Self-regulated learning in physics: A comprehensive study of high school students through the lens of the Rasch Model

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Abstract
This study investigates the Self-Regulated Learning (SRL) profile of high school students in physics within the Indonesian Merdeka Curriculum, which emphasizes student-centered and independent learning. A descriptive quantitative approach with the Rasch model using Winsteps software was employed to analyze data from 72 Grade 11 students at a state high school in Bandung, Indonesia. The Motivated Strategies for Learning Questionnaire (MSLQ) assessed SRL across various subdomains. The instrument demonstrated high reliability (Cronbach Alpha of 0.90), indicating strong internal consistency in measuring SRL abilities. The analysis revealed that most students had a moderate SRL profile, with strengths in Control of Learning Beliefs and Task Values, reflecting strong beliefs in the positive outcomes of their physics learning. However, areas such as Test Anxiety, Critical Thinking, and Effort Regulation showed lower scores, indicating areas for improvement. Additionally, Metacognitive Self-Regulation and Peer Learning enhanced students' understanding of physics. Based on these findings, it is recommended that educators design project-based learning experiences to leverage students' motivation and foster intrinsic interest in learning. Reducing test anxiety through hands-on learning and strengthening metacognitive skills through independent strategies can further support student growth. Encouraging peer learning and promoting critical thinking, mainly through Help-Seeking, are also crucial for enhancing SRL. This research provides valuable insights into SRL profiles in physics learning and offers practical strategies to improve student engagement and performance within the Merdeka Curriculum framework.

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1. Introduction

The Merdeka Curriculum, which has been gradually implemented in Indonesia, is designed to provide flexibility in the teaching and learning process so that students can learn according to their individual needs, interests, and talents (Ndari et al., 2023; Sukarno et al., 2024). This curriculum focuses on student-centred learning so that they have more freedom in determining their learning methods and steps (Utami et al., 2024). In addition, the Merdeka Curriculum aims to develop important competencies such as critical, creative, collaborative, and independent thinking in learning (Hosaini et al., 2024; Nisa et al., 2023; Sappaile et al., 2024). With this approach, this curriculum is expected to form a young generation adaptive to global challenges, especially in understanding complex subjects such as physics.

High school students often find physics challenging due to its abstract concepts and complex mathematical applications, compounded by limited class time and teaching methods that focus more on memorizing formulas than understanding concepts (Assem et al., 2023; Stadermann & Goedhart, 2020; Darmaji et al., 2023). The Merdeka Curriculum offers a solution through project-based learning (PjBL) and independent learning, promoting an understanding of practical physics. PjBL engages students in projects related to real-life applications, encouraging collaboration, critical thinking, and problem-solving (Anekawati et al., 2021; N. A. Lestari et al., 2022). On the other hand, independent learning allows students to learn at their own pace, fostering responsibility for their learning process (Eswaran, 2024; Stewart et al., 2016). These approaches aim to deepen students' understanding of physics while cultivating learning independence, which aligns with the Merdeka Curriculum's principles.

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Self-regulated learning (SRL) has become an important topic in educational research, especially in science learning such as physics. SRL is defined as an individual's ability to manage their learning process independently, starting from planning and monitoring to evaluating the strategies used (Zimmerman, 1989). In physics learning, SRL plays a strategic role because physics not only relies on mastery of theoretical concepts but also demands in-depth analytical and problem-solving skills (Schunk & Zimmerman, 2011). As a complex branch of science, physics learning often requires active student involvement in understanding concepts and applying them to real-world situations (Malik et al., 2019; Ramadhan et al., 2020). Therefore, developing SRL is a key aspect in improving student learning outcomes, especially in the Higher-Order Thinking Skills (HOTS) competency, a priority of the Merdeka Curriculum in Indonesia.

Previous studies have shown that SRL can positively impact physics learning. Achufusi-Aka & Offiah (2011) found that science students in Nigeria who used SRL had better physics learning outcomes than students who did not use the approach. Alpaslan et al. (2016) showed that students' views of knowledge influenced their motivation for independent learning and critical thinking, which ultimately improved their SRL abilities. Meanwhile, Neber et al. (2008) showed that high school students' motivation for learning physics in China tended to decrease in students with higher education levels. Therefore, teacher support, such as feedback and learning strategy guidance, is needed to guide students in developing self-regulated learning. While these studies highlight SRL's potential to improve learning outcomes, they predominantly focus on general educational contexts or regions outside Indonesia. There is a limited exploration of SRL's specific implications in Indonesian physics education, particularly in addressing the unique challenges posed by abstract and calculation-intensive subjects like physics.

Self-regulated learning supports higher-order thinking skills (HOTS) and conceptual understanding in physics learning. SRL helps students develop metacognitive skills, such as planning, monitoring, and reflecting on their learning process. These skills enable students to independently regulate their learning and improve their ability to solve physics problems (Winarti et al., 2022). The implementation of SRL-based learning strategies, such as the use of e-learning modules based on the 7E learning cycle or virtual laboratories, is efficacious in improving students' HOTS and conceptual understanding compared to traditional methods (Lestari & Atun, 2021; Muali et al., 2020). Despite these advancements, existing research focuses on demonstrating the general efficacy of SRL-based strategies rather than analyzing their measurable impact through advanced evaluation tools. Furthermore, little attention has been given to how Indonesian students' SRL profiles can be systematically assessed to reveal specific strengths and weaknesses in their learning processes. This gap highlights the need for a structured, data-driven approach to evaluate SRL's effectiveness in local physics education settings.

Factors such as teacher support, technology-based learning media, and students' self-regulation abilities contribute significantly to the success of SRL (Azevedo et al., 2004; Maison et al., 2019). SRL is important in physics learning because the nature of this subject is often considered difficult by students, mainly because it involves abstract concepts, mathematical calculations, and problem-solving. Through SRL, students can develop the ability to plan, monitor, and reflect on their learning process independently. In addition, SRL encourages students to be more confident in facing the challenges of physics learning. Maison et al. (2019) show that students with good self-regulation can better connect physics concepts with everyday experiences. This connection between physics concepts and real-life applications is crucial in the Indonesian context, where students often struggle with motivation and confidence due to the perceived difficulty of physics. Hence, further research is needed to understand how SRL can bridge this gap by empowering students with the skills to approach physics problems systematically and independently.

Although research on SRL in physics learning in Indonesia is still limited, several studies have provided important insights. Maison et al. (2019) studied 1,003 high school students in Jambi and found that teacher support and cooperation between students were important in improving SRL abilities. Another study by Sholahudin (2024) showed that the learning motivation of junior high school students in West Java positively correlated with their self-regulation abilities. In Yogyakarta, Winarti et al. (2022) found that problem-solving-based physics learning improved students' metacognitive thinking skills and learning outcomes. However, these studies lack a focus on utilizing advanced analytical tools to evaluate the nuances of SRL in physics education. For instance, they do not explore how motivation, task management, and metacognitive skills influence students' learning outcomes in specific physics contexts. Addressing these gaps could enable educators to tailor interventions that better align with student's needs, especially in Indonesian high school physics education.

A strong analytical approach is needed to understand students' SRL in more depth, one of which is using the Rasch Model. The Rasch Model is a probabilistic statistical analysis approach that converts raw scores from test items or questionnaires into a logarithmic, linear scale (van Alphen et al., 1994). The Rasch Model is often used in education and psychology to measure individual abilities or attitudes objectively (Habibi et al., 2019; Ramadhani et al., 2024). The Rach Model can identify students' SRL patterns, evaluate the level of difficulty of each item on the measurement instrument, and ensure the validity and reliability of the instruments used (Ekadiarsi & Khusna, 2022; Habibi et al., 2019; Hwang & Lee, 2019). The Rasch Model also allows for fair comparisons between individuals with different abilities because this model controls item difficulty and student ability separately (Boone et al., 2014b). Using the Rasch Model, researchers can accurately map students' SRL profiles and identify areas needing improvement. In addition, the Rasch Model can be used to analyze aspects of SRL, such as motivation, task management, and self-evaluation, in a more structured and detailed manner (Habibi et al., 2019; Ramadhani et al., 2024).

This study aims to answer several essential questions about students' SRL in physics learning using the Rasch Model as an analytical framework. These questions include: how effective are the SRL instruments in terms of reliability and their ability to differentiate between items and individuals; how well do students' responses align with the Rasch Model, including the identification of misfit patterns; how are students' SRL profiles categorized based on the domains of motivation and learning strategies, including their strengths and weaknesses; and how is the distribution of students' SRL abilities represented through Wright Map and person-measure analysis. Additionally, this study examines the factors influencing students' ability to manage their learning independently, particularly regarding indicators with the highest difficulty levels. By addressing these questions, this research aims to thoroughly understand the variation in students' SRL abilities and identify areas needing intervention to promote more effective and independent physics learning.

This research is important to provide strategic recommendations to educators in designing more effective physics learning. By understanding students' SRL profiles through the Rasch Model, educators can apply scaffolding, project-based learning, or technological aids to support independent learning. In addition, this study is expected to help identify students' SRL weaknesses and provide appropriate interventions to improve their abilities, which are very relevant in physics learning and require critical and creative thinking. This ability is closely related to higher-order thinking skills (HOTS), such as analysis, evaluation, and creation, at the core of physics learning. By improving SRL, students can be more independent in managing their learning process, so they are better prepared to face complex physics learning challenges that require high-level problem-solving.

2. Method

2.1. Research Design

This study employs a descriptive quantitative survey approach to investigate students' self-regulated learning (SRL) profiles in the context of physics education. The choice of a quantitative method is driven by the need for a structured, measurable analysis of students' behaviors, motivations, and learning strategies, offering an objective and statistical representation of their SRL profiles. Through this approach, the study aims to explore how students engage with their physics learning, particularly in terms of their motivation, learning strategies, and the effectiveness of their self-regulation. The descriptive nature of the study allows for a comprehensive overview of these aspects across a group of students, enabling the identification of patterns and trends in SRL. Data was collected using a questionnaire based on the Motivated Strategies for Learning Questionnaire (MSLQ), a validated instrument for assessing students' motivation and learning strategies. The responses from this questionnaire were analyzed using the Rasch Model. This advanced statistical method ensures the validity of the items and the consistency of the students' responses across different contexts, providing a deeper understanding of students' self-regulation and motivation in their physics education.

2.2. Participants

The participants in this study consisted of 72 grade XI students from a state high school in Bandung City, aged between 16 and 18 years. The group included 20 females and 52 males, all enrolled in a physics course under the Merdeka Curriculum. This curriculum focuses on student-centered learning, encouraging students to take responsibility for their learning, which aligns with the goal of this study. The students were selected using purposive sampling, which intentionally selects participants who meet specific criteria essential for the research. In this case, the criteria were that the students should have at least one semester of physics experience and be willing to participate in the study voluntarily. The purposive sampling method ensures that the participants represent the population of interest—students actively engaged in physics learning under the Merdeka Curriculum. Data collection occurred on September 23, 2024, during a scheduled school session, minimizing disruption to the student's regular academic activities.

2.3. Research Instrument

The research instrument used in this study was the Motivated Strategies for Learning Questionnaire (MSLQ), adapted from Pintrich et al. (1991). The MSLQ is a widely used tool for assessing motivation and learning strategies, key self-regulated learning components. The questionnaire consists of 81 items, divided into two main sections: Motivation Scales and Learning Strategies Scales. The motivation scales assess intrinsic and extrinsic goal orientation, task value, self-efficacy for learning and performance, and test anxiety. The learning strategies scales evaluate various strategies used by students, including rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time/study environmental management, effort regulation, peer learning, and help-seeking, as outlined in Table 1 below (Gable & Wolfe, 1993; Pintrich et al., 1993). he Likert scale used in the questionnaire ranges from 1 (Strongly Disagree) to 4 (Strongly Agree), providing a nuanced view of students' responses (Harpe, 2015; Pornel & Saldaña, 2013). The MSLQ was chosen due to its established validity and reliability in educational research, making it a suitable instrument for capturing a holistic view of students' SRL in physics education.

Table 1. MSLQ Components

Part 1: Motivation Scales		Part 2: Learning Strategies Scales	
Scale	# of Items	Scale	# of Items
1. Intrinsic Goal Orientation	4	1. Rehearsal	4
2. Extrinsic Goal Orientation	4	2. Elaboration	6
3. Task Values	6	3. Organization	4
4. Control of Learning Beliefs	4	4. Critical Thinking	5
5. Self-Efficacy for Learning & Performance	8	5. Metacognitive Self-Regulation	12
6. Test Anxiety	5	6. Time/Study Environmental Management	8
		7. Effort Regulation	4
		8. Peer Learning	3
		9. Help Seeking	4
Total Number of Items	31	Total Number of Items	50

2.4. Research Limitations

This study was conducted with a relatively small and localized sample, with participants drawn from only one school. Therefore, the findings are not easily generalizable to a broader population. However, despite this limitation, the results of this study provide valuable insights into the SRL profiles of students within the context of the Merdeka Curriculum. They can serve as a foundation for further studies with a more extensive and diverse sample.

2.5. Data Collection

The data collection process involved administering the MSLQ to the participants during a school session. This allowed for collecting responses without significantly interrupting the students' regular learning activities. The questionnaire was delivered in a paper format, and students were instructed to respond individually to ensure that their answers accurately reflected their personal learning experiences and self-regulation strategies in physics. To ensure the validity of the data, the instructions emphasized the importance of honest and thoughtful responses. The straightforward collection process allowed efficient and organized data gathering from all participants.

2.6. Data Analysis

Data analysis in this study was carried out using the Rasch Model, implemented with Winsteps 3.73 software. The Rasch Model was selected because it offers several advantages over traditional methods, such as Classical Test Theory (CTT), by providing more stable and consistent results. One of its key benefits is its ability to maintain consistent item difficulty estimates across different sample groups. It also efficiently handles missing data, ensuring that the integrity of the analysis remains intact. It can enhance the psychometric quality of assessment instruments, thereby ensuring more reliable and valid results (Howard, 1985). The Rasch Model's robustness in handling missing data and its ability to produce unbiased and precise results make it a suitable choice for objectively and accurately measuring students' abilities (de Bock et al., 2016; Van Zile-Tamsen, 2017).

The analysis included several elements outlined by Boone & Staver (2020) and Sumintono & Widhiarso (2015). Cronbach's Alpha (α) was used to measure the instrument's overall reliability, reflecting the internal consistency of the questionnaire items. A high Cronbach's Alpha value indicates that the instrument can reliably measure students' self-regulated learning (SRL) across different contexts. The interpretation of Cronbach's Alpha values is categorized as follows: $\alpha \geq 0.80$ is very good, $0.71 \leq \alpha < 0.80$ is good, $0.61 \leq \alpha < 0.70$ is moderate, $0.51 \leq \alpha < 0.60$ is low, and $\alpha < 0.50$ is very low.

In addition to Cronbach's Alpha, person, and item reliability were calculated. Person reliability measures how consistently students respond to items, with higher values indicating more consistent responses. Item reliability reflects the consistency of item difficulty in measuring students' abilities, indicating the appropriateness of the items for the research population. The reliability criteria for both person and item are as follows: Person/Item reliability ≥ 0.95 is classified as special, 0.95 > Person/Item ≥ 0.91 is very good, 0.91 > Person/Item ≥ 0.81 is good, 0.81 > Person/Item ≥ 0.68 is enough, and 0.68 > Person/Item is weak.

Person separation and item separation were also analyzed to evaluate the instrument's effectiveness in distinguishing between students of different ability levels and separating items based on their difficulty levels. A person separation value ≥ 1.00 indicates that the instrument can effectively group students by their abilities (Andrich & Marais, 2019). An item separation value of ≥ 2.00 is ideal, demonstrating that the instrument's scale can differentiate between varying levels of student abilities (Boone et al., 2014a).

Additionally, the study included a person measure and Wright Map, where the person measure displays students' SRL ability scores on a logit scale, and the Wright Map visualizes the distribution of both student abilities and item difficulty levels. This visualization helps researchers understand how well the instrument aligns with students' abilities. The item fit statistics were also analyzed, including the Mean Square (MNSQ), Z-Standardized (Z-STD), and Point Measure Correlation (PT Mean Corr.). The MNSQ should ideally range from 0.5 to 1.5, Z-STD should fall between -2 and +2, and PT Mean Corr. should be between 0.4 and 0.85 to ensure that the items fit well with the expected response patterns.

A quantitative descriptive analysis was employed to describe the SRL profiles of students in physics learning. This approach aimed to comprehensively understand the students' SRL levels, covering aspects such as motivation and learning strategies. Descriptive statistics were used to calculate students' average, percentage, and distribution across low, medium, and high SRL categories. These categories were interpreted using quartile criteria as defined by Pintrich et al. (1991). The analysis results were presented in tables and bar charts to make the data more accessible. Bar charts were used to show the average distribution for each SRL sub-domain. At the same time, frequency and percentage tables illustrated the number of students in each SRL level category, providing precise visual and numerical representations of the data. This approach effectively facilitated the understanding of students' SRL profiles.

3. Results and Discussion

3.1. Analysis of the Self-Regulated Learning Instrument

This study's Self-Regulated Learning (SRL) instrument was analyzed using the Rasch model with Winsteps software version 3.73. The results, shown in the Summary Statistics output, provide indicators of reliability and separation for both items and persons. These statistics evaluate the consistency and effectiveness of the instrument in measuring students' SRL. The output, as seen in Figure 1 , indicates the instrument's ability to differentiate between students with varying abilities, ensuring high-quality measurement.

```
     SUMMARY OF 72 MEASURED Person
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE      COUNT     MEASURE  ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     241.0       81.0         .91    .18      1.05    -.2   1.02    -.3 |
| S.D.      18.4         .0         .60    .01       .59    3.3    .55    3.1 |
| MAX.     297.0       81.0        3.05    .23      3.63    9.9   3.08    7.6 |
| MIN.     208.0       81.0        -.04    .16       .30   -6.0    .30   -6.0 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .20 TRUE SD      .56  SEPARATION  2.81  Person RELIABILITY  .89 |
|MODEL RMSE    .18 TRUE SD      .57  SEPARATION  3.22  Person RELIABILITY  .91 |
| S.E. OF Person MEAN = .07                                                   |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = 1.00
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .90

     SUMMARY OF 81 MEASURED Item
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT        OUTFIT    |
|          SCORE      COUNT     MEASURE  ERROR      MNSQ   ZSTD   MNSQ   ZSTD |
|-----------------------------------------------------------------------------|
| MEAN     214.2       72.0         .00    .19       .99    -.3   1.02    -.2 |
| S.D.      20.5         .0         .72    .01       .50    2.6    .54    2.7 |
| MAX.     261.0       72.0        1.55    .24      2.60    7.3   2.78    7.7 |
| MIN.     163.0       72.0       -1.93    .16       .43   -4.0    .44   -3.9 |
|-----------------------------------------------------------------------------|
| REAL RMSE    .20 TRUE SD      .69  SEPARATION  3.40  Item   RELIABILITY  .92 |
|MODEL RMSE    .19 TRUE SD      .69  SEPARATION  3.69  Item   RELIABILITY  .93 |
| S.E. OF Item MEAN = .08                                                     |
-------------------------------------------------------------------------------
UMEAN=.0000 USCALE=1.0000
Item RAW SCORE-TO-MEASURE CORRELATION = -.99
5832 DATA POINTS. LOG-LIKELIHOOD CHI-SQUARE: 10891.30 with 5678 d.f. p=.0000
Global Root-Mean-Square Residual (excluding extreme scores): .6363
```

Figure 1. Reliability of the self-regulated learning instrument

Based on the SRL instrument analysis results shown in Figure 1, this instrument shows very good reliability for both individuals and items. Cronbach's Alpha of 0.90 indicates perfect internal consistency, which means this instrument effectively measures students' SRL abilities consistently. In addition, an individual reliability of 0.89 indicates that this instrument can differentiate students' abilities well, so it can be used to identify differences in SRL ability levels between students. A reliability of 0.92 indicates that the items in this instrument have very good consistency in measuring the aspects referred to in SRL. In the analysis of the score distribution, the average value (mean) for individuals is 241.0 with a standard deviation (s.d.) of 18.4, indicating moderate variation in student abilities. The range of student abilities is quite broad, with a maximum value of 297.0 and a minimum of 208.0. The range of scores from 208.0 to 297.0 shows the diversity of student performance (Lazarev & Khaybullin, 2017). For the items, the mean score was 214.2 with a standard deviation of 20.5, indicating a relatively even distribution of item difficulty. The range of item difficulty also varied, with a maximum score of 261.0 and a minimum of 163.0. The individual separation score of 2.81 indicated that this instrument effectively separated students based on their ability levels. Meanwhile, the item separation score of 3.40 indicated that this instrument could separate items well based on their difficulty levels (Banerjee & Rao, 2022). Overall, the results of this analysis indicate that this SRL instrument can be relied on to measure students' self-regulated learning in physics with excellent reliability.

3.2. Students' Response Fit to the Rasch Model

Analyzing student responses to the Rasch model, particularly Person Fit, is crucial in evaluating the validity of measurement data. Person Fit examines how well students' responses align with the Rasch model's predictions, offering insights into the consistency of student behavior based on their ability levels (Sumintono & Widhiarso, 2015). The Winstep output, specifically the Item Fit Statistic, identifies students whose responses deviate from the expected patterns (misfits), which can reveal potential measurement errors or inconsistencies (Boone & Staver, 2020). The Misfit Order table in Figure 2 highlights these mismatched responses.

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
55	297	81	3.05	.23	3.63	9.9	3.08	7.6	A .29	.31	77.8	69.3	55M
61	208	81	-.04	.16	2.48	7.2	2.45	6.9	B .46	.44	23.5	52.4	61M
65	276	81	2.09	.20	2.37	6.7	2.29	6.5	C .29	.36	38.3	58.7	65F
10	239	81	.81	.17	2.35	6.0	2.23	5.6	D .41	.41	35.8	60.0	10M
68	271	81	1.90	.20	2.16	5.7	1.99	5.2	E .44	.37	38.3	59.3	68M
44	262	81	1.57	.19	2.15	5.5	2.04	5.2	F .44	.38	43.2	60.7	44M
58	275	81	2.05	.20	1.90	4.8	1.91	4.9	G .25	.36	45.7	58.6	58M
72	279	81	2.21	.20	1.71	4.0	1.68	3.9	H .30	.36	44.4	58.8	72F
3	252	81	1.23	.18	1.67	3.4	1.70	3.6	I .34	.39	38.3	60.6	03M
36	212	81	.06	.16	1.65	3.6	1.65	3.6	J .09	.44	35.8	53.1	36M
33	256	81	1.36	.18	1.59	3.1	1.55	3.0	K .49	.39	34.6	60.6	33M
47	271	81	1.90	.20	1.53	3.0	1.49	2.9	L .36	.37	32.1	59.3	47M
21	239	81	.81	.17	1.46	2.5	1.41	2.3	M .28	.41	56.8	60.0	21M
56	274	81	2.01	.20	1.45	2.6	1.33	2.0	N .44	.36	50.6	58.9	56F
8	239	81	.81	.17	1.43	2.3	1.41	2.2	O .52	.41	44.4	60.0	08F
1	222	81	.32	.17	1.42	2.4	1.37	2.1	P .50	.43	44.4	56.6	01M
50	256	81	1.36	.18	1.31	1.8	1.29	1.7	Q .40	.39	64.2	60.6	50M
66	253	81	1.26	.18	1.28	1.6	1.25	1.5	R .53	.39	51.9	60.5	66M
71	241	81	.87	.18	1.24	1.4	1.22	1.3	S .24	.41	55.6	60.0	71F
24	249	81	1.13	.18	1.24	1.4	1.20	1.2	T .45	.40	56.8	60.6	24M
53	232	81	.61	.17	1.23	1.4	1.17	1.1	U .36	.42	64.2	58.8	53F
49	274	81	2.01	.20	1.22	1.4	1.12	.8	V .58	.36	56.8	58.9	49M
63	258	81	1.43	.19	1.20	1.2	1.15	.9	W .43	.39	59.3	60.6	63M
46	230	81	.55	.17	1.17	1.0	1.13	.8	X .45	.42	55.6	58.2	46M
9	233	81	.63	.17	1.13	.8	1.10	.6	Y .40	.42	44.4	58.8	09M
39	255	81	1.33	.18	1.07	.5	1.02	.2	Z .63	.39	58.0	60.7	39M
BETTER FITTING OMITTED													
7	244	81	.97	.18	.85	-.9	.80	-1.3	.53	.40	70.4	60.6	07M
28	212	81	.06	.16	.76	-1.7	.80	-1.3	.02	.44	55.6	53.1	28M
38	221	81	.30	.16	.79	-1.4	.79	-1.4	.57	.43	53.1	56.5	38F
19	223	81	.35	.17	.74	-1.7	.79	-1.4	.64	.43	56.8	56.7	19M
20	242	81	.90	.18	.78	-1.3	.76	-1.5	z .42	.41	72.8	60.2	20M
40	247	81	1.06	.18	.76	-1.5	.74	-1.7	y .52	.40	65.4	60.7	40M
11	248	81	1.09	.18	.75	-1.6	.75	-1.6	x .47	.40	64.2	60.7	11M
16	235	81	.69	.17	.68	-2.1	.72	-1.8	w .41	.41	74.1	59.2	16M
5	224	81	.38	.17	.71	-2.0	.70	-2.1	v .32	.42	64.2	56.9	05M
35	227	81	.46	.17	.70	-2.0	.71	-1.9	u .44	.42	61.7	57.6	35F
15	239	81	.81	.17	.70	-2.0	.70	-2.0	t .20	.41	70.4	60.0	15M
43	247	81	1.06	.18	.69	-2.0	.70	-2.0	s .42	.40	71.6	60.7	43F
59	247	81	1.06	.18	.68	-2.1	.66	-2.3	r .53	.40	74.1	60.7	59M
60	241	81	.87	.18	.64	-2.4	.63	-2.5	q .43	.41	75.3	60.0	60M
25	213	81	.09	.16	.58	-3.2	.57	-3.2	p .39	.44	67.9	53.4	25M
18	251	81	1.19	.18	.57	-3.0	.56	-3.2	o .51	.40	79.0	60.7	18F
42	232	81	.61	.17	.56	-3.1	.56	-3.1	n .56	.42	64.2	58.8	42F
17	211	81	.03	.16	.55	-3.6	.53	-3.7	m .48	.44	66.7	53.0	17M
67	242	81	.90	.18	.50	-3.6	.49	-3.8	l .70	.41	76.5	60.2	67F
54	241	81	.87	.18	.48	-3.8	.50	-3.7	k .41	.41	81.5	60.0	54M
57	232	81	.61	.17	.49	-3.8	.48	-3.9	j .25	.42	80.2	58.8	57M
69	221	81	.30	.16	.49	-4.0	.45	-4.4	i .44	.43	76.5	56.5	69M
6	226	81	.43	.17	.46	-4.2	.43	-4.4	h .44	.42	76.5	57.3	06F
26	213	81	.09	.16	.45	-4.5	.44	-4.6	g .45	.44	69.1	53.4	26F
4	209	81	-.02	.16	.44	-4.8	.43	-4.8	f .49	.44	66.7	52.7	04F
14	235	81	.69	.17	.42	-4.5	.42	-4.5	e .37	.41	77.8	59.2	14M
52	248	81	1.09	.18	.38	-4.9	.39	-4.9	d .41	.40	86.4	60.7	52F
23	234	81	.66	.17	.36	-5.1	.36	-5.2	c .35	.41	84.0	59.0	23M
62	231	81	.58	.17	.33	-5.6	.31	-5.8	b .41	.42	87.7	58.5	62M
30	232	81	.61	.17	.30	-6.0	.30	-6.0	a .44	.42	84.0	58.8	30M
MEAN	241.0	81.0	.91	.18	1.05	-.2	1.02	-.3			61.1	58.8	
S.D.	18.4	.0	.60	.01	.59	3.3	.55	3.1			14.2	2.6	

Figure 2. Student's person fit to the Rasch Model

From the results of the Person Fit analysis in Figure 2 using indicators such as Mean Square (MNSQ), Z-Standardized (Z-STD), and Point Measure Correlation (PT-Measure Corr.), it can be seen that there are students who experience misfit, namely students whose responses do not match the pattern expected by the Rasch model (Boone & Staver, 2020). Misfits can occur due to various factors, such as students with high abilities who answer easy questions incorrectly or inconsistencies in answer patterns at various levels of question difficulty (Edwards & Alcock, 2010; Stacey & Steinle, 2006). The following is a table showing the distribution of students who fall into the misfit category:

Table 2. Distribution of students belonging to the misfit category

Category	Students	Freq.	%
Doesn't meet 2 categories (MNSQ & ZSTD)	04F, 06F, 10M, 26F, 30M, 33M, 44M, 47M, 52F, 55M, 61M, 62M, 68M, 69M	14	19.44
Doesn't meet 2 categories (ZSTD & PT Mean Corr.)	21M, 25M	2	2.78
Doesn't meet 3 categories	03M, 14M, 23M, 36M, 57M, 58M, 65F, 72F	8	11.11

Based on Table 2, the distribution of students included in the misfit category shows that the largest group is students who do not meet two indicators (MNSQ & ZSTD), with 14 students (19.44%). Misfit in this group reflects a response pattern inconsistent with the Rasch model's predictions and significant statistical deviations, indicating instability in students' answer patterns (Rahman et al., 2023). In addition, two students (2.78%) did not meet the ZSTD & PT Mean Corr. indicators, which describe a response pattern that deviates significantly and is irrelevant to the measured abilities. Eight students (11.11%) did not meet all three indicators at once, indicating a very inconsistent response pattern, and its relevance to the overall pattern is very low. Misfits in this group are likely influenced by external factors such as stress, environmental conditions, or mental health, which affect students' performance on the exam (Sulman et al., 2021). Students in this misfit category need further attention and support to provide more consistent responses that reflect their true abilities (Irawan et al., 2021).

3.3. Students' Self-Regulated Learning Profile in Physics Learning

The results obtained on the Self-Regulated Learning (SRL) profile of students in physics learning show a pretty good overall level of SRL in the various sub-domains measured. Figure 3. Students' self-regulated learning profile in physics learning shows the distribution of the average SRL values for each sub-domain, with details describing the strengths and weaknesses in their learning arrangements.

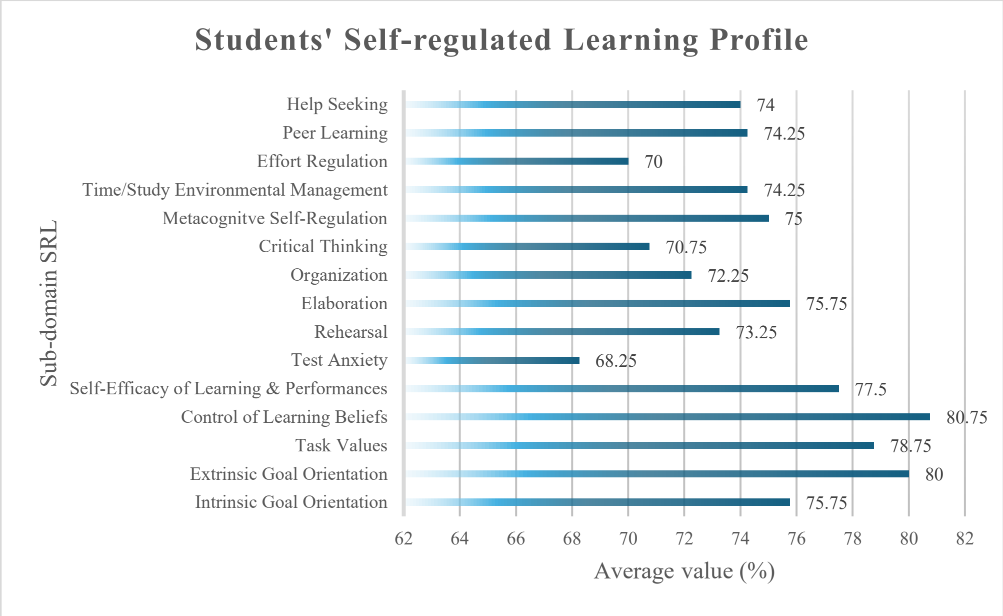

Figure 3. Students' self-regulated learning profile in physics learning

In the Self-Regulated Learning (SRL) motivation domain in physics learning, several sub-domains showed relatively high scores, reflecting how students' attitudes and beliefs affect their learning process. The Control of Learning Beliefs sub-domain recorded an average score of 80.75%, indicating that most students believe their physics efforts will produce positive results. This belief is important to increase students' motivation to persist and face academic challenges (Curione & Huertas, 2016; Duncan & McKeachie, 2005). Furthermore, Extrinsic Goal Orientation and Task Values each had an average of 80% and 78.75%, indicating that students are motivated not only by interest in the material but also by goals given by external parties, as well as their positive views on the importance and usefulness of the physics tasks they face (Khosim & Mohd, 2020). However, the Test Anxiety sub-domain showed a lower score, which was 68.25%, reflecting the level of anxiety of students when facing exams, which can hinder their motivation and performance.

In the Learning Strategies domain, the sub-domain with the highest score was Elaboration (75.75%), which showed that students were quite good at explaining and summarizing in-depth information. Students could connect new information with existing knowledge, which is very important in physics learning, as it involves many interrelated concepts. In addition, Rehearsal (73.25%), Time/Study Environmental Management (74.25%), Metacognitive Self-Regulation (75%), and Peer Learning (74.25%) also showed relatively high scores, reflecting students' ability to manage the learning environment, cognitive strategies, and study with friends. Several sub-domains, such as Critical Thinking (70.75%), Effort Regulation (70%), and Help-Seeking (74%), showed slightly lower areas, although they still reflect important abilities in SRL. However, several areas, such as critical thinking and effort regulation, can still be improved to maximize students' potential to understand physics in depth (Pintrich, Smith et al., 1993; Pintrich et al., 1991).

Meanwhile, to interpret the score results, Pintrich et al. (1991) explained that if a student's score is in the lower quartile (25%), it means that most other students in the class have better motivation or use learning strategies than the student. If the student's score is in the middle quartile (50%), then the student has a level of motivation and use of learning strategies similar to most other students. If a student's score is in the upper quartile (25%), the student feels more motivated or uses more learning strategies than others. The following table shows the distribution of students based on the SRL categories established by Pintrich et al. (1991).

Table 3. Percentage distribution of students' self-regulated learning

Domain	Low		Moderate		High		Total	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Motivation	0	0	68	94	4	6	72	100
Learning Strategies	1	1	71	99	0	0	72	100

Based on the analysis results, the mean for the motivation domain is 3.07, while the learning strategy domain has a mean of 2.93. Referring to the established categories, where the high category is given to values above 3.5, both domains can be considered moderate. In Table 3, for the motivation domain, although students are pretty motivated in learning physics, there is still room for further improvement in intrinsic motivation, task value, and self-efficacy. This can be seen from most students (94%) in the moderate category, with only 6% showing very high motivation. No students are in the low category, indicating that almost all students have good motivation.

On the other hand, for the learning strategy domain, although most students (99%) have used learning strategies quite well, such as repetition, elaboration, and organization, the results still show potential for improvement in the effectiveness of using these strategies. The mean of 2.93 places this domain in the moderate category, meaning that although students are using some learning strategies quite well, such as repetition, elaboration, and organization, there is still room for improvement in their use of these strategies to be more effective in understanding more complex physics concepts. Only 1% of students are in the low category, and no students are in the high category. Overall, although students demonstrate fairly good motivation and use of learning strategies, these results indicate that there is still room for improvement in both domains. In physics learning, it is important to continue developing students' motivation and strengthening their learning strategies. With a more targeted approach and appropriate support, students can more effectively manage their learning and be better prepared to face the challenges of understanding complex physics concepts.

3.4. Implications and Impact of Students' SRL Profiles on Physics Learning

The findings from this SRL analysis highlight the importance of implementing self-regulated learning in physics education to facilitate students' motivation and improve their understanding. One significant finding is students' beliefs in Control of Learning Beliefs (80.75%) and Task Values (78.75%), which indicate that students tend to be motivated by the belief that their efforts will produce good results and that they consider physics tasks to be important and valuable (Intes et al., 2024). Educators can leverage these beliefs to design more relevant and meaningful learning. For example, educators can design real-life-based assignments or projects that show direct links between physics concepts and everyday situations (Rieger et al., 2023). This will further foster a sense of ownership of learning and increase students' intrinsic motivation, which can strengthen their resilience to challenges in physics learning.

However, Test Anxiety, recorded as relatively high (68.25%), needs more attention in physics teaching. This test anxiety can interfere with students' understanding and performance because anxious students are more likely not to be able to bring out their best potential during exams (Achor et al., 2023). Therefore, educators need to adopt approaches to reduce this anxiety, such as project-based learning emphasizing hands-on experience rather than just focusing on written exams. Project-based learning allows students to learn deeply and contextually and reduces reliance on formal exams as the only measure of their achievement (Owenz & Cruz, 2023). This is also more in line with the Merdeka Curriculum, which provides space for a more flexible and contextual approach to the learning process.

Implementing learning strategies based on Metacognitive Self-Regulation (75%) and Peer Learning (74.25%) significantly positively impact physics learning by developing metacognitive skills that allow students to plan, monitor, and evaluate their own learning. These metacognitive skills are important in physics and support the development of higher-order thinking skills (HOTS) needed in modern education curricula, especially in critical, analytical, and creative thinking to solve problems. Students who can evaluate and adjust their learning strategies based on their understanding will be better prepared to face complex problems and apply physics concepts in new contexts. Although the current level of students' metacognitive skills is quite good, there is still room for improvement (Sapulete et al., 2024). Self-regulated learning theory suggests that incorporating metacognitive elements can improve students' cognitive abilities and pedagogical knowledge, improving teaching efficiency and higher-order thinking skills (Hamzah et al., 2023).

In addition, Peer Learning can enhance students’ understanding by introducing different perspectives through group work, allowing students to exchange ideas, solve problems together, and teach each other. This collaborative approach supports physics learning, especially in the Merdeka Curriculum, which emphasizes developing social and collaboration skills. These skills are highly needed in the workplace. Although the full implementation of the Merdeka Curriculum is still limited, especially in specific projects such as P5 (Handayani et al., 2024), peer interaction effectively builds shared knowledge, as seen in physics learning and other complex subjects. When students work collaboratively to solve problems, even if no one knows the solution at the beginning, they can better understand the material (Brundage et al., 2022). Using tools such as mind mapping also enhances students' conceptual understanding of science by facilitating the visualization and organization of information and the co-construction of knowledge that can identify misconceptions (Fung, 2024).

The SRL profile found in this study showed that most students had high motivation, as reflected in high Control of Learning Beliefs (80.75%) and Self-Efficacy for Learning (77.5%). Students who had strong beliefs in their ability to overcome physics difficulties and felt that their efforts would yield positive results were more likely to persist in the face of complex learning challenges. This indicates that approaches that build students' self-confidence, such as providing constructive feedback and strengthening intrinsic motivation, will improve their performance (Liu, 2015). By leveraging high self-efficacy, educators can design learning experiences that lead to deeper and more applicable learning. Understanding students' diverse motivational and self-regulation profiles allows educators to tailor instructional strategies to meet varying needs, thereby increasing overall classroom effectiveness (Outerbridge et al., 2024).

However, despite the majority of students' high self-efficacy, test anxiety (68.25%) remains a significant inhibitory factor in physics learning. This anxiety can interfere with students' ability to demonstrate their understanding in exams or other assessments (Yang & Wang, 2023). Therefore, in addition to reducing reliance on formal exams, it is also important to provide students with more opportunities to demonstrate their understanding through portfolios, project-based assignments, or formative assessments that emphasize the learning process rather than the result (Mallow & Kastrup, 2023). Formative assessments focusing on the learning process rather than the result can help reduce anxiety and improve self-efficacy (Duraku et al., 2023). By reducing exam pressure, students can better understand physics concepts and be more confident in their abilities.

In addition, there is an opportunity to further optimize the development of higher-order thinking skills through learning that combines Elaboration and Metacognitive Self-Regulation strategies. With a good Elaboration strategy, students can connect new knowledge with previous knowledge, which is important for solving complex problems in physics. Students can actively evaluate and adjust their learning strategies through metacognitive skills to achieve a more profound understanding. These skills are essential for developing critical thinking and problem-solving skills (Alpindo et al., 2024). This approach aligns with the objectives of the Merdeka Curriculum, which prioritizes the development of critical thinking and problem-solving skills that are more effective when applied in the context of physics. Students skilled in critical thinking can apply physics principles in more complex and real-world situations, improving the overall quality of physics learning.

Self-regulated learning (SRL) is closely related to the development of higher-order thinking skills (HOTS), which are the main competencies that need to be developed in physics education in the current era (Ismayati et al., 2020). In the Merdeka Curriculum, one of the main focuses is to equip students with critical, creative, and analytical thinking skills, which can only be achieved if students can manage and regulate their learning process independently. Metacognitive skills in SRL help students identify errors in their understanding, plan effective learning strategies, and assess the effectiveness of their approaches. These elements support the development of HOTS because students not only remember or understand physics concepts but can also evaluate, analyze, and apply these concepts in a broader context.

In addition, physics learning involving SRL encourages students to be more active and involved in their learning process, which is very relevant to the Merdeka Curriculum principles, prioritizing a more flexible, contextual, and interest-based approach to students' needs. By allowing students to regulate their learning processes, such as developing learning strategies involving Peer Learning, Metacognitive Self-Regulation, and Elaboration, educators can create a more independent learning environment and focus on developing important 21st-century skills, including higher-order thinking skills.

3.5. Analysis of Students' SRL in Physics Learning Using the SRL Questionnaire

The Winstep application visualizes students' self-regulation abilities in physics learning through the Wright Map, which displays the distribution of student abilities and the difficulty levels of items on a logit scale (Sumintono & Widhiarso, 2015). his map allows for a direct comparison between students' abilities and the difficulty of indicators, offering a comprehensive view of students' SRL achievements in physics learning. The Wright Map is illustrated in Figure 4.

In Figure 4, student abilities are categorized into five levels based on their logit scores. Students in the very high category (logit +3.05) exhibit excellent self-regulated learning (SRL) abilities, such as student 55M, who can independently regulate learning and handle the most challenging tasks. The high ability group (logit +1.51 to +2.11), including students like 65F and 68M, understands SRL indicators but may struggle with certain aspects, such as help-seeking. Most students (69.44%) fall into the moderate category (logit +0.31 to +1.51), with sufficient SRL abilities to handle moderate difficulties but facing challenges with more complex indicators. Students in the low category (logit -0.29 to +0.31), such as 01M and 05M, struggle with SRL and can only understand more straightforward indicators. Lastly, students in the very low category (logit < -0.29), like 25M and 36M, have significant difficulties and require additional guidance.

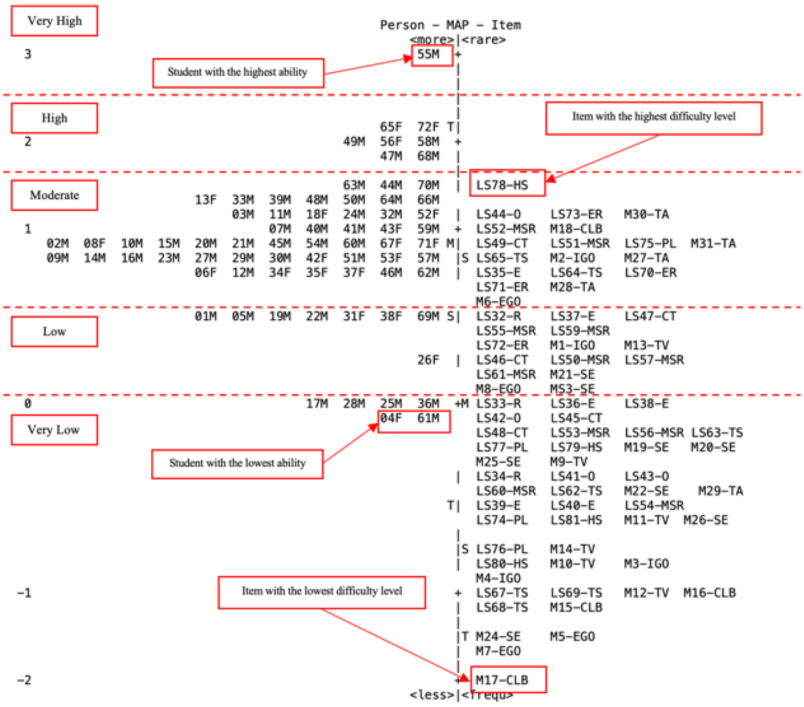

Figure 4. Students' self-regulated learning in physics learning visualized with the wright map

In terms of the level of difficulty of the indicators, it can be seen that the item with the highest level of difficulty is LS78-HS, which is included in the Domain Learning Strategies with the Help-Seeking aspect, which is the question with the highest level of difficulty on the Wright Map. This question's high difficulty level indicates that help-seeking—students' ability to ask for help or seek support from relevant sources—is the most challenging aspect for students. Most likely, only students with high and very high self-regulated learning abilities (high – very high category) could answer this question correctly. This may be due to students' lack of skills in strategically asking for help during physics learning, which requires a good understanding of when and how to ask for help effectively. This question is an important concern for learning interventions, especially in helping students develop learning strategies that involve help-seeking.

in the Motivation Domain with the Control of Learning Beliefs aspect, shows the lowest difficulty level, meaning that most students, even those with low ability, can answer this question correctly. This reflects students' beliefs that their learning efforts and strategies can affect learning outcomes. The ease of this question indicates that many students have a good basic understanding of the relationship between their efforts and learning outcomes, even though this motivational aspect is relatively simple. However, it is important to ensure that this belief is applied in everyday learning practices so students can use it effectively. Meanwhile, items with a moderate level of difficulties, such as LS33-R (Rehearsal), LS36-E (Elaboration), and LS42-O (Organization), test various aspects of students' learning skills, indicating that these learning strategies are more challenging for students with moderate ability (Eilam & Aharon, 2003; Paz-Baruch & Hazema, 2023).

Based on Wright's map, several recommendations can be given. First, for students with high ability, learning can be focused on more complex tasks to improve their self-regulated learning skills. Second, for students with low ability, interventions are needed in the form of additional guidance, practice questions with gradual levels of difficulty, and more adaptive learning approaches to help them recognize and apply effective learning strategies (Lu et al., 2017; Trias Seferian et al., 2021; Wang & Sperling, 2020). Third, the curriculum should include a variety of indicator difficulty levels, ranging from very easy to very difficult, to ensure that all students are well served. Finally, self-regulated learning training integrated into physics learning can help students, especially those with low ability, to develop better self-regulation skills (Theobald, 2021). This approach is expected to improve students' conceptual understanding and make them more independent in their learning process.

The distribution of student abilities, as illustrated in the Wright Map and person-measure table, highlights a varied pattern of strengths and challenges in self-regulated learning (SRL). The person-measure table indicates the extent to which students can independently regulate their learning processes, while the item difficulty levels reflect which aspects of SRL students find most challenging or easy. By comparing the students' abilities with the difficulty of the indicators, insights can be gained into which SRL aspects students have mastered well and which areas need further support. This analysis helps evaluate the comprehensiveness of the SRL questionnaire in describing student abilities and guides appropriate interventions based on each student's ability profile. The following are the logit values for each student based on the output of the person-measure table.

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
55	297	81	3.05	.23	3.63	9.9	3.08	7.6	.29	.31	77.8	69.3	55M
72	279	81	2.21	.20	1.71	4.0	1.68	3.9	.30	.36	44.4	58.8	72F
65	276	81	2.09	.20	2.37	6.7	2.29	6.5	.29	.36	38.3	58.7	65F
58	275	81	2.05	.20	1.90	4.8	1.91	4.9	.25	.36	45.7	58.6	58M
49	274	81	2.01	.20	1.22	1.4	1.12	.8	.58	.36	56.8	58.9	49M
56	274	81	2.01	.20	1.45	2.6	1.33	2.0	.44	.36	50.6	58.9	56F
47	271	81	1.90	.20	1.53	3.0	1.49	2.9	.36	.37	32.1	59.3	47M
68	271	81	1.90	.20	2.16	5.7	1.99	5.2	.44	.37	38.3	59.3	68M
44	262	81	1.57	.19	2.15	5.5	2.04	5.2	.44	.38	43.2	60.7	44M
70	262	81	1.57	.19	.94	-.3	.93	-.4	.37	.38	63.0	60.7	70M
63	258	81	1.43	.19	1.20	1.2	1.15	.9	.43	.39	59.3	60.6	63M
33	256	81	1.36	.18	1.59	3.1	1.55	3.0	.49	.39	34.6	60.6	33M
50	256	81	1.36	.18	1.31	1.8	1.29	1.7	.40	.39	64.2	60.6	50M
39	255	81	1.33	.18	1.07	.5	1.02	.2	.63	.39	58.0	60.7	39M
13	254	81	1.29	.18	.85	-.9	.85	-.9	.49	.39	63.0	60.6	13F
48	253	81	1.26	.18	1.01	.1	.97	-.1	.48	.39	66.7	60.5	48M
64	253	81	1.26	.18	.99	.0	.95	-.2	.45	.39	66.7	60.5	64M
66	253	81	1.26	.18	1.28	1.6	1.25	1.5	.53	.39	51.9	60.5	66M
3	252	81	1.23	.18	1.67	3.4	1.70	3.6	.34	.39	38.3	60.6	03M
18	251	81	1.19	.18	.57	-3.0	.56	-3.2	.51	.40	79.0	60.7	18F
32	250	81	1.16	.18	1.00	.0	.99	.0	.56	.40	60.5	60.6	32M
24	249	81	1.13	.18	1.24	1.4	1.20	1.2	.45	.40	56.8	60.6	24M
11	248	81	1.09	.18	.75	-1.6	.75	-1.6	.47	.40	64.2	60.7	11M
52	248	81	1.09	.18	.38	-4.9	.39	-4.9	.41	.40	86.4	60.7	52F
40	247	81	1.06	.18	.76	-1.5	.74	-1.7	.52	.40	65.4	60.7	40M
43	247	81	1.06	.18	.69	-2.0	.70	-2.0	.42	.40	71.6	60.7	43F
59	247	81	1.06	.18	.68	-2.1	.66	-2.3	.53	.40	74.1	60.7	59M
7	244	81	.97	.18	.85	-.9	.80	-1.3	.53	.40	70.4	60.6	07M
41	243	81	.94	.18	.88	-.7	.85	-.9	.28	.40	63.0	60.4	41M
20	242	81	.90	.18	.78	-1.3	.76	-1.5	.42	.41	72.8	60.2	20M
67	242	81	.90	.18	.50	-3.6	.49	-3.8	.70	.41	76.5	60.2	67F
54	241	81	.87	.18	.48	-3.8	.50	-3.7	.41	.41	81.5	60.0	54M
60	241	81	.87	.18	.64	-2.4	.63	-2.5	.43	.41	75.3	60.0	60M
71	241	81	.87	.18	1.24	1.4	1.22	1.3	.24	.41	55.6	60.0	71F
2	239	81	.81	.17	.99	.0	.95	-.2	.53	.41	55.6	60.0	02M
8	239	81	.81	.17	1.43	2.3	1.41	2.2	.52	.41	44.4	60.0	08F
10	239	81	.81	.17	2.35	6.0	2.23	5.6	.41	.41	35.8	60.0	10M
15	239	81	.81	.17	.70	-2.0	.70	-2.0	.20	.41	70.4	60.0	15M
21	239	81	.81	.17	1.46	2.5	1.41	2.3	.28	.41	56.8	60.0	21M
45	238	81	.78	.17	.84	-.9	.82	-1.1	.52	.41	64.2	59.6	45M
51	236	81	.72	.17	.84	-.9	.86	-.8	.41	.41	61.7	59.3	51M
14	235	81	.69	.17	.42	-4.5	.42	-4.5	.37	.41	77.8	59.2	14M
16	235	81	.69	.17	.68	-2.1	.72	-1.8	.41	.41	74.1	59.2	16M
23	234	81	.66	.17	.36	-5.1	.36	-5.2	.35	.41	84.0	59.0	23M
9	233	81	.63	.17	1.13	.8	1.10	.6	.40	.42	44.4	58.8	09M
27	233	81	.63	.17	.91	-.5	.92	-.4	.60	.42	53.1	58.8	27M
29	232	81	.61	.17	.93	-.3	.94	-.3	.28	.42	65.4	58.8	29M
30	232	81	.61	.17	.30	-6.0	.30	-6.0	.44	.42	84.0	58.8	30M
42	232	81	.61	.17	.56	-3.1	.56	-3.1	.56	.42	64.2	58.8	42F
53	232	81	.61	.17	1.23	1.4	1.17	1.1	.36	.42	64.2	58.8	53F
57	232	81	.61	.17	.49	-3.8	.48	-3.9	.25	.42	80.2	58.8	57M
12	231	81	.58	.17	.87	-.8	.88	-.7	.12	.42	76.5	58.5	12M
37	231	81	.58	.17	.98	-.1	.97	-.1	.24	.42	69.1	58.5	37F
62	231	81	.58	.17	.33	-5.6	.31	-5.8	.41	.42	87.7	58.5	62M
34	230	81	.55	.17	.93	-.4	.92	-.5	.51	.42	56.8	58.2	34F
46	230	81	.55	.17	1.17	1.0	1.13	.8	.45	.42	55.6	58.2	46M
35	227	81	.46	.17	.70	-2.0	.71	-1.9	.44	.42	61.7	57.6	35F
6	226	81	.43	.17	.46	-4.2	.43	-4.4	.44	.42	76.5	57.3	06F
5	224	81	.38	.17	.71	-2.0	.70	-2.1	.32	.42	64.2	56.9	05M
22	224	81	.38	.17	1.06	.4	1.04	.3	.33	.42	53.1	56.9	22M
19	223	81	.35	.17	.74	-1.7	.79	-1.4	.64	.43	56.8	56.7	19M
1	222	81	.32	.17	1.42	2.4	1.37	2.1	.50	.43	44.4	56.6	01M
38	221	81	.30	.16	.79	-1.4	.79	-1.4	.57	.43	53.1	56.5	38F
69	221	81	.30	.16	.49	-4.0	.45	-4.4	.44	.43	76.5	56.5	69M
31	220	81	.27	.16	.84	-1.0	.83	-1.1	.31	.43	55.6	56.0	31F
25	213	81	.09	.16	.58	-3.2	.57	-3.2	.39	.44	67.9	53.4	25M
26	213	81	.09	.16	.45	-4.5	.44	-4.6	.45	.44	69.1	53.4	26F
28	212	81	.06	.16	.76	-1.7	.80	-1.3	.02	.44	55.6	53.1	28M
36	212	81	.06	.16	1.65	3.6	1.65	3.6	.09	.44	35.8	53.1	36M
17	211	81	.03	.16	.55	-3.6	.53	-3.7	.48	.44	66.7	53.0	17M
4	209	81	-.02	.16	.44	-4.8	.43	-4.8	.49	.44	66.7	52.7	04F
61	208	81	-.04	.16	2.48	7.2	2.45	6.9	.46	.44	23.5	52.4	61M
MEAN	241.0	81.0	.91	.18	1.05	-.2	1.02	-.3			61.1	58.8	
S.D.	18.4	.0	.60	.01	.59	3.3	.55	3.1			14.2	2.6	

Figure 5. Logit of each student based on the output table of Pearson *M*easure

Based on the person-measure in Figure 5, the mean value of the students' logit is 0.91 with a standard deviation (SD) of 0.60. Based on the classification of ability levels (Sumintono & Widhiarso, 2015), students with high ability have a measured value of more than 1.51 (mean + SD), students with moderate ability have a measured value between 0.31 and 1.51 (mean - SD to mean + SD), and students with low ability have a measured value of less than 0.31 (mean - SD). The following is a table showing the distribution of students' self-regulated learning levels in physics learning.

Table 4. Distribution of students' self-regulated learning levels in physics learning

Student Ability Level	Freq.	%
High	10	13.89
Moderate	52	72.22
Low	10	13.89

Based on Table 4, it is known that students with high ability have a measured value of more than 1.51 (mean + SD), with as many as 10 students (13.89%) showing excellent ability in managing their learning process independently and being able to complete indicators with the highest level of difficulty. Students in the medium ability category, with measure values between 0.31 to 1.51 (mean - SD to mean + SD), dominate the group with a total of 52 students (72.22%). Students in this category are able to understand most of the SRL indicators with moderate difficulty, although they may face challenges in more complex indicators. On the other hand, as many as 10 students (13.89%) are included in the low ability category, with measure values less than 0.31 (mean - SD). Students in this category show significant difficulties in managing learning independently and require additional support in understanding SRL indicators, especially those related to motivational aspects and learning strategies (Rieger et al., 2023). This distribution shows that most students are at a medium ability level, reflecting the potential for further development through more supportive learning strategies. For students in the low category, additional interventions such as learning strategy training and scaffolding-based support are needed so that they can gradually improve their SRL abilities (Winarti et al., 2022). This approach can help them be better prepared to face challenges in physics learning.

4. Conclusion

Based on the Self-Regulated Learning (SRL) instrument analysis using the Rasch model approach with Winsteps software, this instrument shows very good reliability, with a Cronbach Alpha value of 0.90, indicating good internal consistency in measuring students' SRL abilities. The analysis results also show variations in student abilities, with most students in the moderate SRL category. The students' SRL profile shows that most students have a good level of motivation, reflected in the sub-domains Control of Learning Beliefs and Task Values, which indicate the belief that their efforts in learning physics will provide positive results. However, several areas need to be improved, such as Test Anxiety, Critical Thinking, and Effort Regulation, which still show lower scores. However, Metacognitive Self-Regulation and Peer Learning skills can improve students' understanding of physics material. Based on these findings, educators can first utilize students' beliefs in Control of Learning Beliefs and Task Values in designing more relevant and meaningful learning, such as real-life-based projects that can increase students' intrinsic motivation. Second, to reduce students' test anxiety, a project-based learning approach that prioritizes hands-on experience can be implemented as an alternative to written exams. Third, it is important to continue developing students' metacognitive skills through learning strategies that encourage them to plan, monitor, and evaluate their learning independently and strengthen peer interactions through Peer Learning. Finally, educators need to provide more opportunities for students to develop critical thinking skills and overcome obstacles in Help-Seeking, which can be improved through further practice and support in seeking help strategically during physics learning.

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