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Identification of Students' Readiness and Learning Preferences: A Differentiated Learning Plan for High School Physics (Phase-E)

Rahmat Saifuddin Anwar[1]*, Suryajaya[1], Suyidno[1], Rachmiati[2], and Misbah[3]
[1]Master of Science Education, Universitas Lambung Mangkurat, Banjarmasin, Indonesia
[2]SMA Negeri 6 Banjarmasin, Banjarmasin, Indonesia
[3]Physics Education, Universitas Lambung Mangkurat, Banjarmasin, Indonesia
*saifuddinanwar@outlook.com

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Abstract

This study focused on planning differentiated instruction by identifying students' readiness and learning preferences in the scientific work context of measurement systems. Students' readiness refers to their current knowledge and skills in integrated science process skills, while learning preferences describe their favored ways of processing and engaging with information. The research involved 68 Phase-E students from a senior high school in Banjarmasin and employed a quantitative descriptive approach. Data were collected using the Test of Integrated Science Process Skills II (TIPS II) and the Honey-Mumford Learning Styles Questionnaire. The results indicated that most students exhibited low readiness levels for integrated science process skills, with a mean TIPS II score of 0.349 (SD = 0.0882). Analysis of learning preferences revealed a predominance of assimilator learning styles (38.2%), followed by accommodators (35.3%), convergers (20.6%), and divergers (5.9%). These findings underscore the importance of a differentiated instructional approach that responds to individual students' needs. This study recommends differentiation strategies encompassing content, process, product, and learning environment adjustments based on students' readiness and learning preferences. Additionally, this study highlights the necessity of further exploring students' learning interests as a crucial component of planning differentiated instruction.

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INTRODUCTION

The Fourth Industrial Revolution sparked significant changes across various sectors, including education. In this era, education must go beyond mastering academic content to equip students with essential 21st-century skills such as critical thinking, creativity, collaboration, and communication, which are crucial for navigating a technology-driven world of work (Brown, 2024; Salmon, 2019). Educators must adapt their teaching methods and create innovative and collaborative learning environments to accommodate these skills. Differentiated learning is a promising approach to meet these challenges, which tailors instruction to accommodate students' diverse learning styles and needs (Kalinowski et al., 2024; Langelaan et al., 2024). This approach aims to help students reach their full potential

through personalized learning experiences aligned with the demands of the Fourth Industrial Revolution (Compen et al., 2024; Lase, 2019; McMillan, 2024).

Differentiated learning involves adjusting content, processes, and products and shaping the learning environment to meet individual students' needs (Hoy, 2016; Tomlinson, 2017). Content differentiation involves presenting various materials that suit students' needs and abilities. In contrast, process differentiation involves various methods that allow students to interact with the learning materials. Product differentiation enables learners to demonstrate their understanding in multiple ways (Febriana et al., 2023; Wardani & Darmawan, 2024). To create an optimal learning environment, it is necessary to identify students' learning needs through diagnostic assessments to understand their readiness, interests, and preferences. The results of this assessment help educators design and implement effective differentiation strategies (Arends, 2012; McMillan, 2024).

Planning for compiling differentiated learning is carried out by identifying the characteristics of the students. These characteristics include learners' readiness, interest, and profiles (Doubet & Hockett, 2015; Roberts & Inman, 2022; Tomlinson, 2017). One of the demands of 21st-century learning and the latest Kurikulum Merdeka (Indonesian curriculum) is for students to systematically construct their understanding and skills through skills referred to as science process skills (Chen et al., 2023; Thornhill-Miller et al., 2023). These skills are divided into two categories: basic science process skills and integrated science process skills (Ernawati et al., 2022; Gizaw & Sota, 2023).

Basic science process skills are generally developed by lower-level students, such as those in Phase D (Maiyanti et al., 2024; Chamidah et al., 2024). However, integrated science process skills can further intensify in Phase E, particularly in science learning. In addition, the learning process is expected to accommodate student interests using various activities and learning strategies (Amany et al., 2023; Harefa, 2023). Finally, one of the other essential characteristics educators identify is the varied learning preferences of individuals (Moore & Craciun, 2024; Yotta, 2023).

The Honey-Mumford model describes learning styles which are activist, reflective, theoretical, and pragmatic. This model can be matched with Kolb's experiential learning theory, which identifies four learning preferences: divergers, assimilators, convergers, and accommodators (Chapman, 2023; Kolb, 2015; Liao, 2019). Each of these preferences represents a different approach and must be considered by educators when designing a curriculum to better suit the needs of students.

Various studies have successfully identified students' readiness, interests, and learning preferences, showing that learning outcomes are optimal when learning preferences are adjusted to these factors. However, there is still a research gap in identifying students' readiness, interest, and learning preferences on physics topics (or competencies), such as in the "Measurement Systems in Scientific Work" competency, especially in South Kalimantan. Although the importance of understanding students' readiness and learning preferences in implementing differentiated learning has been recognized, research on how these aspects are realized in Banjarmasin high schools still needs improvement (Grecu, 2023; Lestari et al., 2023). Without empirical studies on this topic, educators may face challenges in designing instruction that effectively accommodates the diverse needs of students, potentially impeding the development of essential scientific competencies.

This study aims to fill this gap by identifying students' readiness and learning preferences on a measurement system for scientific work competency in a senior high school in Banjarmasin. The theoretical framework used in this study refers to the concept of differentiated learning planning (Tomlinson, 2017). The results of this study are expected to contribute to teachers who design differentiated learning that is more in line with the needs of students. This finding is expected to serve as a reference for further research on implementing learning differentiation in the South Kalimantan region.

METHODS

This study adopted a quantitative descriptive approach to comprehensively analyze students' readiness and learning preferences regarding physics, specifically for the "Measurement Systems in Scientific Work" competency. Data were collected at one of the high schools in Banjarmasin in October 2024, involving 68 Phase-E students selected using the purposive sampling technique.

The instruments used for data collection included the Test of Integrated Science Process Skills II (TIPS II), which has been previously validated (Burns et al., 1985). The integrated science process skills (SPS) indicators analyzed in this study include (1) identifying variables, (2) formulating operational definitions of variables, (3) stating hypotheses, (4) drawing graphs and interpreting data, and (5) designing investigations.

Students' learning preferences were assessed using a 40-item questionnaire adapted from the Honey-Mumford Learning Styles Questionnaire. The results of the students' SPS abilities were then grouped as listed in Table 1. The dominant students' learning preferences were labeled as assimilators, accommodators, convergers, and divergers. Quantitative data analysis was performed using descriptive statistics in Jamovi and Microsoft Excel.

Table 1 Categories of students' SPS (Widoyoko, 2009)

Interval Score	Category
$x > 0.800$	Very Good
$0.600 < x \leq 0.800$	Good
$0.400 < x \leq 0.600$	Fair
$0.200 < x \leq 0.400$	Poor
$x \leq 0.200$	Very Poor

RESULTS AND DISCUSSION

Students' learning readiness in integrated science process skills

The Test of Integrated Science Process Skills II (TIPS II) analysis showed that students' learning readiness levels varied. The average TIPS II score was 0.349, with a standard deviation of 0.0107. Students' learning readiness was reviewed based on their integrated science process skills, as presented in Tables 2 and 3.

Table 2 Descriptive statistics on students' readiness for integrated SPS.

	SPS Indicator					SPS Total Score
	(1)	(2)	(3)	(4)	(5)	
N	68	68	68	68	68	68
Missing value	0	0	0	0	0	0
Mean (M)	0.357	0.316	0.249	0.409	0.500	0.349
Mean st. dev.	0.0166	0.0188	0.0134	0.0248	0.0348	0.0107
Median	0.330	0.330	0.220	0.330	0.670	0.340
St. dev. (SD)	0.137	0.155	0.110	0.204	0.287	0.0882
Min	0.00	0.00	0.00	0.00	0.00	0.170
Max	0.670	0.670	0.440	1.00	1.00	0.620
Skewness	-0.134	0.372	-0.102	0.368	-0.147	0.466
Kurtosis	0.308	0.115	-0.182	0.329	-0.613	0.326

Note: SPS Indicators – (1) identifying variables, (2) formulating operational definitions of variables, (3) stating hypotheses, (4) drawing graphs and interpreting data, and (5) designing investigations (Burns et al., 1985)

Table 3 Frequency table based on students' ability to do integrated SPS.

SPS Category	SPS Indicators (Number of Students)					All SPS Indicator
	(1)	(2)	(3)	(4)	(5)	
Very Good	0	0	0	4	7	0
Good	1	4	0	7	29	1
Not Good	26	11	8	21	0	12
Bad	34	30	47	22	23	52

SPS Category	SPS Indicators (Number of Students)					All SPS Indicator
	(1)	(2)	(3)	(4)	(5)	
Very Bad	7	23	13	14	9	1
Total	68	68	68	68	68	68

Students' learning preferences

Students were divided into four learning style categories: assimilator, converger, accommodator, and diverger. The data obtained showed that as many as 26 students (38.2%) tended to be assimilators, followed by 24 accommodators (35.3%), 14 convergers (20.6%), and four divergers (5.9%). The results of the distribution of learning preferences are displayed in Figure 1 to provide a clear visual picture of students' learning style tendencies.

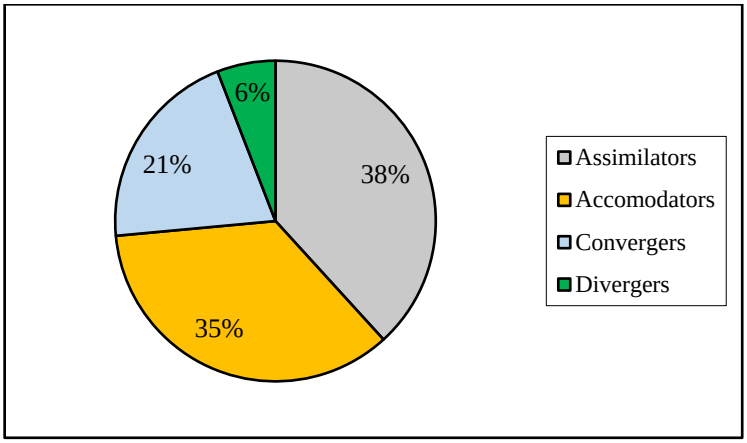

Figure 1 Distribution of students' dominant learning preferences

Learning differentiation strategies based on students' readiness

The concepts of students' readiness and learning preferences are pivotal in understanding and enhancing educational outcomes. Students' readiness refers to learners' preparedness to engage effectively in the learning process, encompassing various dimensions such as physical, mental, and cognitive aspects. The results of TIPS II showed significant variations in integrated science process skills. With an average TIPS II score of 0.349 (SD = 0.0882), most students were still at a relatively low level of readiness (not exceeding the 'not good' category). These findings align with other research indicating that integrated science process skills are often challenging for high school learners (Özgelen, 2012; Siregar et al., 2023). The investigation design skills showed the highest performance.

The distribution of student readiness towards doing integrated SPS tends to be low (76.5% is in the category of not good to very bad for the total SPS score), indicating the urgency for appropriate learning interventions. These findings reinforce the importance of developing science process skills as a foundation for scientific thinking (Özdeniz et al., 2023). In the context of learning competency, this variation in readiness requires a differentiated learning approach.

Based on the readiness profile revealed, the application of differentiated learning strategies in the "Measurement Systems in Scientific Work" competency, which includes (essentials) chapters: The Nature of Physics and Scientific Methods, Units and Dimensions of Physical Quantities, and Physical Quantities Measurement Instruments, can be carried out through a product, process, content, and learning environment approach, with specific application examples for each section. In the Nature of Physics and Scientific Methods chapter, students with a low ability to formulate hypotheses can be assisted through *multilevel* scaffolding (Liu & Huang, 2022; Su, 2020). For example, students may be given guidance in formulating simple hypotheses about density and volume relationships. In

contrast, students with higher abilities may be tasked with formulating hypotheses and designing experiments to test something (for example, Archimedes' law) without guidance.

Process differentiation includes various learning methods that allow students to interact differently with materials. For example, on Units and Dimensions of Physical Quantities, collaborative projects can be applied to help students improve their ability to compile scientific investigations. In groups, students can work together to design an experiment that tests the results of the conversion of units of length from meters to centimeters using various measuring tools, such as calipers and rulers, thereby strengthening their understanding of measurement concepts and correcting weaknesses in the process of designing investigations (Hoy, 2016; Hunaidah et al., 2018). Content differentiation focuses on providing materials that suit learners' abilities and needs. While learning about Units and Dimensions of Physical Quantities, students with excellent theoretical understanding can be given scientific articles or more complex additional materials, such as the application of dimensions in modern physics measurements. On the other hand, for learners who need a stronger foundation, teachers can simplify concepts by connecting units and dimensions into daily activities, for example, by comparing units in the context of the size of objects around them (Mustikasari et al., 2022).

Differentiating learning environments ensures that the classroom atmosphere supports diverse learning styles. Regarding Physical Quantities Measurement Instruments, students who prefer to work in a quiet environment can learn independently by exploring the theoretical principles of measuring instruments such as calipers and micrometers. Meanwhile, for students who learn through practice, the laboratory environment can be optimized to provide the opportunity to perform direct measurements using various measurement tools. In this way, students can learn according to their learning style, both theoretically and practically.

Learning differentiation strategies based on students' learning preferences

Learning preferences pertain to students' individual styles and approaches when engaging with educational content. These concepts are interrelated and significantly influence educational strategies and student success. The analysis of students' learning preferences revealed a diverse distribution among the four categories of learning styles according to the Kolb model (Kolb, 2015). The results showed that most students tended to be assimilators, followed by accommodators, convergers, and divergers. This distribution reflects the diversity of the ways students process and internalize information. The dominance of assimilator learning styles among learners indicates their tendency to excel in abstract thinking and reflective observation. Individuals with this learning style tend to have a solid theoretical understanding and integration of information into coherent conceptual models (Kartono et al., 2019; Morris, 2020).

A significant proportion of students with accommodative learning styles (35.3%) showed that some groups tended to learn through concrete experiences and active experimentation. Mumford (2006) stated that learners with this style excel in situations that require quick adaptation and practical problem-solving. Students with convergent (20,6%) and divergent (5.9%) learning styles complete the spectrum of classroom learning preferences. Convergers that combine abstract conceptualization with active experimentation tend to be strong in the practical application of ideas (Chapman, 2023; Kolb, 2015). Meanwhile, divergers who combine concrete experiences with reflective observation often excel in creativity and the ability to see situations from multiple perspectives.

The diversity of students' learning preferences significantly impacts implementing differentiated learning strategies. In the context of competencies, various differentiation strategies can be applied, involving adjusting the content, processes, products, and learning environments, as shown in Table 4. However, it is essential to note that differentiation

based on learning preferences does not mean that teachers should specifically group students according to their learning style. Research has shown that such an approach is less effective because learners only sometimes learn better if they focus on their preferences (Newton & Miah, 2017). Instead, teachers should provide various teaching methods to develop all aspects of students' learning preferences, allowing them to expand their abilities through various learning styles.

Table 4 Examples of differentiated learning strategies based on students' learning preferences

Learning Preferences	Examples of Learning Strategies
Assimilators	Differentiating By Product: - A theoretical essay on the principles of physics. - Compile conceptual reports on units and dimensions - Create theoretical reports on the accuracy and precision of the tools. Differentiating By Process: - Discuss abstract concepts using the scientific method. - Preparation of formulas and units in depth. - Discussion on the use of measuring instruments based on theory Content Differentiation Strategy: - Provide scientific articles to study. - Enrichment of the concept of units and dimensions through mathematical models. - Understand the working principle of measuring instruments from the perspective of physics theory. Learning Environment Differentiation Strategy: - A calm learning environment that supports theoretical exploration. - A convenient place to study for conceptual analysis. - Group discussion area for critical analysis.
Accommodators	Differentiating By Product: - Creating a physical model of a physics concept. - Create a simple tool that applies measurement concepts. - Create a complete experiment report with video documentation. Differentiating By Process: - A simple experiment to test the theory of the scientific method. - Hands-on practice in converting physical units. - Perform measurement experiments with minimal instructions. Content Differentiation Strategy: - Simplifying concepts through hands-on practice. - Connecting unit theory with actual experiments. - The use of measuring instruments in practical activities Learning Environment Differentiation Strategy: - An environment that encourages direct engagement and experimentation. - Supportive laboratory practice areas. - An environment that allows direct interaction with the measuring instrument
Convergers	Differentiating By Product: - Problem-solving projects based on scientific methods. - Projects solve real problems using units. - Create a real-world measuring tool application project. Differentiating By Process: - Exploration of the application of scientific methods in daily life. - Discussion of unit application in real-life scenarios. - Measurement experiments with a focus on practical applications. Content Differentiation Strategy: - Preparation of systematic scientific method steps.

Learning Preferences	Examples of Learning Strategies
	- Providing examples of dimensional applications in technology and industry. - Understanding of the application of measuring instruments in modern technology. Learning Environment Differentiation Strategy: - An environment that supports structured experiments - An experimental area that is conducive to problem-solving. - A learning atmosphere that supports the application of concepts in experiments.
Divergers	Differentiating By Product: - Make a visual presentation about the creative aspects of the scientific method. - Make a mind map about the dimensions of physical quantities. - Create creative presentations on the use of measuring instruments. Differentiating By Process: - Exploration of ideas and reflective discussions about the scientific method. - Develop ideas about interdimensional relationships. - Creative reflection on measurement and its application Content Differentiation Strategy: - Provides challenging scenarios for concept evaluation. - Simplifying the concept of units and dimensions with a visual approach. - Provide a video demonstration of the measuring instrument. Learning Environment Differentiation Strategies: - An environment that supports creativity and reflection. - A space that encourages visual and collaborative exploration. - Areas that support creative and reflective presentations

This study underscores the need for differentiated learning approaches that adapt content, processes, and outcomes to align with students' readiness levels, interests, and learning profiles. Teachers can employ strategies such as multilevel scaffolding to enhance science process skills (Haryati et al., 2024; Rahmani et al., 2013). This can be combined with a multimodal teaching approach that caters to various learning styles. Implementing this differentiated learning strategy requires support through consistent and formative assessments (McMillan, 2024; Tomlinson, 2017). The science process skills rubrics can be tailored to students' readiness levels or portfolios that showcase their comprehension through various types of work (Chapman, 2023). This research bridges the gap between theory and practice by detailing specific applications. Furthermore, the study offers novel insights by demonstrating how science process skills indicators can be customized to align with students' readiness levels. Implementing these strategies must also account for students' abilities and the resources available within the educational institution.

Finally, this study has limitations in identifying students' learning interests, which is the third key component of Tomlinson's differentiated learning model (Chapman, 2023; Roberts & Inman, 2022). Therefore, conducting a comprehensive assessment of learners' interests in the context of science and technology is recommended, perhaps through surveys or in-depth interviews. Additionally, this study is limited to identifying students' learning readiness and preferences in one senior high school in Banjarmasin, which may affect the generalizability of the findings to a broader educational context. Investigating the interplay between learning readiness and preferences within the context of science education may offer valuable insights for developing curricula and teacher-training programs that are more responsive to the needs of diverse learners.

CONCLUSION

This research reveals a complex picture of differentiated learning planning by identifying students' readiness and learning preferences in the context of the "Measurement Systems in Scientific Work" competency in high school physics. This shows that most learners have low readiness levels in integrated SPS but display significant diversity in learning style preferences. This pattern confirms the importance of differentiated learning approaches responding to students' needs. This research also underscores the need to further explore students' learning interests as an important component of differentiated learning planning.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

AUTHOR CONTRIBUTIONS STATEMENT

RSA and MM were responsible for manuscript preparation, while RR conducted data collection. RSA, SS, and SS performed analysis, data interpretation, review, and manuscript editing. MM and RR led the study's conceptualization. All authors have read and approved the final manuscript for publication.

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AUTHOR PROFILES

Rahmat Saifuddin Anwar, S.Pd.
saifuddinanwar@outlook.com
Master of Science Education, Lambung Mangkurat University, Banjarmasin, Indonesia.
https://scholar.google.com/citations?user=85u2XY0AAAAJ
https://orcid.org/0009-0001-7252-5055

Dr. Suryajaya, S.Si., M.Sc. Tech.
suryajaya@ulm.ac.id
Expertise: Physics
Master of Science Education, Lambung Mangkurat University, Banjarmasin, Indonesia.
https://scholar.google.com/citations?user=kWpp5SMAAAAJ
https://orcid.org/0000-0003-1446-655X
Sinta ID: 5977753
Scopus ID: 23026202500

Dr. Suyidno, S.Pd., M.Pd.
suyidno_pfis@ulm.ac.id
Expertise: Science Education
Master of Science Education, Lambung Mangkurat University, Banjarmasin, Indonesia.
https://scholar.google.com/citations?user=6-IYIlAAAAA
https://orcid.org/0000-0002-5608-3381
Sinta ID: 6020039
Scopus ID: 57217176368

Hj. Rachmiati, S.Pd., M.Pd.
rachmiatisahla@gmail.com
SMA Negeri 6 Banjarmasin, Banjarmasin, Indonesia.

Misbah, S.Pd., M.Pd.
misbah_pfis@ulm.ac.id
Expertise: Physics Education
Bachelor of Physics Education, Lambung Mangkurat University, Banjarmasin, Indonesia.
https://scholar.google.com/citations?user=UGfSsuwAAAAJ
https://orcid.org/0000-0002-8035-1702
Sinta ID: 53160
Scopus ID: 57195480182