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ORIGINAL RESEARCH

SiGMA: A Self-Regulated Learning Strategy for Kinesthetic Learning Styles in Online Education

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Abstract
This study aims to identify the challenges faced by students with a kinesthetic learning style in online learning and to design the SiGMA strategy (Set Goals, Implement strategies, Monitor Progress, Adapt Results) based on Self-Regulated Learning (SRL) to meet their needs. Using a mixed-method approach with an explanatory sequential design, the study involved 50 physics students (17 males and 33 females, aged 17–21). The instruments used were the SiGMA-LQ (SiGMA Learning Questionnaire) and semi-structured interviews. Data were analyzed using SPSS 27 and NVivo 15. The Kruskal-Wallis test showed a significant difference among learning styles ($p < 0.05$), with the lowest SRL score observed in kinesthetic learners ($M = 3.7$). The findings revealed that these students face major challenges in planning and monitoring during independent online learning. This supports the SiGMA strategy as an adaptive framework that can enhance SRL abilities among kinesthetic learners in digital learning environments.

Keywords: Kinesthetic learning style · Online learning · Self-regulated learning · SiGMA strategy

INTRODUCTION

The core of the educational process is learning, thus improving the quality of education can be achieved by enhancing the quality of learning (Novita & Hutasuhut, 2020). However, the education sector has been significantly affected since the onset of the Covid-19 pandemic (Abidah et al., 2020). During the pandemic, learning has not always proceeded effectively (Chaturvedi et al., 2021). From April 2020 to May 2021, most educational activities shifted to online or remote learning systems (Bali & Musrifah, 2020).

The transition from face to face to online learning introduced new challenges, particularly as online learning does not always yield optimal outcomes. Online learning relies on internet connectivity and is characterized by high accessibility and flexibility. It occurs without direct physical meetings between instructors and students, utilizing digital platforms to support the teaching and learning process remotely (Firman & Rahayu, 2020). Nevertheless, a UNICEF report in 2020 revealed that about one-third of students worldwide were unable to access online learning during school closures (see Figure 1).

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Area	Minimum proportion of school children who cannot access distance learning (%)	Minimum number of school children who cannot access distance learning
East and Southern Africa	49%	67 million
West and Central Africa	48%	54 million
East Asia and Asia Pacific	20%	80 million
Middle East and North Africa	40%	37 million
South Asia	38%	147 million
Eastern Europe and Central Asia	34%	25 million
Latin America and the Caribbean	9%	13 million
Global	**31%**	**463 million**

Figure 1. Data on difficulties accessing online learning (Source: https://www.unicef.org/indonesia/id)

Unequal access to online learning has resulted in many students experiencing a decline in learning quality, including motivation. Beyond the technological difficulties, previous studies have shown that students' motivation tends to decrease in online learning environments. (Firmansyah, 2021) found that high school students experienced a decrease in learning motivation during online learning in the pandemic. Research by (Kusumaningrum & Wijayanto, 2020) on the effectiveness of online mathematics learning showed it was less effective due to signal disruptions. Also, studies such as for example those of (Mamolo, 2022) in the teaching of Mathematics and (Klein ., 2021) in the teaching of Physics, identified a negative influence of online learning on psychological factors such as motivation and self-efficacy but also on learning factors. In addition, the findings of (Setiawan, 2020) study showed that the implementation of adaptive learning methods contributed to the improvement of students' learning motivation, which is correlated with their physics learning outcomes.

One key factor determining learning success, especially in online contexts, is students' learning styles. (Pace ., 2020) stated that 73% of students with a strong understanding of their learning styles achieve better outcomes, as this enables them to recognize their strengths and weaknesses, design effective strategies and evaluate their methods. For the issue of learning styles, important theories have been formed in the last 30-40 years (Bornstein & Gardner, 1986; Dunn & Schweitzer, 2005; Kolb, 2000). In all these approaches that classify subtle aspects of learning styles, they are distinguished by three learning styles namely visual, auditory and kinesthetic. Visual learners grasp material more easily by seeing or observing, auditory learners rely on listening while kinesthetic learners absorb information through direct physical involvement and object manipulation and real-life experiences (Dutta, 2020).

However, limited physical interaction in online learning often poses difficulties for kinesthetic learners. The lack of hands-on activities and direct engagement leads to increased boredom and difficulty concentrating, especially when lectures are the main method (Irawan et al., 2020). Surveys and reports show low satisfaction and effectiveness in online learning for this group that found 53% of students spent less time on coursework, 39% saw no direct benefit and about 75% had a negative view of online learning (Maqableh & Alia, 2021). Brookings

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Institute data showed a significant drop in mathematics achievement during the pandemic, especially among lower-grade students (Soland et al., 2020).

The low level of learning achievement is further exacerbated by the lack of optimal attention to the diversity of student learning styles in online systems. Kinesthetic learners are particularly at risk of facing significant difficulties because their learning style is not optimally accommodated. In fact, the kinesthetic learning style is commonly found among students in science and engineering fields, which require direct involvement in practical activities and exploration.

To address these challenges, it is necessary to strengthen students' Self-Regulated Learning (SRL) abilities. In this context, SRL becomes extremely important. SRL is the ability of learners to manage their own learning process independently, starting from planning, execution, to evaluation. It encompasses self-awareness, self-control, observation and evaluation of the ongoing learning process (Wolters & Brady, 2021). Research conducted by (Jannah ., 2022) showed that the implementation of self-regulated learning can support students with a kinesthetic learning style through strategies that emphasize physical activities and hands-on practice, thereby making the learning process more optimal. (Reimers ., 2020) emphasize that effective learning behavior can only be achieved if learners recognize their responsibilities and are able to manage their time independently. In the context of online learning, SRL skills are a crucial prerequisite to ensure that the learning process remains effective and efficient (Alvarez et al., 2022). Moreover, self-efficacy, or students' belief in their ability to achieve learning goals, also plays a critical role in supporting self-regulated learning, especially in online settings (Aviyanti et al., 2025). Supporting this view, (Kholifudin, 2020) found that higher levels of learning independence among students are associated with better learning outcomes.

However, not all online learning systems are currently able to foster these SRL skills, especially for kinesthetic students who require a more adaptive approach. Today's online learning systems do not yet fully provide equal learning opportunities for all students, particularly those with a kinesthetic learning style. There is a need for learning strategies specifically designed to accommodate their needs while also strengthening SRL skills.

Based on this background, this research aims to identify the challenges faced by kinesthetic learners: (a) in online education (alternative hypothesis proposed is that students with a kinesthetic learning style experience significantly greater difficulties in online learning compared to those with other learning styles) and (b) to design the SiGMA strategy (Set Goals, Implements Strategies, Monitor Progress, Adapt Results) based on Self-Regulated Learning (SRL) to meet their needs.

METHOD

This study employs a mixed-method approach with an explanatory sequential design, as illustrated in Figure 2. Explanatory sequential design is a mixed-methods approach in which quantitative data are first collected and analyzed, followed by qualitative data to further explain or elaborate on the quantitative results (Creswell, 2014). This approach was chosen to comprehensively describe the challenges faced by students with a kinesthetic learning style in online education and to evaluate the SiGMA strategy within the context of Self-Regulated Learning (SRL). The use of a survey in the quantitative stage was deliberately selected to

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broadly map students' initial difficulties, while the qualitative stage was employed to provide deeper contextual insights.

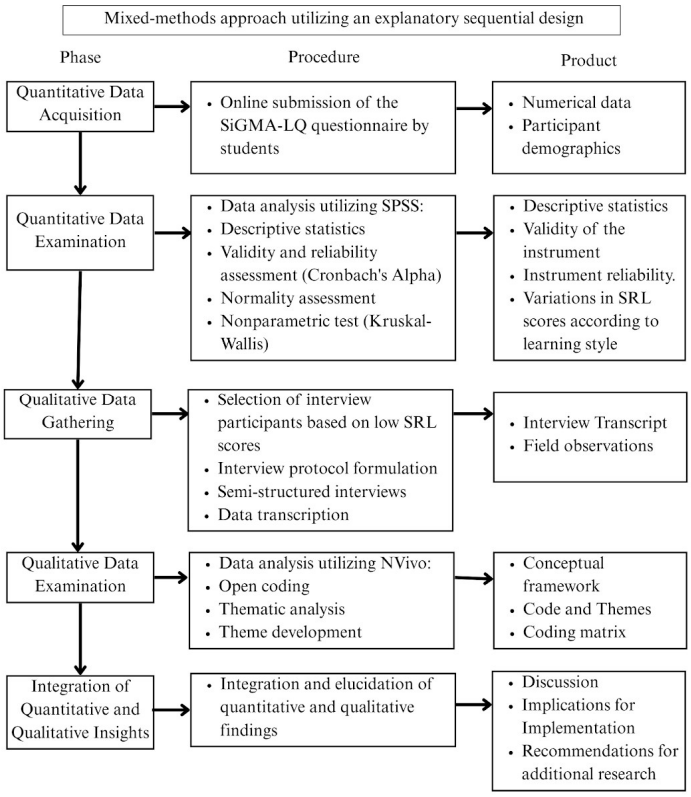

Figure 2. Design Explanatory Sequential (Source: Author)

This study was conducted in the Physics Education Study Program at Universitas Pendidikan Indonesia (UPI) over a period of two months, from April to May 2025. Quantitative data collection was carried out online via the Google Forms platform from April 12 to 17, 2025, while qualitative interviews were conducted offline at the UPI campus on May 30, 2025. This study received approval from the Research Ethics Committee of Universitas Pendidikan Indonesia. Informed consent was obtained from all participants, and confidentiality and anonymity were strictly maintained throughout the study. The population of this research consisted of all active students in the Physics Education Study Program. The sample was determined using purposive sampling with the following criteria: (1) active students in semesters 2 to 6, (2) identified as having a predominantly kinesthetic learning style, as determined through structured observation by the researcher and student self-report during lessons and workshops (Pantidos et al., 2008; Scherr, 2008) and (3) having participated in online learning. It is acknowledged that learning styles are not inherently distinct or fixed categories; therefore, the identification of kinesthetic learners in this study refers to students whose dominant preference tends toward kinesthetic learning, while other styles may also be present. The total sample consisted of 50 students, comprising 17 male and 33 female students, with ages ranging from 17 to 21 years.

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The instrument used in this study was the SiGMA-LQ (SiGMA Learning Questionnaire), which was specifically designed to measure the level of implementation of Self-Regulated Learning (SRL) strategies among students with a kinesthetic learning style in online learning. The questionnaire consists of 10 statements divided into two main sections: five statements to assess students' difficulties in online learning and five statements to measure the suboptimal use of kinesthetic learning styles related to SRL. Based on the validity test results, all items in the SiGMA-LQ had a significance value of less than 0.05, indicating that all items were valid. The reliability was tested using Cronbach's Alpha, which produced an α value of 0.924. This value indicates a very high level of reliability, showing that the questionnaire is consistent and stable in measuring Self-Regulated Learning (SRL) strategies. Examples of the statements used can be seen in Figure 3.

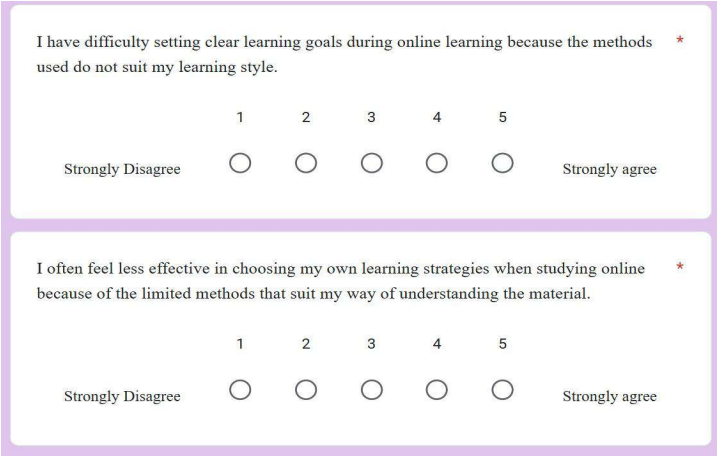

Figure 3. Sample of Questions (Source: Author)

In this questionnaire, each statement is assessed using a Likert scale of 1-5, where 1 means "strongly disagree", 2 "disagree", 3 "neutral", 4 "agree" and 5 "strongly agree". SiGMA-LQ is distributed through the Google Forms platform to ensure efficient and fast data collection. Qualitative data is collected through semi-structured interviews. The qualitative data analysis followed a thematic approach, beginning with open coding, axial coding, and subsequent theme construction using NVivo 15, to ensure systematic categorization and replicability. Data collection occurred in two stages: quantitative data were analyzed using SPSS (normality tests: Kolmogorov-Smirnov, Shapiro-Wilk; group differences: Kruskal-Wallis). Qualitative data from interviews with low-SRL kinesthetic learners were analyzed using NVivo 15.

RESULTS AND DISCUSSION

Challenges of Kinesthetic Learners in Online Learning

The research findings were obtained using the SiGMA-LQ instrument, with responses collected from students representing various learning styles. The normality test, as shown in Figure 4, yielded a significance value (P Value) of 0.123 (> 0.05), indicating that the data are normally distributed.

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Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	LEARNINGSTYLE	Statistic	df	Sig.	Statistic	df	Sig.
SCALE	Visual	.206	5	.200*	.942	5	.680
	Auditory	.193	5	.200*	.933	5	.619
	Kinesthetic	.321	5	.102	.823	5	.123

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Figure 4. Normality Test Results (Source: Author)

Although the data are normally distributed, the type of data used in this study is ordinal. Therefore, further analysis was conducted using a non-parametric test, specifically the Kruskal-Wallis test. This test was employed to determine whether there are significant differences between groups based on learning styles in relation to the level of difficulty experienced in online learning.

Ranks

	LEARNINGSTYLE	N	MEAN RANK
SCALE	Visual	5	9.70
	Auditory	5	10.60
	Kinesthetic	5	3.70
	Total	15	

Test Statistics[a,b]

	SCALE
Kruskal-Wallis H	7.176
df	2
Asymp. Sig.	.028

a. Kruskal Wallis Test
b. Grouping Variable: LEARNINGSTYLE

Figure 5. Kruskal-Wallis Test Results (Source: Author)

Data collection was conducted on 50 respondents. However, an imbalance in the distribution of learning styles was found, so 15 respondents were selected by purposive sampling to represent the diversity. In Figure 5. with the results of the Kruskal-Wallis test analysis showing the value of Asymp. Sig (P-Value) <0.05 which indicates a significant difference between learning styles. Thus, the null hypothesis (H0) is rejected and the alternative hypothesis (Ha) is accepted. This means that there is a significant difference in the level of difficulty in participating in online learning, where students with a kinesthetic learning style experience greater difficulties compared to other learning styles.

This finding confirms that students with kinesthetic learning styles experience significant difficulties in participating in online learning compared to students with other learning styles. This is shown by the lowest SRL score in the kinesthetic group (M = 3.7). This is supported by research by (Pardede ., 2021) which revealed that during the Covid-19 pandemic, students with kinesthetic learning styles experienced learning difficulties because learning was only in the form of documents and there was no direct practice, making it difficult for students to understand the material. Furthermore, the map of challenges and difficulties in online learning is obtained from the results of interviews through the project map in Figure 6. The project map refers to the coding results used to explore and present data connections.

Qualitative mapping (see Figure 6) revealed key obstacles: limited devices, unstable internet, lack of enthusiasm from students and instructors and environmental distractions. These hinder initial problem comprehension, planning and execution. During learning, difficulties included minimal note-taking, limited practical tools, insufficient explanations and reduced

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opportunities to ask questions or observe demonstrations. Final phase issues included accumulating assignments, fatigue and tight schedules, reducing reflection and verification.

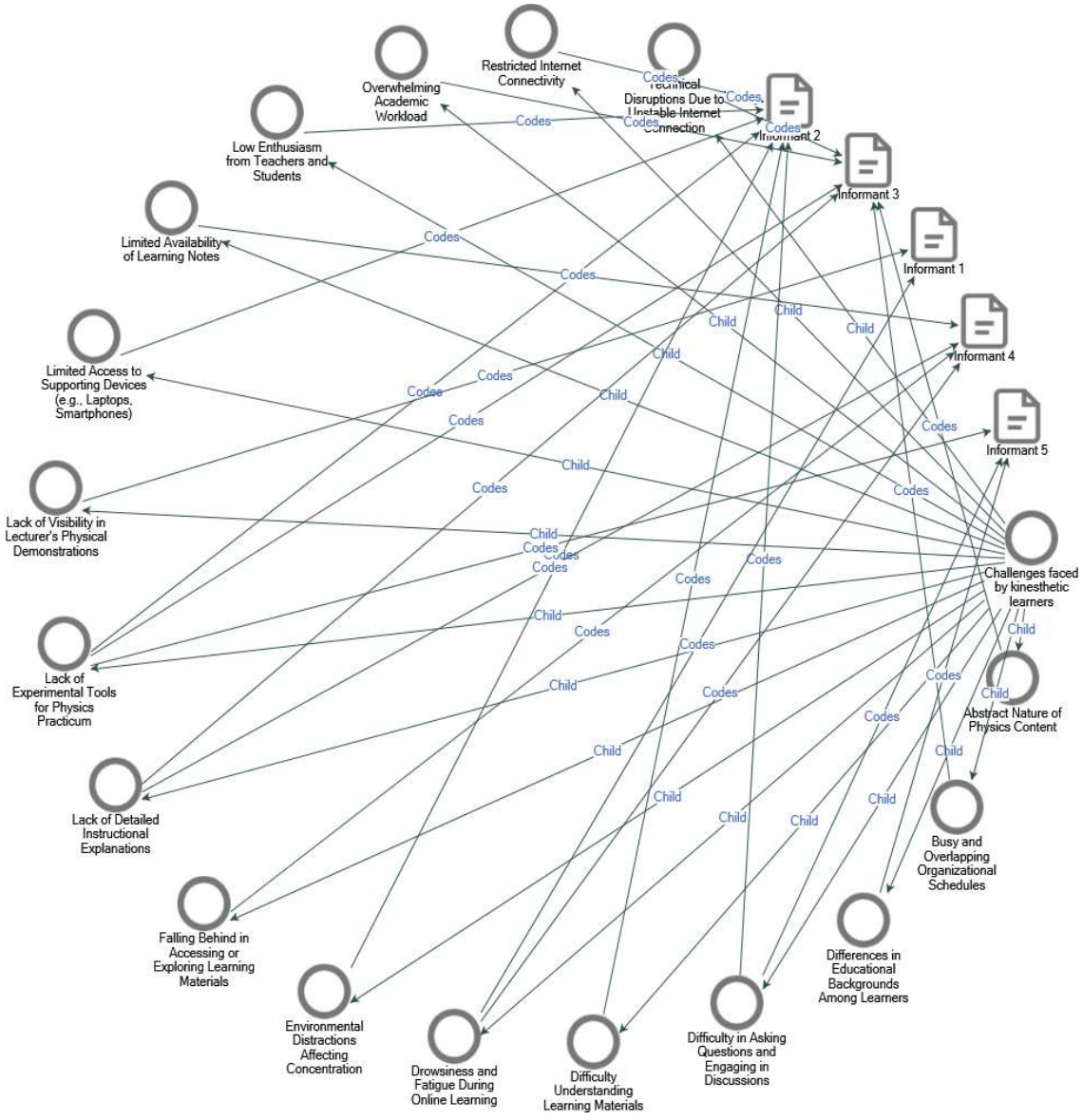

Figure 6. Challenges Faced by Kinesthetic Learners (Source: Author)

Further visualization (Figure 7) showed kinesthetic learners struggled to adapt, with minimal physical activity and practical engagement, leading to procrastination, confusion, lack of motivation and poor comprehension. Barriers stemmed from both internal and systemic limitations, such as restricted interaction and time management challenges.

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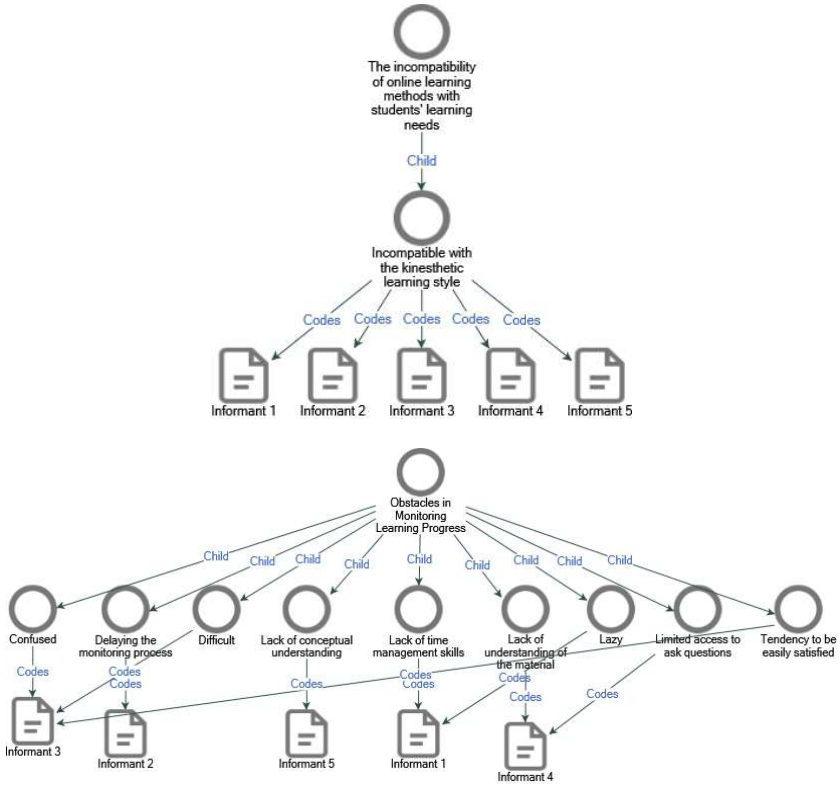

Figure 7. Project Map Mismatch of Methods and Obstacles to Online Learning (Source: Author)

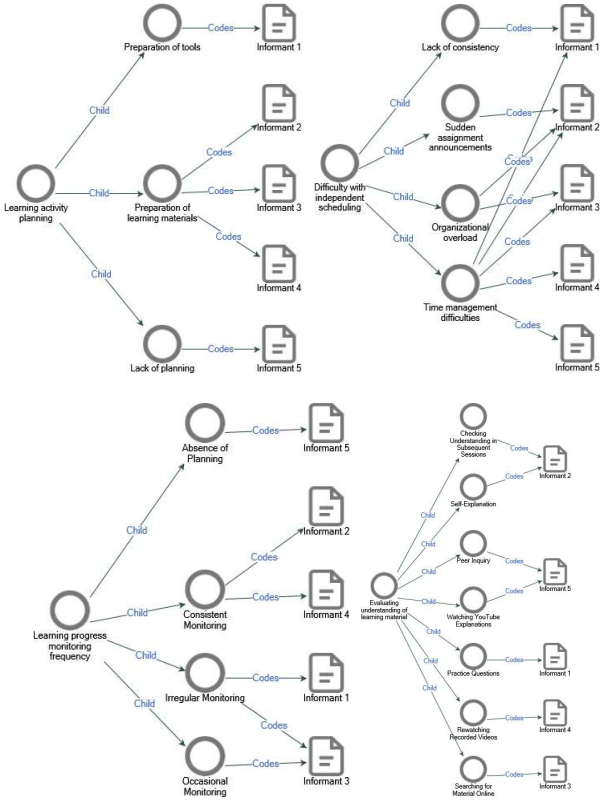

Figure 8. Project Map Self-Regulated Learning Kinesthetic Students in Online Learning. (Source: Author)

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Based on Figure 8, it can be seen that students with kinesthetic learning styles show deficiencies in several main aspects of Self-Regulated Learning (SRL) abilities, especially in the planning, monitoring and self-evaluation phases. This can be seen from three main nodes, namely, planning learning activities, intensity of monitoring learning progress and evaluating understanding of the material. There are informants who state that there is no planning, lack of routine in monitoring learning progress and difficulty in evaluating understanding, for example only relying on videos or friends without an active and independent approach. In addition, there are several external factors such as "sudden assignment announcements" and "many organizational agendas" which exacerbate the irregularity in managing independent learning schedules.

This is relevant to research by (Rahmawati ., 2023) which shows that some students do not yet have the ability to regulate themselves in their learning process. Students are not yet able to determine learning targets and strategies, are not consistent in implementing these strategies and do not evaluate strategies that are no longer effective.

Development of the SiGMA Strategy Based on Self-Regulated Learning

The findings show low self-regulated learning (SRL) abilities of students, especially those with kinesthetic learning styles. This indicates that students face various internal and external challenges during online learning, such as difficulty understanding the material, lack of motivation, lack of learning planning, limited devices and networks and learning methods that are not in accordance with their characteristics that require physical activity and direct practice. This gap has a direct impact on students' failure to carry out the three main phases of SRL according to (Zimmerman, 2002), namely the planning, implementation and evaluation phases.

To address these issues, a strategy was designed that synthesizes key processes from established Self-Regulated Learning (SRL) theory namely Set Goals, Implement Strategies, Monitor Progress, Adapt Results (abbreviated as SiGMA). This adaptation refers to the SRL phases described by Zimmerman (2002), structured in a way that is practical for online education and particularly responsive to the needs of kinesthetic learners, who benefit from clear, action-oriented steps. To date, no widely published evidence exists for a conceptual framework titled ‘SiGMA’ thus in this study, SiGMA is introduced as a reorganization and contextualization of SRL principles for independent learning in the digital era. Grounded in SRL principles, it emphasizes active goal setting, monitoring, regulation and adaptation of cognitive, motivational and behavioral processes.

Figure 9. Four SiGMA Strategies (Source: Author)

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There are four main strategies systematically designed for students to optimize self-directed learning during online education, especially for physics students with a kinesthetic learning style. The first step, "Set Goals," emphasizes the importance of determining specific, relevant and measurable goals before beginning the learning process. By setting clear objectives and targets, the learning process becomes more meaningful and can motivate students. This stage serves as a foundation so that the next strategies are aligned with the students' needs and the strengths of their learning style.

The next stage, "Implements Strategies," plays a crucial role in supporting the learning process for students with a kinesthetic learning style. Students actively choose learning methods that suit their style, such as creating concrete models of the concepts being studied, manually drawing mind maps, or arranging steps of the material in a visual flow. Additionally, virtual simulations and demonstration videos are also effective learning tools, as they allow students to learn by practicing the material. This strategy not only helps in understanding the material conceptually but also maintains student engagement and focus in an online learning environment with minimal direct contact.

The third stage, "Monitor Progress," focuses on students' ability to actively monitor, evaluate and assess their learning progress during online education. For kinesthetic learners, this monitoring can be done through activities involving real actions, such as recording daily achievements in a learning journal, checking off completed assignments, or reflecting on understanding through direct practice. By regularly monitoring progress, students not only know how far they have achieved their learning goals, but also can identify obstacles that arise during the learning process. This stage is essential for building metacognitive skills and strengthening independent learning abilities in a flexible yet directed context.

The final stage is "Adapt Results." With this stage, students can evaluate the effectiveness of the approaches they have used. They will reflect on whether certain strategies helped achieve learning goals, improved understanding and maintained motivation. If the strategies used in the learning process are not optimal, students can adjust by trying new approaches or modifying existing methods. For example, if manual note-taking is less effective, they can add video elements or hands-on practice as complements.

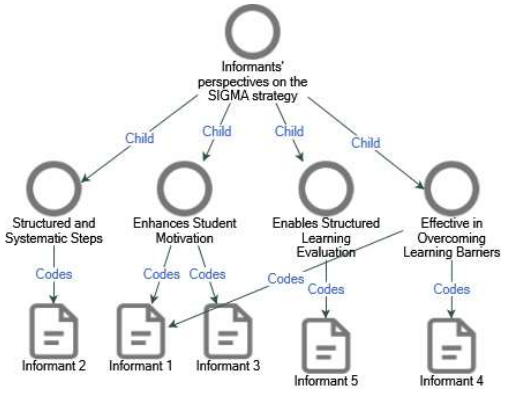

Figure 10. Project Map Resource Person's Views Regarding SiGMA's Strategy to Overcome Kinesthetic Learning Style Difficulties. (Source: Author)

Next, Figure 11 presents the results of interviews regarding the informants' perspectives on the SiGMA strategy (Set Goals, Implements Strategies, Monitor Progress and Adapt

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Results) as a way to overcome learning difficulties during online education, especially for students with a kinesthetic learning style. In this visualization, four main themes emerge: "overcoming learning obstacles," "motivating," "structured," and "measurable".

When viewed in the context of self-regulated learning, this strategy aligns with Zimmerman's (2002) three-phase model: planning, performance and reflection. The aspects of "structured" and "measurable" support the planning phase by providing clear direction and learning objectives. The "motivating" theme relates to the performance phase, where students maintain active engagement during the learning process. Meanwhile, "overcoming learning obstacles" corresponds to the reflection phase, where students evaluate and improve their learning strategies. In addition to using a project map, this study also employs a concept map as a visual tool to present the relationships among findings from various stages of the research. (Yin, 2016) states that visual mapping, such as concept maps, can help build theory and explain patterns in qualitative data.

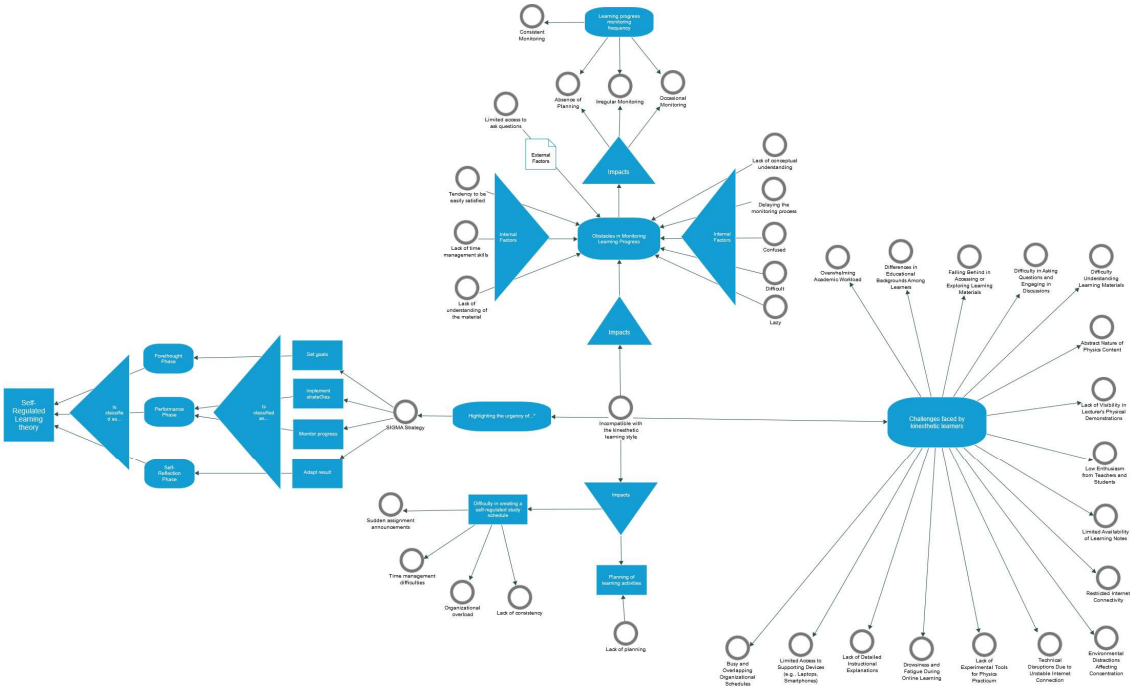

Figure 11. Combined Concept Map Interview Results (Source: Author)

The concept map begins with the initial node "Low self-regulated learning ability," which is described as the result of a number of internal and external challenges. Internal challenges include difficulties in understanding material, lack of motivation and the absence of a clear learning plan. External challenges include limited devices and connectivity, mismatched methods with the kinesthetic learning style and minimal interaction or movement from instructors during online classes. These obstacles exacerbate the ineffectiveness of the learning process for kinesthetic students, who rely on hands-on practice and physical activity. Furthermore, the concept map illustrates that these mismatches impact the three main phases of SRL according to Zimmerman (2002): (1) planning phase (not making study schedules, not setting goals); (2) performance phase (laziness, procrastination, lack of enthusiasm); and (3) evaluation phase (not evaluating understanding, relying only on videos or peers).

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To address these issues, the concept map highlights the intervention of the SiGMA strategy (Set Goals, Implements Strategies, Monitor Progress, Adapt Results). This strategy is placed at the central node as a solution that leads to improved SRL skills. The four components of the SiGMA strategy are clarified with their positive effects: a more organized learning structure, increased motivation, progress monitoring and improvement of learning strategies. Implementing this strategy is expected to bridge the gap between kinesthetic learning styles and the demands of online education.

This is consistent with the research by (Barnard-Brak ., 2010), which states that learners with low self-regulated learning abilities tend to fail in planning their studies and are unable to evaluate their progress in a structured manner, especially in the context of online learning. In addition, (Zeidner & Stoeger, 2019) supports the finding that students with low self-regulated learning often lack clear learning strategies and are deficient in utilizing feedback or self-reflection regarding their individual learning achievements.

CONCLUSION

The findings indicate that students with a kinesthetic learning style face major challenges in planning and monitoring during independent online learning. These obstacles result in low effectiveness, requiring active and reflective engagement. The SiGMA strategy proves to be a relevant adaptive framework to strengthen SRL abilities, especially for kinesthetic learners. With its four systematic stages Set Goals, Implements Strategies, Monitor Progress and Adapt Results. This strategy bridges the learning needs of kinesthetic learners with the demands of online learning. It is recommended that educational institutions integrate SRL-based strategies like SiGMA into online curricula and provide special support for kinesthetic learners to improve online learning quality and ensure optimal learning opportunities for all.

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