancangan Pembelajaran dengan Pendekatan Ubd. *Jurnal Penelitian, Pendidikan dan Pengajaran*, 4(3), 170-174

Som, I., Turkan, A., & Altun, S. (2016). Design of introduction to educational sciences course using UbD: The evaluation of prospective teachers' achievement, attitudes and opinions about the course. *International Journal of Social Sciences and Education Research Online, 2*(4), 1659-1672.

Wiggins, G., & McTighe, J. (2005). *Understanding by design*. www.ascd.org

Yurtseven, N., & Altun, S. (2017). Understanding by design (UbD) in EFL teaching: Teachers' professional development and students' achievement. *Educational Sciences: Theory and Practice, 17*(2), 437-461

Yurtseven, N., & Dogan, S. (2018). UbD Implementations in Preschool Teaching: Reflections from the Teacher and Student Perspective. *Hacettepe University Journal of Education Faculty,* 33(3), 656-671.