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# DIFFERENTIATED INSTRUCTION SCENARIO ON PHYSICS LEARNING: REFLECTION OF READINESS AND FUTURE IMPLEMENTATION

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**ABSTRACT**

This study has successfully constructed the scenario of differentiated instruction (DI) on physics learning as a reflection of readiness and future implementation through undergraduate students' beliefs. Differentiated instruction (DI) is an approach that enables teachers to plan strategically to meet the needs of every student. However, differentiated instruction in physics may or may not challenge its users in reality as it depends on beliefs and views about the nature of science, instruction, and pedagogical content knowledge. This quantitative-qualitative study involved 56 undergraduate students and consisted of three main stages: preliminary, analysis, and rendition. In the first and second stages, we found a strong negative correlation between the proportion of mathematics-conceptual knowledge of the topics and the possibility of implementing differentiated instruction (r =-0,576). Meanwhile, belief in self-proficiency is directly proportional to the DI implementation possibility (r = 0.828). In conclusion, we created two scenarios based on analysis, representing the current reality of how DI will be implemented and future implementation expectations. Moreover, this research strengthens the theory that beliefs influence the possibility of using differentiated instruction. We suggest a demand for an effective introduction to differentiation instruction during science teacher preparation programs and leading professional learning that may support the development of undergraduate students at the beginning of their careers.



Keywords: beliefs; differentiated instruction; pedagogical content knowledge; Physics

## INTRODUCTION

Differentiated instruction (DI) is an approach that enables teachers to plan strategically to meet the needs of every student. This concept is rooted in the concept that because there is variability among any group of learners, teachers should expect student diversity and adjust their instruction accordingly (Tomlinson, 2014; Tomlinson, 2017; Putra, 2023). Differentiated instruction focuses on a diversity-based approach (Tomlinson et al., 2003), which can help students meet their learning needs based on different aspects such as readiness, interests, and learning profiles (Tomlinson, 2014; Tomlinson, 2017; Du Plessis, 2019; Gheyssens et al., 2022). Differentiated instruction may open opportunities for inclusivity in learning for all students, relinquishing the concept of one size fits all (Tapper & Horsley, 2019; Johler & Krumsvik, 2022). The definition of differentiated instruction sparks the idea of students as central key players. However, the teacher is the most influential stakeholder in accommodating differentiated instruction satisfactorily (Aykutlu et al., 2015), as teachers' response is critical to this approach (Zerai et al., 2021).

Differentiated instruction in physics may or may not challenge teachers in reality. It depends

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on their beliefs about differentiated instruction and their view about the nature of science and instruction (Mesci et al., 2023). Physics in secondary school provides a wide range of materials, from the basics to advanced concepts such as modern physics and atomic physics. Most students perceive physics as a difficult subject because it includes various forms of representation (Angell et al., 2004). Furthermore, it is more convoluted because to fulfil students' needs and diversity in physics learning, teachers must realize the importance of the sociocultural context linking to contextual learning (Jardim et al., 2021). However, the difficulty of physics learning may concoct a silver lining of differentiated instruction where it can provide multiple learning possibilities.

Over the next ten years, the current undergraduate students will pioneer twenty-first-century education. This statement reflects how investigating undergraduate students is extremely important. Although undergraduate students do not yet have their professional identity, their perception of professional vision is crucial to constructing a connection to their classroom expectations (Vantieghem et al., 2020). This notion supports the statement that beliefs in differentiated instruction link to their future use of differentiated instruction (Whitley et al., 2019) and as a research basis (Nicolae, 2014). Furthermore, belief is not the only aspect of student teachers' professional identity and vision but also pedagogical content knowledge (Krumphals et al., 2019). In undergraduate students, pedagogical content knowledge is constructed throughout their study at the tertiary level as a basis for their teaching journey ahead. If linking back to physics, pedagogical content knowledge in physics is considered unique because it consists of separable topics. The required pedagogical content knowledge that undergraduate physics students must possess to be eligible as secondary school teachers is listed in the table 1. These topics consist typically of mathematical and conceptual knowledge.

Therefore, as undergraduate students build pedagogical content knowledge, it influences their beliefs about the possibility of implementing differentiated instruction. Belief must be considered while designing differentiated instruction because it will influence the implementation of differentiated instruction in the classroom (Aftab, 2015; Whitley et al., 2019; Roose et al., 2022), giving student teachers the option of whether they perceive particular topic as "possible" or "not possible" to be implemented within differentiated instruction. This study will create a general scenario for differentiated instruction implementation in physics learning based on the topic. Furthermore, this study will explore the possibility of implementing differentiated instruction based on undergraduate students' beliefs about physics topics and their perception of the ability of mathematical and conceptual knowledge of particular topics.

**Table 1.** List of Physics Topics in Secondary School

| Code | Topics |
|---|---|
| T1 | The nature of physics and the scientific method |
| T2 | Unit and measurement. |
| T3 | Vector |
| T4 | Kinematics |
| T5 | Circular motion |
| T6 | Newton's laws of motion. |
| T7 | Newton's laws of gravity and Kepler's laws. |
| T8 | Work and energy |
| T9 | Impulse and momentum |
| T10 | Oscillation |
| T11 | Rotational dynamics and equilibrium |
| T12 | Elasticity |
| T13 | Static fluid |
| T14 | Dynamic fluid |
| T15 | Heat and temperature |
| T16 | Kinetic theory of gases |
| T17 | Thermodynamics |

| | |
|---|---|
| T18 | Characteristics of mechanical waves |
| T19 | Traveling and stationary waves |
| T20 | Sound |
| T21 | Light |
| T22 | Dynamics electricity |
| T23 | Static electricity |
| T24 | Magnetic field and Electromagnetic induction |
| T25 | Alternating current |
| T26 | Electromagnetic radiation |
| T27 | Relativity |
| T28 | Quantum phenomena |
| T29 | Data storage and transmission |
| T30 | Radioactivity |

No research related to the scenario implementation of DI has been conducted. However, a previous study about the students' perspective of DI assessment is closely linked to this research. In this previous study, the authors analyzed the correlation between behavioral intention to use DI assessment and expected performance (Majuddin et al., 2022). This previous research was conducted based on students' beliefs, but not the teachers or pre-service teachers as key players. Furthermore, another study investigates beliefs about DI only in chemistry teaching and learning (Easa & Blonder, 2023). So, this research may fill the gaps in the previous research.

## METHODS

This research was a quantitative-qualitative study. First, we use correlational research to analyze the connection between variables. Thus, two scenarios and descriptive analysis were created from the result of correlation. Fifty-six undergraduate students (second and third year) from the Physics Education Study Program at Yogyakarta State University, Indonesia, participated as the sample. This study consisted of three stages: preliminary (introduction to differentiated instruction), analysis, and scenario rendition. The researchers informed the participants about the purpose of the study. The data were kept confidential, and consent statements were distributed to all participants before data collection. The participation of undergraduate students (pre-service teachers) was voluntary. It was clearly stated that no person would be identified. The preliminary stage intended for the samples to comprehend the concept of differentiated instruction thoroughly. In this stage, the definition of differentiated instruction, the benefits and drawbacks, and the concrete example of the implementation of differentiation in physics learning were given.

After fully apprehending all the information, the samples were given a survey. This survey intended to explore and investigate beliefs about mathematical and conceptual knowledge, beliefs about the ability to understand particular topics, and the possibility of implementing differentiated instruction on those particular topics. Although it was inconceivable to quantify beliefs, the question in the survey was based on the Likert scale within 30 different topics. The instrument was converted into quantitative data, for example, very likely worth five and impossible worth one. The sample questions and the topics are shown in the table 2.

**Table 2.** Sample Question

**Question:**

**Based on your perception, how about the possibility of implementing differentiated instruction on these topics?**

| No | Topics | Choices | | | | |
|---|---|---|---|---|---|---|
| 1 | The nature of physics and the scientific method | Impossible | Unlikely | Even Chance | Likely | Very Likely |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2 | Unit and measurement. | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 3 | Vector | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 4 | Kinematics | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 5 | Circular motion | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 6 | Newton's laws of motion. | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 7 | Newton's laws of gravity and Kepler's laws. | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 8 | Work and energy | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 9 | Impulse and momentum | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 10 | Oscillation | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 11 | Rotational dynamics and equilibrium | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 12 | Elasticity | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 13 | Static fluid | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 14 | Dynamic fluid | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 15 | Heat and temperature | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 16 | Kinetic theory of gases | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 17 | Thermodynamics | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 18 | Characteristics of mechanical waves | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 19 | Traveling and stationary waves | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 20 | Sound | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 21 | Light | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 22 | Dynamics electricity | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 23 | Static electricity | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 24 | Magnetic field and Electromagnetic induction | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 25 | Alternating current | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 26 | Electromagnetic radiation | Impossible | Unlikely | Even Chance | Likely | Very Likely |

| | | | | | | |
|---|---|---|---|---|---|---|
| 27 | Relativity | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 28 | Quantum phenomena | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 29 | Data storage and transmission | Impossible | Unlikely | Even Chance | Likely | Very Likely |
| 30 | Radioactivity | Impossible | Unlikely | Even Chance | Likely | Very Likely |

In the analysis stage, the complexity of the work was prominent. This stage consisted primarily of quantitative methods. First, the data obtained from the preliminary stage were analyzed through Pearson correlation (Punch & Oancea, 2014) using SPSS with four hypotheses: H0a: There is no correlation between undergraduate students' beliefs about their ability on particular topics and the possibility of implementing differentiated instruction on those particular topics.; H1a: There is a correlation between undergraduate students' beliefs about their ability on particular topics and the possibility of implementing differentiated instruction on those particular topics.; H0b: There is no correlation between undergraduate students' beliefs about the component of mathematical and conceptual knowledge of particular topics and the possibility of implementing differentiated instruction on those particular topics.; H1b: There is a correlation between undergraduate students' beliefs about the component of mathematical and conceptual knowledge of particular topics and the possibility of implementing differentiated instruction on those particular topics.

We used bivariate correlational statistics. Bivariate correlational statistics intends to analyze data that involve two variables (Gall et al., 2010). Internal consistency was used to measure the reliability of the quantitative instrument. The analysis provided the basis for taxonomy creation. The criteria of the correlation are shown in the table 3.

**Table 3.** Correlation Criteria (Mujis, 2004)

| r Value | Description |
|---|---|
| 0.00-0.09 | Weak |
| 0.10-0.29 | Modest |
| 0.30-0.49 | Moderate |
| 0.50-0.79 | Strong |
| 0.80-1.00 | Very Strong |

The previous research had no scenario rendition and ended at the correlation analysis stage. This is the new research modification we conducted to create larger implications for the current practice. There are two scenarios of how differentiated instruction will be implemented in secondary school, particularly in physics. The scenarios are the middle scenario and the best possible scenario. We used the framework based on the possibility of implementation and beliefs about difficulty. In this stage, particular topics were scattered into the X-Y axis. The details of the framework are provided in Figure 1.

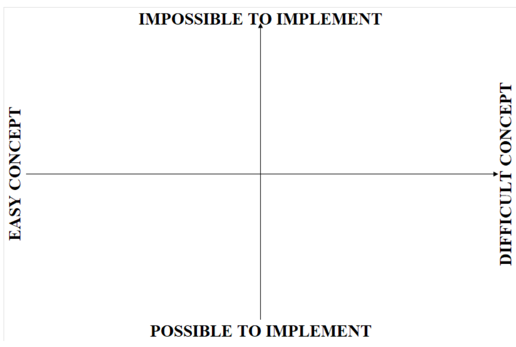


**Figure 1**. Scenario Framework

## RESULTS AND DISCUSSION

Based on the Pearson Correlation, we prove that H0a is rejected, which means that there is a strong negative correlation (r = -0.576) between undergraduate students' beliefs about the component of mathematical and conceptual knowledge of particular topics and the possibility of implementing differentiated instruction on those particular topics. In this case, when the samples believe the component is more mathematical than conceptual, they perceive it is impossible to use differentiated instruction on those particular topics. The details are provided in Table 4.

**Table 4.** Correlation between implementation possibility and composition of PCK

| | | Beliefs about possibility to implement DI on particular topic | Beliefs about the composition of mathematical and conceptual knowledge on particular topic |
|---|---|---|---|
| Beliefs about possibility to implement DI on particular topic | Pearson Correlation | 1 | -.576** |
| | Sig. (2-tailed) | | .001 |
| Beliefs about the composition of mathematical and conceptual knowledge on particular topic | Pearson Correlation | -.576** | 1 |
| | Sig. (2-tailed) | .001 | |

**. Correlation is significant at the 0.01 level (2-tailed).

Similarly, H0b is rejected, which means a very strong correlation (r = 0.828) exists between undergraduate students' beliefs about their ability on particular topics and the possibility of implementing differentiated instruction on those particular topics. This result indicates that beliefs influence the possibility of using differentiated instruction. When the samples believe they have mastered those particular topics, the possibility of implementing DI increases. The details are provided in Table 5.

**Table 5.** Correlation between the possibility of implementation and beliefs about ability

| Correlations | | | |
|---|---|---|---|
| | | Beliefs about possibility to implement DI on particular topic | Beliefs about ability on particular topic |
| Beliefs about possibility to implement DI on particular topic | Pearson Correlation | 1 | .828** |
| | Sig. (2-tailed) | | .000 |
| Beliefs about ability on particular topic | Pearson Correlation | .828** | 1 |
| | Sig. (2-tailed) | .000 | |

**. Correlation is significant at the 0.01 level (2-tailed).

The first classification is based on the topic difficulty. From the overall survey, we figure that 18 topics are easy for most samples, while most samples perceive the rest as challenging. The second classification is based on the possibility of implementing differentiated instruction for particular topics. We find that 20 topics are perceived as eligible, while the rest are perceived as less eligible. The overall classification based on the framework is shown in the Figure 2.

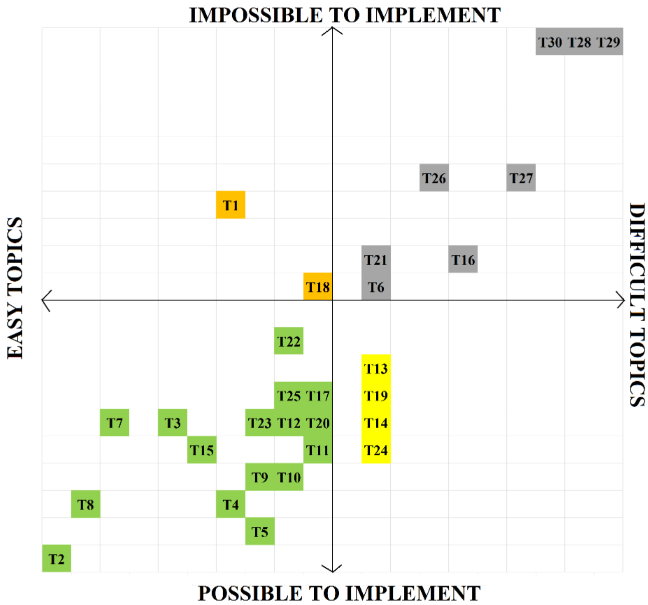


**Figure 2.** Middle Scenario of DI

Although we only focus on content in this research, the implementation of differentiated instruction is often based on content, process, and product (assessment) (Tomlinson, 2014; Tomlinson, 2017; Bondie et al., 2019). This notion emphasizes the role of content before implementation. The middle scenario in Figure 2 represents the current reality of how DI will be implemented. Based on the middle scenario, it is prominent that most contents, which the samples believe to be difficult and either have too much conceptual (and theoretical) knowledge or mathematical knowledge, will be excluded from differentiation. This strengthens the role of beliefs before implementation (Wan, 2016; Whitley et al., 2019; Griful-Freixenet et al., 2020; Zólyomi, 2022).

Meanwhile, the best scenario (shown in Figure 3) describes the future goal of implementing DI in physics content in secondary schools. The change constricts the gaps between beliefs about the possibility of differentiating difficult content and easy content. This best scenario can only be achieved in multiple ways, but changing beliefs is primarily the fundamental aspect (Heng & Song, 2020). However, the real implementation will be more complex and challenging (van Geel et al., 2019; Gheyssens et al., 2022).

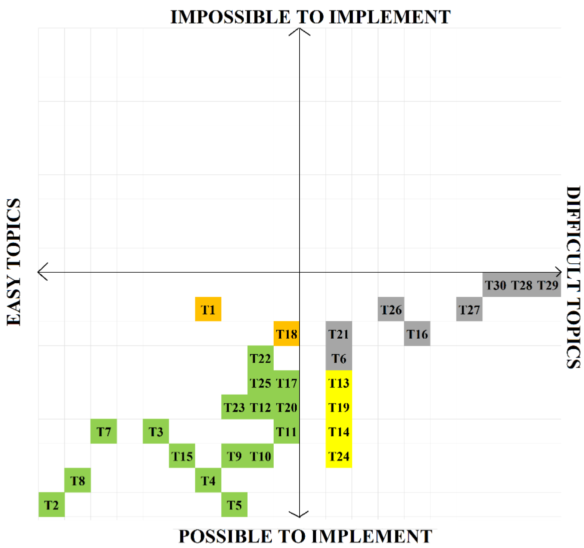


**Figure 3**. Best Possible Scenario of DI

Furthermore, we witness a huge disparity between the most to least favorable content for differentiated instruction in the middle scenario. For example, topics T28 (Quantum Phenomena), T29 (Data Transmission and Storage), and T30 (Radioactivity) are located in the very upper right corner (see middle scenario). All are considered the least possible for DI implementation and the most difficult by most samples. In contrast, T2 (Unit and Measurements) is located in the bottom left corner and is considered the ideal content for differentiated instruction. This disparity proves that undergraduate students' perceptions may create potential and challenge simultaneously. This disparity also signs the struggle to generalize that physics is eligible for differentiated instruction even though differentiated instruction allows for variation in content without losing sight of the curriculum (Levy, 2008). This links belief and the possibility of implementation (Pozas et al., 2020; Letzel et al., 2023). Therefore, there is a demand for effective differentiation during science teacher preparation programs that may support the development of pre-service teachers' DI. Changing the middle scenario to the best scenario is possible by promoting professional learning for pre-service teachers when they start their teaching careers as beginning teachers (Dixon et al., 2014; Maeng & Bell, 2015; Suprayogi et al., 2017; Dack, 2019; Smets & Struyven, 2020; Wan, 2020; Kahmann et al., 2022), as well as through coursework (Dack, 2018) and introduction to collaborative action research at the university level (Dulfer et al., 2021), providing an extensive understanding regarding differentiated instruction (Woollacott, 2014; Onyishi & Sefotho, 2020; Scarparolo & Subban, 2021; Nepal et al., 2021; Bi et al., 2023; Obrovská et al., 2023), and raising awareness of differentiated instruction (Gheyssens et al., 2021) as it will influence the teachers' perception and belief about teaching and learning, and instruction (Tomlinson, 2014; Schwab et al., 2022; Maia & Freire, 2023; Schwab & Woltran, 2023) Lastly, this research may reflect the future implementation of differentiated instruction on physics learning in secondary school through scenario rendition. It may implicate the school leaders in the future on how important leading professional learning (Le Fevre et al., 2020) to support the current undergraduate students regarding their future work and maintain the quality of teaching and learning in secondary school, as well as building a capacity for improvement (Campbell et al., 2018).

## CONCLUSION

This research has successfully created the middle and future scenarios of differentiated instruction. As stated through the middle and best scenarios, we acknowledge that beliefs play a big role in DI implementation. This research also finds that belief is critical for the future implementation of differentiated instruction practice in secondary school. Hence, changing beliefs is essential to transform the middle scenario into the best possible scenario and to narrow the gaps between beliefs about the possibility of DI on particular topics in teaching physics and topic difficulty. However, this study includes samples of teacher education from only one institution, so our result is less likely to be generalized. To determine whether our results are idiosyncratic or generalizable, future research should replicate our study with a larger or nationwide sample that includes a wide range of teacher education programs.

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