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Fostering Self-Regulated Learning through Character-Integrated Inquiry Laboratory Learning in Basic Elementary Physics

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ABSTRACT
This study examines the contribution of character-integrated inquiry-based laboratory learning to enhancing Self-Regulated Learning (SRL) in the Basic Concepts of Elementary Physics course. A descriptive quantitative approach with a posttest-only design was employed. The participants consisted of 68 second-semester students enrolled in the Primary School Teacher Education Program (PGSD) at Universitas Adzkia, including 53 female and 15 male students. All participants were taking the Basic Concepts of Elementary Physics course, which involves laboratory-based inquiry activities. The sample was selected using purposive sampling from two classes with similar academic characteristics.Data were collected using a validated Likert-scale questionnaire measuring key SRL dimensions, including planning, self-monitoring, self-control, reflection, intrinsic motivation, self-efficacy, independence, and responsibility. Data were analyzed using descriptive statistics, including mean scores and percentage distributions.The findings indicate that students demonstrated consistently high levels across all SRL indicators following the implementation of character-integrated inquiry-based laboratory learning. The integration of character values such as responsibility, independence, honesty, perseverance, and curiosity strengthened students' cognitive, motivational, and behavioral regulation. These results suggest that embedding character values within inquiry-based laboratory learning provides a holistic instructional approach that supports both self-regulation and professional development.

Keywords: *self-regulated learning, inquiry-based laboratory, character integration, pre-service elementary teachers, basic concepts of elementary physics*

INTRODUCTION

The demands of 21st-century higher education extend beyond conceptual mastery toward the development of autonomous, reflective, and strategically engaged learners. Among the competencies emphasized in contemporary educational research, self-regulated learning (SRL) has emerged as a central construct. SRL refers to learners' capacity to plan, monitor, control, and evaluate their cognitive, motivational, and behavioral processes in pursuit of academic goals (Wang, 2025). Accumulating evidence demonstrates that SRL significantly predicts academic achievement, persistence, motivation, and deep engagement across disciplines (Kubsch, 2025). In science education in particular, SRL is indispensable because meaningful learning requires experimentation, hypothesis testing, data interpretation, and reflective reasoning (Hsu, 2026).

The urgency of strengthening SRL becomes more pronounced in teacher education programs. Pre-service elementary teachers are not merely expected to acquire subject knowledge

but to cultivate pedagogical competence capable of fostering autonomy and responsibility in their future students. However, early-semester university students often experience a transitional gap as they move from highly structured secondary schooling to the autonomy-demanding environment of higher education. Empirical observations indicate that many first- and second-year students remain dependent on instructor direction, demonstrate limited initiative in seeking learning resources, and rarely engage in systematic self-reflection. Without early intervention, this pattern risks being reproduced in their future classrooms, limiting their ability to design learning environments that promote autonomy and responsibility among elementary learners. This condition reflects a critical instructional problem, as insufficient development of SRL at this stage may hinder both academic success and the ability of future teachers to cultivate independent learners in elementary classrooms.

This issue is particularly critical in courses such as Basic Concepts of Elementary Physics. Elementary science learning requires concrete, contextualized, and experience-based instruction aligned with the developmental characteristics of young learners. Consequently, pre-service teachers must first engage in authentic scientific inquiry experiences that mirror the epistemic practices of science. Inquiry-based laboratory learning provides such a context by positioning students as active investigators who formulate questions, design experiments, analyze data, and reflect on their findings (Jong, 2021). Theoretically grounded in constructivism, inquiry-based learning has been shown to enhance conceptual understanding, critical thinking, and engagement (Yusmanila & Widya, 2020). Furthermore, the iterative phases of inquiry planning, monitoring, and evaluating align closely with the core regulatory processes underlying SRL.

Despite its theoretical promise, laboratory implementation in higher education often remains procedural or "cookbook-oriented," with students following predetermined steps and making minimal epistemic decisions. In such contexts, laboratory work risks becoming a task-completion exercise rather than a self-regulated learning experience (Wu, 2020). Emerging evidence suggests that inquiry does not automatically foster SRL unless accompanied by explicit scaffolding and intentional design (Newman, 2023). This reveals a significant pedagogical gap between the theoretical potential of inquiry learning and its actual implementation in fostering SRL.

An underexplored dimension within this design challenge is the role of character values. Science laboratory learning inherently involves responsibility, perseverance, discipline, honesty in data reporting, and curiosity, traits that are foundational for both scientific integrity and professional teaching identity (Rantika, 2023). However, these values often emerge implicitly and are rarely integrated systematically as explicit learning objectives. Research on inquiry-based learning predominantly emphasizes cognitive and process-skill outcomes (Chang, 2023), while SRL research has largely focused on digital or online learning contexts rather than embodied laboratory environments (Ng, 2024). Consequently, a conceptual and empirical gap persists regarding how the explicit integration of character values within inquiry-based laboratory learning may strengthen the motivational and metacognitive components of SRL (Kubsch, 2025).

Addressing this gap is particularly relevant in elementary teacher education, where character formation and pedagogical modeling are inseparable. If inquiry-based laboratory learning is intentionally designed to embed character dimensions such as responsibility, independence, and reflective accountability, it may provide a more holistic mechanism for cultivating SRL among pre-service teachers (Agustini et al., 2024). Rather than treating cognitive regulation and character education as separate domains, integrating them within the inquiry process may generate synergistic effects that reinforce both (Afrizon & Dwiridal, 2017).

Based on this rationale, the present study investigates the contribution of systematically integrating character values into inquiry-based laboratory learning toward enhancing self-regulated learning among second-semester pre-service elementary teachers enrolled in the Basic Concepts of Elementary Physics course (Prawijaya et al., 2022). The novelty of this study lies in its instructional design framework, which explicitly embeds character dimensions into each phase of the inquiry laboratory process and empirically examines their influence on students' planning, monitoring, strategic control, and reflective evaluation. By conceptualizing cognitive regulation, motivational engagement, and character formation as an integrated system, this study aims to advance theoretical discourse and provide empirical evidence for more holistic laboratory learning models in teacher education.

The significance of this study lies in its potential to contribute to both theory and practice. Theoretically, it extends existing SRL frameworks by incorporating character-based dimensions into self-regulation processes. Practically, it offers an instructional model for designing inquiry-based laboratory learning that integrates cognitive, motivational, and ethical aspects, thereby supporting the development of more autonomous, reflective, and professionally competent future teachers.

METHODOLOGY

This study employed a descriptive quantitative research method with a post-test-only design to examine students' Self-Regulated Learning (SRL) following the implementation of inquiry-based laboratory learning integrated with character values. The primary objective of this research was to describe the profile and level of SRL demonstrated by students after participating in the learning intervention. The research procedure consisted of four stages: (1) preparation of learning design and research instruments, (2) implementation of inquiry-based laboratory learning integrated with character values, (3) post-intervention data collection, and (4) descriptive statistical data analysis.

The research subjects were second-semester students in the Primary School Teacher Education Study Program (PGSD) enrolled in the course Basic Concepts of Elementary Physics. The research population consisted of 13 classes taking the course. Two classes were selected using purposive sampling based on similarities in academic characteristics and class schedules to ensure comparable learning conditions. The total number of respondents in this study was 68 students, including 53 females and 15 males. All students in the selected classes participated as research samples. The participants were in their second semester (approximately 18–20 years old) and had relatively similar academic backgrounds, as they were enrolled in the same study program and course. The research object was students' Self-Regulated Learning after the implementation of inquiry-based laboratory learning integrated with character values.

The intervention consisted of inquiry-based laboratory learning integrated with five character values: responsibility, independence, curiosity, honesty, and cooperation. These values were systematically embedded throughout the inquiry process, including problem formulation, experimental design, data collection, data analysis, and reflection. The learning activities were conducted over several meetings in accordance with the Semester Learning Plan (RPS). The main data for the study were students' Self-Regulated Learning scores collected via a questionnaire. Classroom observations were conducted only to support the understanding of the learning process and were not used as research data.

Data were collected using a Self-Regulated Learning questionnaire based on a Likert scale. The questionnaire was developed based on four core SRL indicators: planning, self-monitoring, self-control, and reflection. The instrument was constructed based on established SRL theoretical frameworks and evaluated by field experts to ensure validity. Furthermore, data analysis employed descriptive statistical techniques, including mean score calculation, percentage distribution, and categorization of SRL levels into high, medium, and low. This analytical approach aimed to provide a comprehensive description of students' Self-Regulated Learning profile following the implementation of inquiry-based laboratory learning integrated with character values.

RESULT AND DISCUSSION

This study aims to describe the levels of character, Self-Regulated Learning (SRL), and learning independence in students' learning processes within inquiry-based laboratory activities. Data were collected using a closed-ended questionnaire developed based on key indicators reflecting students' readiness for independent learning, responsibility, and intrinsic motivation. The instrument consisted of 26 items grouped into eight indicators: goal setting, planning, self-monitoring, learning strategies, self-evaluation, intrinsic motivation, self-efficacy, and independence and responsibility.

The respondents in this study were 68 second-semester students enrolled in the Basic Concepts of Elementary Physics course, comprising 53 females and 15 males. All participants were actively involved in laboratory-based inquiry activities. They were asked to respond to each statement using a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree." The collected data were analyzed using descriptive quantitative techniques to identify patterns and tendencies in students' self-regulated learning and character development. The results show that the majority of students demonstrated a high level of readiness for independent learning across all indicators. It is reflected in the dominance of "Agree" and "Strongly Agree" responses. Students showed strong responsibility in completing tasks, actively engaged in reflective evaluation, and demonstrated high intrinsic motivation during the learning process.

These findings indicate that students have developed a solid foundation in Self-Regulated Learning, particularly in planning, monitoring, and self-reflection. It suggests that integrating character values into inquiry-based laboratory learning contributes not only to cognitive development but also to the strengthening of motivational and behavioral aspects of learning. Such conditions are essential in preparing students to become autonomous and responsible learners in the context of 21st-century education.

Aspect of Learning Goal Setting

Determining learning objectives is the process of consciously formulating specific, measurable learning targets that students want to achieve within a specified time period, as part of a strategy for organizing and directing the learning process independently (Schunk, 2023). Based on the questionnaire results, the majority of students responded "Agree" to "Strongly Agree" to statements regarding learning goal setting. This indicates that students have a good initial awareness of how to plan their learning direction, both theoretically and practically, before the laboratory activities begin. The results for the learning goal setting aspect can be seen in Figure 1.

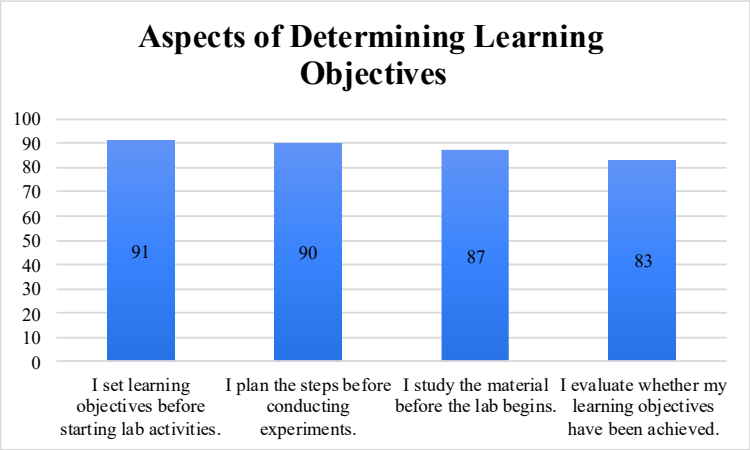

Figure 1. Graph of Learning Goal Setting Aspects

The Figure 1 shows that the results for the learning goal-setting aspect are in the high category. It indicates that students are already able to set effective learning goals. Setting learning goals is the initial step in self-regulated learning (SRL). The SRL process begins with an individual's ability to set learning goals, determine strategies, and independently evaluate their results. Students who set clear learning goals will find it easier to maintain focus, map out activity steps, and increase study time efficiency (Triquet et al., 2017).

The results of the study indicate that the application of the Inquiry Lab learning model significantly strengthens the learning goal-setting aspect within the framework of students' Self-Regulated Learning (SRL). In the inquiry labs, students are encouraged to actively formulate questions, design experiments, and determine the steps of the investigation (Chaerunisa et al., 2023). This process indirectly trains their ability to set specific, relevant, and measurable learning goals, in accordance with the main characteristics of SRL goal-setting. Students are no longer passively awaiting the lecturer's directions but are consciously determining what they want to achieve, both in terms of conceptual understanding and science process skills (Callan et al., 2021).

The main indicators of self-directed learning readiness include the ability to set learning goals, identify personal learning needs, and systematically plan learning activities (Tarmilia et al., 2021). Therefore, the results of this study indicate that students have quite good SDL readiness. Their meta-analysis found that setting learning goals significantly influences cognitive engagement and academic outcomes (Chen, 2022).

Furthermore, in the context of 21st-century learning, the ability to set learning goals is associated with lifelong learning competencies (Cleary et al., 2023). This reinforces the fact that this habit is not only relevant in the classroom but also crucial for long-term professional development. In this study, students not only demonstrated that they set learning goals but also planned steps and prepared materials before the lesson began. Students with strong goal-setting abilities tend to have better self-regulation and higher academic achievement (Zeidner & Stoeger, 2019).

Aspect of Learning Planning

The learning planning aspect is crucial for students to ensure their learning process proceeds effectively. The analysis results of the learning planning aspect can be seen in Figure 2.

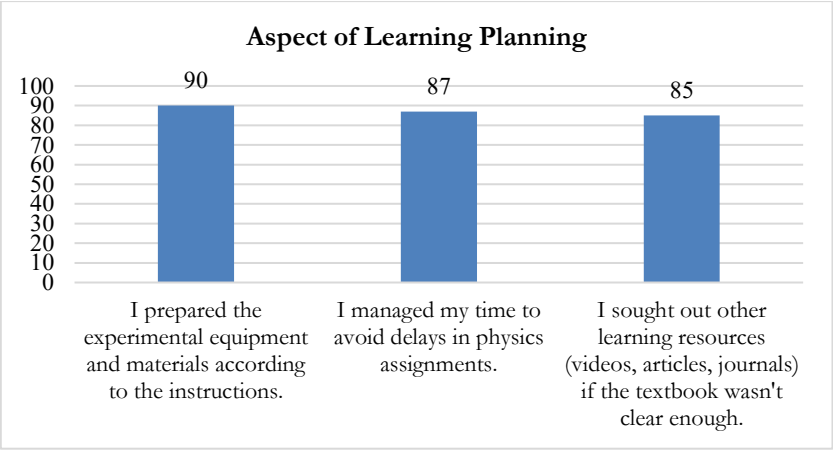

Figure 2. Results of the Learning Planning Aspect

The diagram above indicates that students have developed good habits in planning learning steps before starting activities. They not only prepared experimental tools and materials according to instructions, but also demonstrated time awareness in avoiding procrastination and the ability to seek alternative learning resources when textbooks are insufficient**.** In this approach, students are directly involved in designing experimental steps, formulating scientific questions, determining activity objectives, and selecting necessary tools and materials (Ramdani et al., 2022). This process requires students to thoroughly plan before beginning laboratory activities. Inquiry Lab also provides space for students to think ahead, map out the steps of scientific work, and manage their time and resources independently (Ananda & Usmeldi, 2023). It suggests that, through the Inquiry Lab, students not only gain experimental experience but are also trained to develop structured, relevant learning plans that address the cognitive and procedural objectives they seek to achieve. Students who are trained in planning learning steps will be better prepared to face learning challenges, especially in environments that require independent learning, such as laboratories or project-based learning (Rasifah, 2025).

Aspect of Self-Monitoring

The aspect of self-monitoring in the context of self-regulated learning (SRL) refers to students' ability to actively observe, evaluate, and control their own learning process on an ongoing basis. The results of the self-monitoring questionnaire are shown in Figure 3.

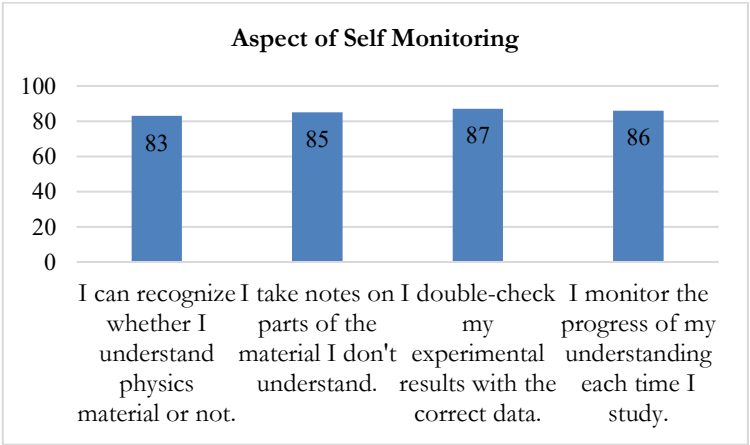

Figure 3. Results of Self Monitoring Aspect

The Figure shows that students' self-monitoring is in the high category. It indicates that students are accustomed to checking their understanding of the material, noting areas they have not mastered, and reflecting on their learning progress. Furthermore, students also demonstrate a habit of critically reviewing laboratory experiment results, ensuring that the data obtained is valid and appropriate. Inquiry Lab-based learning has been shown to have a strong relationship with the development of self-monitoring in students' Self-Regulated Learning (SRL). These activities require students to continuously evaluate conceptual understanding, adjust work steps, and correct procedural errors that occur during the experiment (Afriana, 2023). It reflects the practice of self-monitoring, where students are aware of their own thinking processes and performance in achieving learning outcomes. The Inquiry Lab creates a learning context that stimulates students to focus not only on the outcome but also on the learning process itself, which is the core of self-regulation skills (Algiani et al., 2023). The presence of this self-monitoring indicates that students are not only carrying out experimental procedures but also consciously controlling and directing their learning activities on an ongoing basis.

Self-monitoring is a key component of Self-Regulated Learning (SRL) and Self-Directed Learning (SDL), referring to learners' ability to observe and evaluate their learning progress, including understanding, strategy use, and time management. This ability is closely linked to metacognition, particularly awareness and control of one's cognitive processes. In inquiry-based laboratory learning, self-monitoring becomes essential as students must track experimental progress and adjust strategies independently. In higher education, monitoring skills are crucial because learning tends to be independent and complex. Self-monitoring is a strong predictor of academic success in online and blended learning. Students with high self-monitoring skills tend to have stronger intrinsic motivation and to complete assignments independently and more consistently. Thus, the results of this study demonstrate that students are not merely passive learners but are actively involved in observing and evaluating their own progress. This self-monitoring ability is an important foundation in developing independent learners who are reflective, responsible, and ready to face learning challenges at a more complex level.

Aspect of Learning Strategy

Learning strategies are a series of deliberate and planned actions or approaches by an individual to facilitate the effective acquisition, storage, and application of information. Learning strategies encompass cognitive and metacognitive techniques that students use to understand and remember material, as well as to regulate and control their learning process (Oxford, 2016). The results of the learning strategy aspect can be seen in Figure 4.

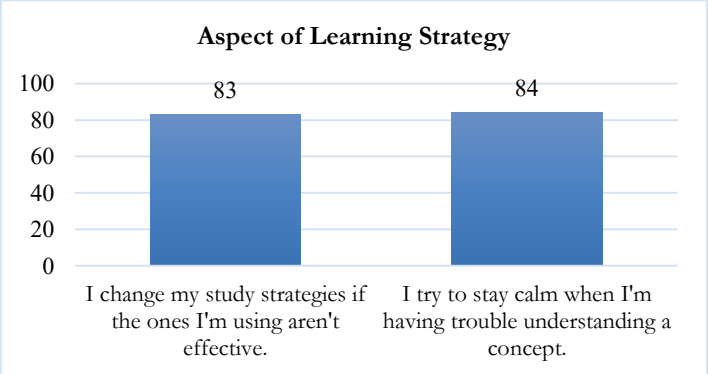

Figure 4. Results of the Learning Strategy Aspect

This finding indicates that students have flexibility in choosing learning approaches and the ability to manage emotions when facing academic obstacles. The Inquiry Lab learning model significantly contributes to the development of students' Self-Regulated Learning (SRL) strategies. In inquiry-based learning, students are faced with various scientific challenges that require them to actively select and apply appropriate learning strategies to understand theoretical concepts, design experiments, analyze data, and draw conclusions (Adauyah & Aznam, 2024). Students do not simply rely on memorization but are required to use cognitive strategies such as making predictions, comparing experimental results with theory, and constructing arguments based on data. All of this demonstrates that Inquiry Lab is a learning environment that stimulates students to develop and apply a variety of learning strategies flexibly and contextually (Alfakihuddin et al., 2022). It aligns with SRL's goal of creating learners who can independently select, manage, and evaluate their learning strategies in response to the demands of the learning situation.

Students who can adapt their learning strategies when faced with difficulties have a higher level of learning independence and are more successful in online, flexible learning environments (Broadbent & Poon, 2015). Furthermore, the ability to use learning strategies is also closely related to emotional regulation, especially when students feel frustrated or do not understand the material. The ability to remain calm and avoid panic is a non-cognitive strategy that supports the learning process. In active learning contexts such as laboratories or projects, mastery of these cognitive and affective learning strategies is crucial for academic success.

Aspect of Self Evaluation

Self-evaluation focuses not only on final results (such as test scores) but also on the learning process, the strategies used, and attitudes during learning. Self-evaluation is the critical ability to assess one's own assumptions, attitudes, and learning habits. It serves as the basis for reflective learning and is crucial for the development of higher-order thinking skills. The results of this self-evaluation aspect can be seen in Figure 5.

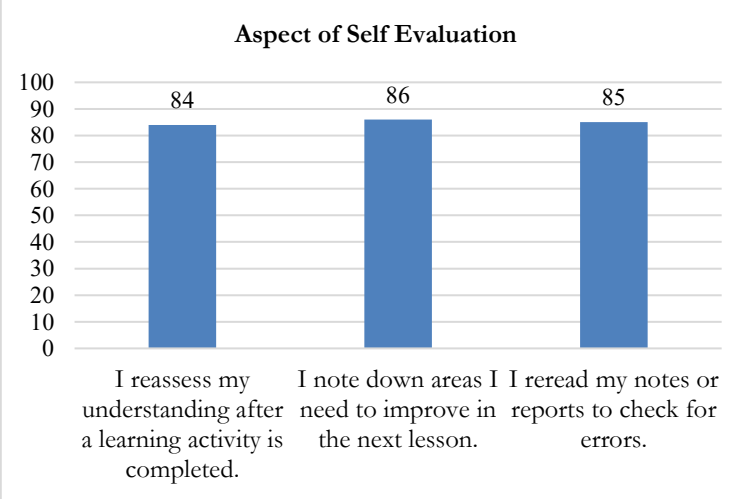

Figure 5. Self-Evaluation Results

The questionnaire results indicate that students actively assess their learning achievements, recognize their weaknesses, and strive to correct mistakes from previous learning. This self-evaluation is conducted both after completing assignments and after participating in practical exercises or other learning activities. Inquiry Lab-based learning is closely linked to strengthening

self-evaluation within the Self-Regulated Learning (SRL) framework. In the inquiry process, students are not only required to carry out experimental procedures systematically but also to reflect on the effectiveness of each step taken (Yan, 2020). This process trains them to conduct in-depth self-evaluation of their performance and learning outcomes, which is the core of the self-reflection phase in SRL. Through this activity, students also learn to identify weaknesses, correct conceptual errors, and plan more effective strategies for subsequent learning (Algiani et al., 2023).

Self-evaluation is a crucial stage in self-regulated learning (SRL) frameworks. Self-evaluation is the ability to reflect on the learning process and outcomes, including identifying strengths, weaknesses, and areas for improvement (Callan et al., 2021). Students who conduct self-evaluation are better able to adjust their learning strategies to achieve their goals more effectively in the future. Self-evaluation is part of the internal control within the SRL process, supporting independent learning. These findings indicate that students not only engaged in procedural learning but also demonstrated the ability to reflect critically on their learning processes and outcomes**.**

Intrinsic Motivation

Intrinsically motivated people learn because they enjoy the learning process (Dan et al., 2025). Intrinsic motivation is the purest form of motivation because it drives someone to act based on curiosity, enjoyment, and personal satisfaction with an activity. The results on the intrinsic motivation aspect can be seen in Figure 6.

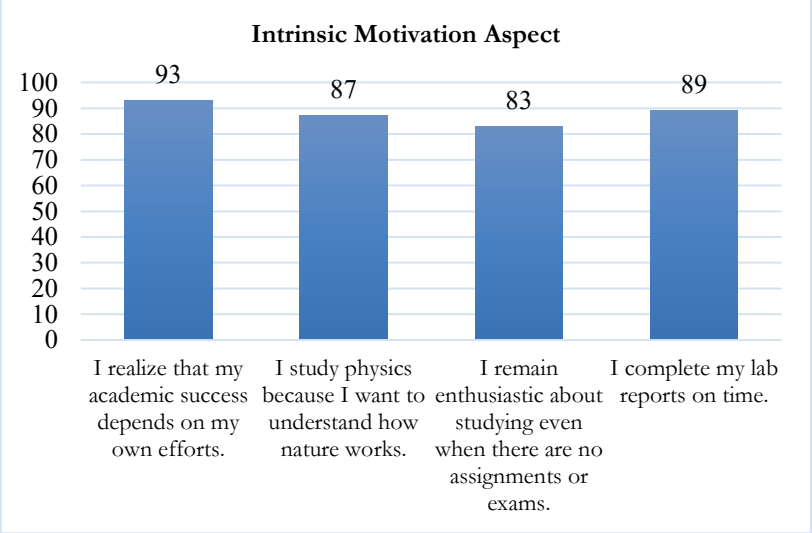

Figure 6. Results of Intrinsic Motivation Aspect

The implementation of the Inquiry Lab learning model has been shown to significantly increase students' intrinsic motivation in the context of Self-Regulated Learning (SRL). Inquiry Lab positions students as active subjects in the knowledge-seeking process, encouraging them to ask questions, design experiments, explore concepts, and draw conclusions independently (Lister, 2015). Inquiry Lab not only equips students with science process skills but also serves as an effective vehicle for cultivating and maintaining intrinsic motivation as a foundation for self-regulation in learning (Teng, 2024).

Intrinsic motivation is an internal drive that leads individuals to engage in an activity because it is enjoyable, challenging, or meaningful. Intrinsic motivation arises when a person feels autonomy (freedom of choice), competence (ability to perform well), and connectedness (meaningful to themselves). In the context of self-directed learning, intrinsic motivation is crucial because it serves as the primary driving force that drives students to learn actively without external direction or pressure (Luo et al., 2021). Intrinsic motivation enhances self-regulation and significantly impacts learning outcomes. Students who are intrinsically motivated are more open to challenges, experience higher learning satisfaction, and are more independent in taking responsibility for their learning process (Xu et al., 2023). Thus, it can be concluded that intrinsic motivation is a key force in supporting the success of student self-directed learning. In higher education, which emphasizes self-directed and lifelong learning, strengthening intrinsic motivation is a crucial component of effective learning design.

Aspect of Self Efficacy

Self-efficacy in SRL refers to students' positive perceptions of their capacity to successfully carry out learning activities independently, including planning, monitoring, strategizing, and self-evaluation to achieve learning goals. The results of the self-efficacy aspect can be seen in Figure 7.

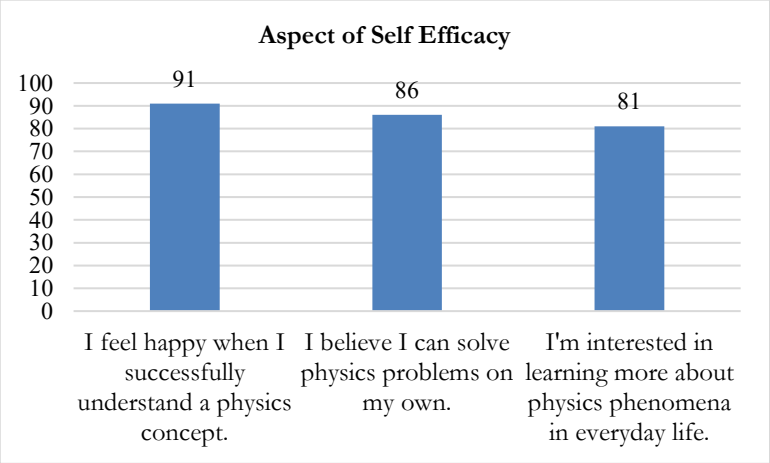

Figure 7. Aspects of Self Efficacy

The integration of character values into inquiry-based lab learning plays a crucial role in building students' self-confidence in managing their independent learning (Harahap, 2017). Character values such as responsibility, independence, courage, perseverance, and curiosity form the psychological foundation that strengthens students' self-confidence as they face the challenges of inquiry-based learning. Inquiry-based lab learning requires students to explore, think critically, and solve problems independently and actively. In this situation, character values serve as guides for students' attitudes and actions, helping them avoid giving up easily when they encounter difficulties in the practicum.

Furthermore, character values such as perseverance and hard work also help students develop a reflective attitude toward failure. In inquiry labs, failed experiments or disproven hypotheses are commonplace (Anggraeni & Khuzaeni, 2025). This relationship is also evident in how integrating character into learning encourages students to more actively set their own learning goals and strategies (Al-Duhani et al., 2024). The values of independence and curiosity, for example,

encourage students to design their own experiments, seek additional references, and set challenging achievement targets. This process reflects high levels of SRL activity, and it begins with the confidence that they can carry out the task. Thus, character values not only shape attitudes but also increase confidence in their ability to manage their learning process independently. Overall, it can be concluded that integrating character values into inquiry lab learning significantly increases self-confidence in SRL (Cho et al., 2017). Character, systematically developed through active and reflective learning, strengthens students' positive perceptions of their own abilities.

Aspects of Independence and Responsibility

Learning independence is a person's ability to manage their learning process consciously, actively, and responsibly without relying on others. It includes the ability to plan, implement, monitor, and evaluate learning activities independently. The results for the aspects of independence and responsibility can be seen in Figure 8.

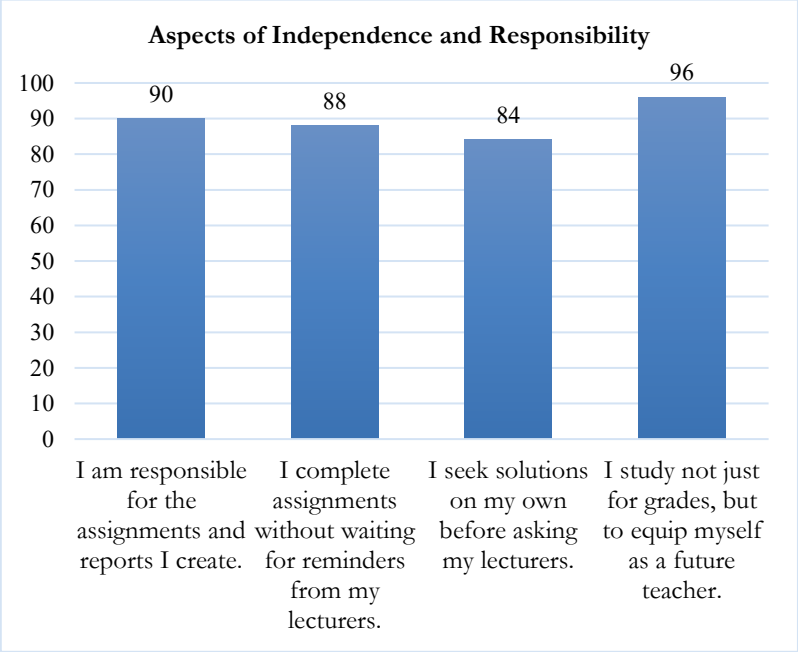

Figure 8. Aspects of Independence and Responsibility

Students have also proven capable of managing their own time, completing assignments on time, and avoiding procrastination in academic work (Astuti & Rozikin, 2024). This is a concrete illustration of strong learning independence and an internally developed sense of responsibility. The integration of character values into inquiry labs is closely linked to strengthening the independence and responsibility aspects of Self-Regulated Learning (SRL). Inquiry labs naturally encourage students to be active participants in their learning process, designing experiments, testing hypotheses, analyzing data, and drawing their own conclusions. Character values such as independence and self-confidence are crucial in this process (Safitri & Budhi, 2017). As students become accustomed to approaching laboratory challenges with a problem-solving approach, they will increasingly develop as independent learners.

Meanwhile, the responsibility aspect of SRL is evident in students' willingness to complete assignments on time, adhere to scientific procedures, maintain academic integrity (such as not manipulating data), and take responsibility for their own learning outcomes (Yunus et al., 2022). In inquiry labs, instilling the value of responsibility is highly relevant, as experiments cannot succeed

without students' active involvement and commitment. The integration of character values in this context also strengthens students' emotional regulation. These abilities directly contribute to maturity in SRL, as SRL encompasses not only cognitive strategies but also emotional control, reflective attitudes, and motivation management, all of which are influenced by the character values instilled in the learning process (Sari & Setiawaty, 2018). Thus, integrating character into inquiry labs not only adds "moral content" but also concretely strengthens two important aspects of SRL: independence and responsibility. Students who are accustomed to values-based learning and reflective practice will grow into responsible, independent learners, ready to face academic and life challenges more maturely.

Learning independence is defined as an individual's ability to take initiative, organize, and direct their own learning process, including planning, implementing, and evaluating learning. Independent learners are those who can diagnose their own needs, formulate goals, identify resources, and evaluate their own results. Meanwhile, taking responsibility means an individual consistently carries out their academic obligations without relying on external pressure or supervision. In higher education, independence and responsibility are crucial competencies, particularly in self-regulated learning (SRL) systems that require students to be active, creative, and goal-oriented learners. These findings are consistent with 21st-century learning objectives, which emphasize the development of essential soft skills, such as independence, self-leadership, and decision-making. The results indicate a shift in students' roles from passive recipients of information to active, self-directed learners who take responsibility for their academic development.

Integration of Character Values in Inquiry-Based Laboratory Learning as a Mechanism to Strengthen Self-Regulated Learning

The results of this study indicate that the enhancement of pre-service elementary teachers' Self-Regulated Learning (SRL) is not solely influenced by the structure of Inquiry-Based Laboratory Learning, but is also significantly reinforced by the explicit integration of character values at every stage of the laboratory learning process. Traditionally, SRL has been understood as a set of cognitive and metacognitive skills involving planning, monitoring, and evaluating learning (Arellano, 2024). However, this study's findings highlight that the affective and moral dimensions internalized through character education are essential foundations that support the success of self-regulation processes. The integration of character values in the laboratory functions not merely as a normative addition but as a mechanism that strengthens students' motivation, behavior, and reflective awareness.

Inquiry Stages and Character Value Integration

At the initial stage, students are required not only to formulate hypotheses and design experiments but also to take full responsibility for procedural clarity, equipment safety, and the distribution of roles within groups. The dominant character values at this stage are responsibility and independence (Arafah, 2024). Responsibility encourages students to plan activities carefully before acting, reinforcing the *planning* component of SRL (Verk, 2021). Meanwhile, independence is reflected in students' ability to make decisions without complete reliance on instructor guidance, fostering self-confidence and decision-making skills in the context of laboratory learning.

The second stage emphasizes character values such as discipline, perseverance, and scientific honesty. Discipline manifests through adherence to laboratory procedures and time management, while perseverance emerges when students encounter measurement errors or results that do not align with their hypotheses (Bleazby, 2020). Scientific honesty is central to recording and reporting data, ensuring that students do not manipulate results to fit theoretical expectations. These values strengthen SRL's monitoring and control aspects as students learn to oversee their work ethically and consistently.

At the analysis stage, character integration emphasizes reflectiveness, openness to feedback, and curiosity as key learning dispositions. Students are encouraged to evaluate procedural errors, compare results with theoretical expectations, and identify factors influencing the experiment. This reflective process extends beyond cognitive evaluation to include moral awareness, particularly regarding accuracy, responsibility, and accountability in scientific practice. Accordingly, this stage strengthens the evaluation component of Self-Regulated Learning (SRL) while simultaneously fostering academic integrity and professional ethics. Beyond technical laboratory activities, character integration also occurs through class discussions and individual reflection sheets, where students document their learning experiences, strategies employed, and character values practiced.

The findings indicate that character values act as psychological drivers in strengthening SRL, operating at three interrelated levels: (1) Behavioral Level: observable actions such as completing tasks on time, adhering to procedures with discipline, and maintaining academic integrity; (2) Motivational Level: intrinsic drive to learn due to a sense of responsibility and meaningful goals; (3) Metacognitive Level: increased reflective awareness in evaluating learning processes and outcomes honestly and objectively.

For instance, the value of responsibility strengthens students' commitment to achieving learning goals, supporting planning and monitoring phases of SRL. Honesty enhances the quality of reflection because evaluation is based on actual performance rather than mere academic formalities (Al-Duhani et al., 2024). Perseverance helps students manage emotions when facing experimental failures or conceptual difficulties, supporting emotional regulation, while curiosity reinforces intrinsic motivation, which sustains continuous engagement in learning. Without integrity and responsibility, self-regulation risks becoming a procedural activity devoid of reflective depth (Xu et al., 2023). Character provides an ethical structure that reinforces authentic SRL practice.

Implications for Pre-Service Elementary Teacher Education

In the context of pre-service elementary teacher education, integrating character values has strategic implications. Students in elementary teacher education programs not only learn physics concepts concretely through experiments but also experience firsthand how character values shape responsible, reflective, and independent learning processes (Astuti & Rozikin, 2024). This experience has the potential to be transferred to future teaching practice, ensuring that science learning in elementary schools is not only cognitively oriented but also focused on developing students' character and autonomous learning skills.

Conceptually, these findings support the view that SRL development in teacher education requires a holistic approach that simultaneously integrates cognitive, motivational, and character dimensions (Aningsih, 2022). Inquiry-Based Laboratory Learning, designed with integrated

character values, functions as a learning ecosystem that stimulates scientific exploration while simultaneously shaping pre-service teachers' professional identity as responsible, reflective, and ethical individuals (Dan et al., 2025). This finding provides empirical evidence that integrating character values within inquiry-based laboratory activities does not merely accompany the learning process but actively contributes to enhancing students' cognitive, metacognitive, and motivational regulation. Such an integrated learning environment supports the simultaneous development of cognitive regulation, emotional resilience, and moral responsibility, which are reflected in students' ability to plan, monitor, evaluate, and take responsibility for their learning processes. Hence, it can be concluded that it has important implications for teacher education, suggesting that laboratory learning design should intentionally incorporate character values to promote not only academic competence but also the development of professional character and autonomous learning skills.

CONCLUSION

This study demonstrates that integrating character values into inquiry-based laboratory learning in the Basic Concepts of Elementary Physics course effectively enhances pre-service elementary teachers' Self-Regulated Learning (SRL), as evidenced by consistently high levels across all measured indicators, including goal setting, planning, self-monitoring, learning strategies, self-evaluation, intrinsic motivation, independence, and responsibility. Inquiry-based laboratory activities enable students to actively engage in concept discovery, experimentation, and reflective analysis, thereby encouraging them to set learning goals, plan strategies, monitor progress, and evaluate outcomes. These processes directly address the initial research problem related to students' limited autonomy and dependence on instructor guidance by fostering more independent and self-directed learning behaviors. The integration of character values such as responsibility, independence, discipline, perseverance, honesty, collaboration, curiosity, and reflective thinking further strengthens SRL across cognitive, motivational, and behavioral dimensions, indicating that SRL development is supported not only cognitively but also through ethical and affective dimensions. At the behavioral level, students demonstrate responsibility and adherence to procedures; at the motivational level, they show increased intrinsic motivation and sustained engagement; and at the metacognitive level, they exhibit improved reflective awareness and self-evaluation. Empirically, improvements across all SRL indicators suggest that students not only develop strategic learning skills but also build a strong foundation for independent and responsible learning, particularly in laboratory-based inquiry contexts. In the context of pre-service elementary teacher education, this approach contributes not only to academic competence but also to the development of professional identity, ethical responsibility, and reflective teaching practices. Thus, this study offers a meaningful contribution by proposing a holistic learning model that integrates cognitive, motivational, and moral dimensions within SRL development. However, these findings should be interpreted within the limitations of the study, including the use of a descriptive design, a single-institution sample, and reliance on self-reported data, which may affect generalizability; therefore, future research is recommended to employ experimental or longitudinal approaches and involve broader samples to validate further and extend these findings.

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REFERENCES

Adauyah, R., & Aznam, N. (2024). Guided Inquiry Learning Model in Chemistry Education: A Systematic Review. *Jurnal Penelitian Pendidikan IPA*, (Query date: 2025-08-04 03:50:33). https://jppipa.unram.ac.id/index.php/jppipa/article/view/6373

Afriana, L. (2023). Improving Learning Outcomes of Chemistry Subjects through the Application of the Guided Inquiry Learning Model. *Journal of Social Work and Science* , (Query date: 2024-08-20 20:24:48). http://ejournal.sembilanpemuda.id/index.php/jswse/article/view/478

Afrizon, R., & Dwiridal, L. (2017). Upaya Menumbuhkan Karakter Peduli Lingkungan Melalui Kajian Konsep Fisika Pada Arsitektur Kearifan Lokal Budaya Sumatera Barat. *Jurnal Eksakta Pendidikan (JEP)*, (Query date: 2024-07-31 02:02:50). https://www.academia.edu/download/75089740/32.pdf

Agustini, A., Rahmawati, S., Annisha, D., & ... (2024). Inquiry-Based Learning dalam Kurikulum Merdeka. *Penerbit Mifandi* …, (Query date: 2025-08-03 03:41:15). http://jurnal.mifandimandiri.com/index.php/penerbitmmd/article/view/112

Al-Duhani, F., Saat, R., & Abdullah, M. (2024). Effectiveness of web-based virtual laboratory on grade eight students' self-regulated learning. *Eurasia Journal of Mathematics* …, (Query date: 2025-08-04 03:50:33). https://www.ejmste.com/article/effectiveness-of-web-based-virtual-laboratory-on-grade-eight-students-self-regulated-learning-14282

Alfakihuddin, M., Surahman, E., & ... (2022). The Application of Inquiry Intelligent Tutoring System in Biology Practicum. *Journal of Education* …, (Query date: 2025-08-04 03:50:33). https://ejournal.undiksha.ac.id/index.php/JET/article/view/48466

Algiani, S., Artayasa, I., Sukarso, A., & ... (2023). Application of guided inquiry model using self-regulated learning approach to improve student's creative disposition and creative thinking skill in biology subject. *Jurnal Penelitian* …, (Query date: 2025-08-04 03:50:33). https://jppipa.unram.ac.id/index.php/jppipa/article/view/2836

Ananda, P., & Usmeldi, U. (2023). Validity and practicality of e-module model inquiry based online learning to improve student competence. *Jurnal Penelitian Pendidikan IPA*, (Query date: 2024-08-20 20:24:48). https://jppipa.unram.ac.id/index.php/jppipa/article/view/3563

Anggraeni, M., & Khuzaeni, N. (2025). Pengaruh Model Pembelajaran Inquiry untuk Meningkatkan Self-Efficacy Siswa. *Indonesian Research Journal on Education*, (Query date: 2025-08-05 11:19:34). http://www.irje.org/irje/article/view/1960

Aningsih. (2022). How is the Education Character Implemented? The Case Study in Indonesian Elementary School. *Journal of Educational and Social Research*, *12*(1), 371–380. https://doi.org/10.36941/jesr-2022-0029

Arafah, B. (2024). Character Education Values in Pullman's The Golden Compass. *Journal of Language Teaching and Research*, *15*(1), 246–254. https://doi.org/10.17507/jltr.1501.27

Arellano, M. A. R. (2024). Self-regulated learning. Subjective, behavioral and context factors. Conceptual mapping, part III. *Interdisciplinaria*, *41*(1). https://doi.org/10.16888/interd.2024.41.1.6

Astuti, A., & Rozikin, A. (2024). The Role of Self-Regulated Learning in Strengthening Students' Independent Learning Character: Literature Review. *English Language in Focus (ELIF)*, (Query date: 2025-08-05 11:31:59). https://jurnal.umj.ac.id/index.php/ELIF/article/view/24031/0

Bleazby, J. (2020). Fostering moral understanding, moral inquiry & moral habits through philosophy in schools: A Deweyian analysis of Australia's Ethical Understanding curriculum. *Journal of Curriculum Studies*, *52*(1), 84–100. https://doi.org/10.1080/00220272.2019.1650116

Broadbent, J., & Poon, W. (2015). Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. *The Internet and Higher Education*, (Query date: 2025-08-04 04:23:39). https://www.sciencedirect.com/science/article/pii/S1096751615000251

Callan, G., Rubenstein, L., Ridgley, L., & ... (2021). Measuring self-regulated learning during creative problem-solving with SRL microanalysis. … *, Creativity, and the* …, (Query date: 2025-08-04 03:35:11). https://psycnet.apa.org/fulltext/2019-12070-001.html

Chaerunisa, Z., Ramli, M., & ... (2023). Students' inquiry skills progression based on STEM approach and inquiry lab. *JPBI (Jurnal Pendidikan* …, (Query date: 2024-08-20 20:24:48). https://ejournal.umm.ac.id/index.php/jpbi/article/view/25698

Chang, D. H. (2023). Educational Design Principles of Using AI Chatbot That Supports Self-Regulated Learning in Education: Goal Setting, Feedback, and Personalization. *Sustainability Switzerland*, *15*(17). https://doi.org/10.3390/su151712921

Chen, J. (2022). The effectiveness of self-regulated learning (SRL) interventions on L2 learning achievement, strategy employment and self-efficacy: A meta-analytic study. *Frontiers in Psychology*, (Query date: 2025-08-04 02:54:21). https://doi.org/10.3389/fpsyg.2022.1021101

Cho, M., Kim, Y., & Choi, D. (2017). The effect of self-regulated learning on college students' perceptions of community of inquiry and affective outcomes in online learning. *The Internet and Higher Education*, (Query date: 2025-08-04 04:56:43). https://www.sciencedirect.com/science/article/pii/S1096751617301677

Cleary, T., Slemp, J., Reddy, L., Alperin, A., & ... (2023). Characteristics and uses of SRL microanalysis across diverse contexts, tasks, and populations: A systematic review. *School*

Psychology …, (Query date: 2025-08-04 02:54:21). https://doi.org/10.1080/2372966X.2020.1862627

Dan, Q., Yin, H., & Bai, B. (2025). Three paradigms of inquiry into self-regulated learning (SRL): A critical analysis and ways to transformative and integrated practices. *Asia Pacific Education Review*, (Query date: 2025-08-04 04:56:43). https://doi.org/10.1007/s12564-025-10035-4

Harahap, R. (2017). *Hubungan Kepercayaan Diri dan Dukungan Orangtua dengan Self-Regulated Learning (SRL) di Madrasah Aliyah Swasta Pab 1 Sampali*. repositori.uma.ac.id. https://repositori.uma.ac.id/jspui/handle/123456789/8587

Hsu, Y. T. (2026). Support for self-regulated learning in immersive virtual reality – An experimental design for science learning. *Education and Information Technologies*, *31*(1), 269–300. https://doi.org/10.1007/s10639-025-13807-y

Jong, T. de. (2021). Understanding teacher design practices for digital inquiry–based science learning: The case of Go-Lab. *Educational Technology Research and Development*, *69*(2), 417–444. https://doi.org/10.1007/s11423-020-09904-z

Kubsch, M. (2025). Self-regulated Learning in the Digitally Enhanced Science Classroom: Toward an Early Warning System. *Educational Psychology Review*, *37*(2). https://doi.org/10.1007/s10648-025-10011-9

Lister, C. (2015). *A framework for implementing inquiry-based learning in the elementary classroom*. (Query date: 2025-08-04 03:50:33). https://dspace.library.uvic.ca/bitstream/1828/6950/1/Lister_Christopher_MEd_2015.pdf

Luo, Y., Lin, J., & Yang, Y. (2021). Students' motivation and continued intention with online self-regulated learning: A self-determination theory perspective. *Zeitschrift Für Erziehungswissenschaft*, (Query date: 2025-08-05 10:03:48). https://doi.org/10.1007/s11618-021-01042-3

Newman, R. S. (2023). Adaptive Help Seeking: A Strategy of Self-Regulated Learning. *Self Regulation of Learning and Performance Issues and Educational Applications*, (Query date: 2026-02-28 14:59:58), 283–302. https://doi.org/10.4324/9780203763353-12

Ng, D. T. K. (2024). Empowering student self-regulated learning and science education through ChatGPT: A pioneering pilot study. *British Journal of Educational Technology*, *55*(4), 1328–1353. https://doi.org/10.1111/bjet.13454

Oxford, R. (2016). *Teaching and researching language learning strategies: Self-regulation in context*. taylorfrancis.com. https://doi.org/10.4324/9781315719146

Prawijaya, S., Rozi, F., & Siregar, A. (2022). Optimalisasi Pembelajaran Berbasis Sipda Dengan Menggunakan E-Modul Interaktif Berbasis Canva Pada Mata Kuliah Konsep Dasar Fisika Prodi Pgsd Fip …. *Jurnal Sekolah*, (Query date: 2024-07-31 02:02:50). https://www.academia.edu/download/89280102/18406.pdf

Ramdani, A., Artayasa, I., Sulawanti, E., & ... (2022). Analysis of students' self-regulated learning in terms of gender using blended learning-based laboratory inquiry teaching materials. *AIP*

Conference …, (Query date: 2025-08-04 03:50:33). https://pubs.aip.org/aip/acp/article-abstract/2600/1/070008/2830626

Rantika, K. (2023). *PENGARUH MODEL PEMBELAJARAN DISCOVERY LEARNING TERHADAP HASIL BELAJAR FISIKA DITINJAU DARI SELF-REGULATED LEARNING*. repository.radenintan.ac.id. https://repository.radenintan.ac.id/id/eprint/29088

RASIFAH, R. (2025). *INVESTIGATING SELF DIRECTED LEARNING OF STUDENTS'ACADEMIC ACHIEVEMENT AT ENGLISH EDUCATION DEPARTMENT OF STATE ISLAMIC* …. repository.uin-suska.ac.id. http://repository.uin-suska.ac.id/89513/

Safitri, S., & Budhi, W. (2017). Pengaruh model pembelajaran inkuiri terhadap hasil belajar IPA ditinjau dari kemandirian belajar siswa. *Natural: Jurnal Ilmiah Pendidikan IPA*, (Query date: 2025-08-05 11:34:53). http://download.garuda.kemdikbud.go.id/article.php?article=769213&val=12553&title=PENGARUH%20MODEL%20PEMBELAJARAN%20INKUIRI%20TERHADAP%20HASIL%20BELAJAR%20IPA%20DITINJAU%20DARI%20KEMANDIRIAN%20BELAJAR%20SISWA

Sari, R., & Setiawaty, S. (2018). Hubungan Keaktifan dan Kemandirian Belajar dengan Hasil Belajar Siswa Melalui Model Pembelajaran Inkuri Berbasis Pendekatan Saintifik. *KATALIS: Jurnal Penelitian Kimia Dan* …, (Query date: 2025-08-05 11:34:53). https://ejurnalunsam.id/index.php/katalis/article/view/1000

Schunk, D. (2023). Self-regulation of self-efficacy and attributions in academic settings. *Self-Regulation of Learning and Performance*, (Query date: 2025-08-04 02:54:21). https://api.taylorfrancis.com/content/chapters/edit/download?identifierName=doi&identifierValue=10.4324/9780203763353-4&type=chapterpdf

Tarmilia, T., Yuliatun, I., Ramadhani, N., & Lestari, S. (2021). Pelatihan Penentuan Tujuan untuk Meningkatkan Regulasi Diri Belajar. *Abdi Psikonomi*, (Query date: 2025-08-04 03:18:30). https://journals2.ums.ac.id/abdipsikonomi/article/view/484

Teng, L. (2024). Individual differences in self-regulated learning: Exploring the nexus of motivational beliefs, self-efficacy, and SRL strategies in EFL writing. *Language Teaching Research*, (Query date: 2025-08-04 02:54:21). https://doi.org/10.1177/13621688211006881

Triquet, K., Peeters, J., & Lombaerts, K. (2017). Self-regulated learning online. … *SRL Part to TeachUp. A Policy* …, (Query date: 2025-08-04 03:05:36). http://teachup.eun.org/documents/556205/1092039/TeachUP_D1.1b_Self-Regulated-Learning-Online.pdf

Verk, N. (2021). A Dynamic Review of the Emergence of Corporate Social Responsibility Communication. *Journal of Business Ethics*, *168*(3), 491–515. https://doi.org/10.1007/s10551-019-04232-6

Wang, Y. (2025). Exploring self-regulated learning within online informal language learning: A case study. *Computer Assisted Language Learning*, (Query date: 2026-02-28 11:12:14). https://doi.org/10.1080/09588221.2025.2497506

Wu, P. H. (2020). Constructing a model of engagement in scientific inquiry: Investigating relationships between inquiry-related curiosity, dimensions of engagement, and inquiry abilities. *Instructional Science*, *48*(1), 79–113. https://doi.org/10.1007/s11251-020-09503-8

Xu, L., Duan, P., Ma, L., & Dou, S. (2023). Professional identity and self-regulated learning: The mediating role of intrinsic motivation and the moderating role of sense of school belonging. *SAGE Open*, (Query date: 2025-08-05 10:03:48). https://doi.org/10.1177/21582440231177034

Yan, Z. (2020). Self-assessment in the process of self-regulated learning and its relationship with academic achievement. *Assessment &Evaluation in Higher Education*, (Query date: 2025-08-04 04:56:43). https://doi.org/10.1080/02602938.2019.1629390

Yunus, A., Danial, M., & ... (2022). Pengembangan e-modul berbasis inkuiri terbimbing untuk meningkatkan kemandirian belajar dan hasil belajar peserta didik pada materi koloid. *Chemistry …*, (Query date: 2025-08-05 11:34:53). http://download.garuda.kemdikbud.go.id/article.php?article=2822289&val=25283&title=Pengembangan%20E-Modul%20Berbasis%20Inkuiri%20Terbimbing%20untuk%20Meningkatkan%20Kemandirian%20Belajar%20dan%20Hasil%20Belajar%20Peserta%20Didik%20pada%20Materi%20Koloid

Yusmanila, W., & Widya, W. (2020). Analisis Peningkatan Literasi Sains Dengan Penerapan Pembelajaran Group Investigation Dengan Metode Inquiry Labs. *Jurnal Riset Fisika Edukasi Dan Sains*, (Query date: 2025-08-03 03:47:00).

Zeidner, M., & Stoeger, H. (2019). Self-Regulated Learning (SRL): A guide for the perplexed. *High Ability Studies*, (Query date: 2025-08-04 02:54:21). https://doi.org/10.1080/13598139.2019.1589369