Implementation of new strategies to enhance Self-Directed Learning among grade 10 science students

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Abstract

This study investigated how to enhance the self-directed learning (SDL) among grade 10 students in a Sri Lankan school using various instructional strategies. Despite the increasing priority on student centered learning, usual teaching learning process continue to be heavily dependent on the teacher making teacher centered classroom. The study was led by the Kemmis and McTaggart action research approach and took place in two cycles spanning one and a half months during the third school term. A mixed-methods approach was used to investigate changes in students' SDL behaviors, including quantitative and qualitative methodologies. Thirty students were selected from grade 10 studying science as participants using a purposive sampling technique.The intervention comprised of eight scientific sessions prepared utilizing four SDL oriented strategies: goal-setting, inquiry-based learning, problem-based learning, and flipped classroom teaching. Lessons were designed using the National Institute of Education's (NIE) model and Zimmerman's Self-Regulated Learning framework, with an emphasis on preparation, performance, and reflective practice. Data were gathered via pre- and post-SDL surveys, observation checklists, structured interviews, and student reflection sheets, which were then analyzed using descriptive statistics and thematic analysis. The findings revealed that students initially displayed low SDL levels, which were characterized by significant teacher reliance and low self-monitoring abilities. Following the intervention, there were considerable gains in motivation, goal-setting, reflection, and autonomous learning practices. The study shows that using structured SDL techniques efficiently enhances student autonomy and suggests their implementation in secondary scientific teaching.

Keywords: Self-Directed Learning, Science Education, Inquiry-Based Learning, Autonomous Learning

Introduction

Science education is crucial in helping children develop their critical thinking, problem-solving ability, and inquisitive skills. It is not limited to the transfer of factual knowledge, but also includes the development of curiosity, creativity, and the capacity to apply scientific principles in real-world circumstances. According to modern educational approaches, scientific learning should be student-centered, encouraging active involvement and independent thinking (Lawson, 1994; Uus et al., 2022). However, scientific education in many poor countries, including Sri Lanka, remains predominantly teacher-centered and examination-oriented, limiting students' possibilities to actively participate in their learning (Bandara, 2021; Nawastheen et al., 2020).

Science education in Sri Lankan secondary schools, notably at the Grade 10 level, is heavily impacted by the General Certificate of Education (G.C.E.) Ordinary Level test. As a result, classroom procedures frequently emphasize syllabus completion, memorization, and teacher-led instruction. Students tend to rely extensively on teachers for explanations and supervision, which limits the development of autonomous learning abilities. Hence, students have a restricted capacity to think critically, solve issues independently, and apply scientific knowledge in unexpected circumstances (Jayawardena et al., 2017; Khalid et al., 2020).

Despite the recognized importance of self-directed learning (SDL) in modern education, many Grade 10 science students in Sri Lanka lack the necessary skills to learn independently. They struggle with goal-setting, self-monitoring, and reflective thinking, which are essential components of SDL (Zimmerman, 2000; Tekkol & Demirel, 2018). Students often depend on teachers for instructions and validation, limiting their ability to take responsibility for their learning.

This issue became more evident during the COVID-19 pandemic, when students were required to engage in independent learning. Many students experienced difficulties in managing their studies due to a lack of self-regulation skills and motivation (Kaushalya et al., 2021; Chitra et al., 2022). In addition, teachers face challenges such as limited time, heavy curricular demands, and lack of training in implementing student-centered strategies (Bandara, 2021; Nawastheen et al., 2020).

Therefore, there is a need to explore effective new strategies to enhance self-directed learning among grade 10 science students.

Research Question:
How can instructional strategies be implemented to enhance self-directed learning among Grade 10 science students?

Research Objectives:

1. To investigate the current levels of self-directed learning among Grade 10 science students
2. To design and implement instructional strategies to improve SDL
3. To evaluate the impact of these strategies on students' learning behaviors
4. To identify challenges faced by students in adopting self-directed learning

This study is significant as it addresses a key issue in Sri Lankan science education, the lack of student autonomy and independent learning skills. By focusing on self-directed learning, the study contributes to improving students' motivation, engagement, and academic performance. The findings provide practical strategies for teachers to implement learner-centered approaches in their classrooms.

Furthermore, the study supports national educational goals that emphasize the development of critical thinking, problem-solving, and lifelong learning skills. It also contributes to bridging the gap between educational policy and classroom practice by demonstrating how SDL strategies can be effectively applied in real teaching contexts.

This study focuses on Grade 10 science students in a selected Sri Lankan school and examines the impact of specific instructional strategies, goal-setting, inquiry-based learning, and problem-based learning on self-directed learning. The study is limited to a small sample and a short intervention period, which may affect the generalizability of the findings. Additionally, factors such as time constraints and resource limitations may influence the implementation of the strategies.

Literature Review

Self-directed learning (SDL) has become a central concept in modern education, particularly in fostering independent, lifelong learners capable of adapting to rapidly changing knowledge environments. It is widely recognized that traditional teacher-centered approaches are insufficient in preparing students for the demands of the 21st century, especially in science education, where inquiry, problem-solving, and critical thinking are essential. This section reviews the theoretical foundations, instructional strategies, and empirical evidence related to SDL, with a particular focus on science education and the Sri Lankan context.

The concept of SDL was first systematically introduced by Knowles (1975), who defined it as a process in which learners take initiative in diagnosing their learning needs, setting goals, identifying resources, implementing strategies, and evaluating outcomes. This definition emphasizes learner autonomy and responsibility, highlighting the shift from teacher-directed to learner-centered education.

Garrison (1997) expanded this perspective by proposing a comprehensive model of SDL consisting of three key dimensions: self-management, self-monitoring, and motivation. According to this model, effective learning requires not only cognitive engagement but also the ability to regulate behavior and sustain motivation. This aligns with the idea that SDL is both a process and a personal attribute influenced by learners' internal and external environments.

Zimmerman's (2000) Self-Regulated Learning (SRL) theory further complements SDL by describing learning as a cyclical process involving forethought, performance, and self-reflection. In the forethought phase, learners set goals and plan strategies, in the performance phase, they apply and monitor these strategies, and in the reflection phase, they evaluate outcomes and make adjustments. This cyclical process is particularly relevant to science education, where students must plan experiments, conduct investigations, and reflect on results (Tekkol & Demirel, 2018).

Constructivist learning theory also provides a strong foundation for SDL. According to Piaget (1952), learners actively construct knowledge through interaction with their environment, while Vygotsky (1978) emphasized the role of social interaction in cognitive development. These perspectives suggest that learning is an active and collaborative process, making instructional approaches such as inquiry-based and problem-based learning highly compatible with SDL principles.

Additionally, Self-Determination Theory (Deci & Ryan, 1985) highlights the importance of autonomy, competence, and relatedness in motivating learners. When students feel autonomous and capable, they are more likely to engage in self-directed learning behaviors. This theoretical integration demonstrates that SDL is supported by multiple complementary frameworks, all emphasizing learner autonomy, motivation, and reflection.

Self-Directed Learning in Science Education

Science education aims to develop scientific literacy by enabling students to understand concepts, apply knowledge, and engage in inquiry-based reasoning. According to Lawson (1994), effective science learning requires active participation, questioning, and experimentation. Similarly, Uus et al. (2022) emphasize that science education should foster curiosity and independent thinking rather than rote memorization.

However, in many educational contexts, including Sri Lanka, science teaching remains predominantly teacher-centered. Studies indicate that students are often passive recipients of knowledge, relying heavily on teachers for explanations and guidance (Bandara, 2021; Nawastheen et al., 2020). This approach limits opportunities for students to develop SDL skills such as planning, monitoring, and reflection.

Research has shown that students in such environments often struggle with independent learning tasks and exhibit low levels of motivation and engagement. Khalid et al. (2020) found that students who lack opportunities for inquiry and self-reflection demonstrate weaker problem-solving abilities. Similarly, Jayawardena et al. (2017) reported that limited use of student-centered approaches in Sri Lankan classrooms results in reduced participation and critical thinking.

The importance of SDL became particularly evident during the COVID-19 pandemic, when students were required to engage in remote learning. Studies revealed that many students faced difficulties managing their learning independently due to a lack of self-regulation skills (Kaushalya et al., 2021; Chitra et al., 2022). These findings highlight the urgent need to integrate SDL strategies into regular classroom practices.

Instructional Strategies for Promoting SDL

Several instructional strategies have been identified as effective in promoting SDL, particularly in science education. Among these, goal-setting, inquiry-based learning (IBL), and problem-based learning (PBL) are widely recognized.

Goal-setting is a key component of SDL, as it helps learners establish clear objectives and monitor their progress. According to Zimmerman (2000), goal-setting is part of the forethought phase of learning and plays a crucial role in motivation and self-regulation. Locke and Latham (2002) found that specific and challenging goals significantly improve performance. In science education, goal-setting enables students to plan their learning activities and evaluate their understanding.

Inquiry-Based Learning (IBL) encourages students to explore scientific concepts through questioning, experimentation, and analysis. Bell (2010) describes IBL as a process that promotes active engagement and critical thinking. Studies have shown that IBL enhances students' curiosity, understanding, and ability to apply scientific knowledge (Uus et al., 2022). In the Sri Lankan context, Jayawardena et al. (2017) found that inquiry-based approaches increased student participation and engagement in science lessons.

Problem-Based Learning (PBL) involves presenting students with real-world problems that require investigation and solution. According to Wale and Bishaw (2020), PBL develops critical thinking, collaboration, and independent learning skills. It encourages students to take responsibility for their learning and apply knowledge in practical contexts. Research indicates that PBL significantly improves students' motivation and problem-solving abilities (Tekkol & Demirel, 2018).

These strategies align closely with SDL and SRL theories, as they require learners to plan, act, and reflect on their learning processes. When combined, they provide a comprehensive framework for developing self-directed learners.

Empirical Studies on Self-Directed Learning

Empirical research on SDL has consistently demonstrated its positive impact on academic achievement and learner autonomy. International studies show that students who engage in SDL exhibit higher motivation, better problem-solving skills, and improved academic performance. Tekkol and Demirel (2018) found that SDL readiness is a strong predictor of academic success. Similarly, Khalid et al. (2020) reported that SDL enhances critical thinking and analytical skills.

In developing countries, studies have highlighted the challenges of implementing SDL due to limited resources and traditional teaching practices. Wale and Bishaw (2020) found that PBL improved student engagement in Ethiopian science classrooms despite resource constraints.

In Sri Lanka, research on SDL is still emerging. Bandara (2021) reported that teachers recognize the importance of SDL but face difficulties in implementation due to curriculum pressure and lack of training. Nawastheen et al. (2020) found that teacher-centered practices dominate classrooms, limiting opportunities for student autonomy. However, studies such as Jayawardena et al. (2017) demonstrate that even small-scale interventions can significantly improve student engagement and learning outcomes.

Research Gap

Despite extensive research on SDL, several gaps remain, particularly in the Sri Lankan context. First, there is limited classroom-based research examining how SDL strategies can be effectively implemented in secondary science education. Second, most studies focus on individual strategies rather than integrating multiple approaches such as goal-setting, IBL, and PBL. Third, there is insufficient attention to students' experiences and challenges during the transition from teacher-dependent to self-directed learning.

Therefore, this study aims to address these gaps by implementing a combination of SDL strategies within a classroom action research framework and evaluating their impact on Grade 10 science students.

Methodology

Research Design

This study adopted a mixed-method research design within a quasi-experimental action research framework to investigate the effectiveness of instructional strategies in enhancing self-directed learning (SDL) among Grade 10 science students. A mixed-method approach was selected to provide a comprehensive understanding of the research problem by integrating both quantitative and qualitative data. Quantitative data enabled the measurement of changes in students' SDL levels, while qualitative data provided deeper insights into students' experiences, behaviors, and perceptions during the intervention process (Creswell & Clark, 2018).

The action research design was based on the model proposed by Kemmis and McTaggart (1988), which involves a cyclical process of planning, acting, observing, and reflecting. This approach was particularly suitable for the study as it allowed the teacher-researcher to implement instructional strategies, evaluate their effectiveness, and refine them through iterative cycles. The research was conducted over two cycles, each consisting of four lessons, enabling continuous improvement of teaching practices and student learning outcomes.

The quasi-experimental aspect of the study was reflected in the use of pre-test and post-test measurements to assess changes in students' SDL levels. However, random assignment of participants to control and experimental groups was not feasible due to the natural classroom setting. Therefore, the same group of students was observed before and after the intervention, allowing for comparison of learning outcomes.

Participants and Sampling

The study was conducted in a government secondary school in Sri Lanka, involving thirty students from grade 10 studying science. The participants were selected using a purposive sampling technique, as the study focused on a specific classroom where the researcher was directly involved in teaching.

The selected group represented a typical classroom setting with mixed ability levels, providing a realistic context for implementing and evaluating SDL strategies. Prior observations indicated that students in this class demonstrated low levels of self-directed learning, including high dependency on teacher guidance, limited participation in inquiry activities, and weak reflective skills. These characteristics made the group suitable for investigating the impact of instructional interventions aimed at enhancing SDL.

Intervention Design

The intervention consisted of implementing four key instructional strategies designed to promote SDL:

- Goal-setting
- Inquiry-based learning (IBL)
- Problem-based learning (PBL)
- Flipped classroom approach

These strategies were integrated into eight science lessons conducted over a period of approximately six weeks. The intervention was structured into two action research cycles:

- Cycle 1: Initial implementation of SDL strategies
- Cycle 2: Modified implementation based on reflections from Cycle 1

Each lesson was designed following the National Institute of Education (NIE) model, incorporating elements of Zimmerman's (2000) Self-Regulated Learning framework, including planning, performance, and reflection phases.

In Cycle 1, students were introduced to SDL strategies and guided through structured activities such as setting learning goals, conducting simple experiments, and solving problems collaboratively. Observations from this cycle revealed challenges such as limited student participation and difficulty in independent thinking.

In Cycle 2, the strategies were refined to provide more scaffolding and opportunities for student autonomy. Additional support was provided through guided questioning, group discussions, and reflection activities, resulting in improved student engagement and participation.

Data Collection Methods

Data were collected using multiple instruments to ensure triangulation and enhance the validity of the findings. Student SDL Questionnaire (Pre-test and Post-test) measured students' levels of self-directed learning across domains such as goal-setting, motivation, self-monitoring, and reflection. Observation Checklist in classroom observations were conducted to assess students' behaviors, participation, and engagement during lessons. In addition, structured Interviews were conducted with selected students to gain insights into their experiences and perceptions of the SDL strategies. Student Reflection Sheets from students were used to reflect on their learning after each lesson, providing qualitative data on their progress and challenges.These multiple data sources allowed for a comprehensive analysis of both measurable outcomes and experiential changes in students' learning.

Data Analysis Techniques

Quantitative data collected from the SDL questionnaires were analyzed using descriptive statistics, including mean scores, percentages, and standard deviations. These measures were used to compare students' SDL levels before and after the intervention.Qualitative data from observations, interviews, and reflection sheets were analyzed using thematic analysis. This involved identifying recurring patterns and themes related to student engagement, motivation, and challenges in adopting SDL.The combination of quantitative and qualitative analysis enabled a holistic understanding of the impact of the intervention, ensuring that both numerical trends and contextual insights were considered.

Ethical Considerations

Ethical principles were strictly followed throughout the study. Permission was obtained from the school administration prior to conducting the research. Students were informed about the purpose of the study, and their participation was voluntary. Confidentiality and anonymity were maintained by ensuring that students' identities were not disclosed in any part of the research.

Results

The results are organized according to the research objectives, focusing on changes in students' self-directed learning (SDL) before and after the intervention collected through questionnaires, observation checklists, interviews, and student reflections.

Pre-Intervention SDL Levels

The pre-test questionnaire results indicated that students initially demonstrated low levels of self-directed learning across all measured domains. Most students relied heavily on teacher guidance and showed limited ability to set goals, monitor their progress, or reflect on their learning.

Observation data supported these findings, revealing that students were passive during lessons and hesitant to participate in inquiry-based activities. They frequently waited for teacher instructions before engaging in tasks and showed low confidence in independent problem-solving.

Intervention SDL Improvement

Following the implementation of the instructional strategies, a significant improvement in students' SDL levels was observed. The post-test results showed increased mean scores across all domains, indicating enhanced learner autonomy and engagement.

Table 1: *Pre-Test and Post-Test SDL Mean Scores (N = 30)*

SDL Domain	Pre-Test Mean	Post-Test Mean	Improvement
Goal-Setting	2.1	3.8	+1.7
Motivation	2.5	4.0	+1.5
Self-Monitoring	2.0	3.7	+1.7
Reflection	2.2	3.9	+1.7

The results clearly indicate that the intervention had a positive impact on all SDL domains. The greatest improvements were observed in goal-setting and reflection, suggesting that students developed stronger planning and evaluative skills.

Classroom observations conducted during both cycles revealed a noticeable shift in student behavior. During Cycle 1, students required significant guidance and demonstrated limited independence. However, by Cycle 2, students showed increased participation, actively engaged in group discussions, and demonstrated greater confidence in completing tasks independently.

Table 2: *Observation Checklist Mean Scores Across Cycles*

SDL Behavior Domain	Cycle 1 Mean	Cycle 2 Mean	Improvement
Participation	2.4	3.9	+1.5
Independence	2.2	3.8	+1.6
Collaboration	2.6	4.1	+1.5
Reflection	2.3	3.9	+1.6

These findings indicate that students became more engaged and self-reliant as the intervention progressed. The improvement in collaboration also suggests that group-based learning strategies, such as problem-based learning, were effective in promoting peer interaction and shared responsibility.

Qualitative data from student reflections and interviews further supported the quantitative results. Several key themes emerged:

- Increased Motivation: Students expressed greater interest in science lessons, particularly during inquiry and problem-solving activities.
- Improved Confidence: Many students reported feeling more confident in expressing their ideas and completing tasks independently.

- Enhanced Reflection Skills: Students demonstrated an improved ability to evaluate their learning and identify areas for improvement.
- Shift from Teacher Dependence: Students gradually relied less on teacher guidance and took more initiative in their learning.

For example, one student noted that, *"setting goals helped me understand what I need to do and how to improve."* Another student highlighted that group problem-solving activities made learning "more interesting and easier to understand."

Overall, the results indicate that the implementation of goal-setting, inquiry-based learning, and problem-based learning significantly improved students' self-directed learning abilities. The combination of quantitative and qualitative data demonstrates a clear progression from teacher-dependent learning to increased autonomy and engagement.

Although some challenges were observed during the initial stages, such as difficulty in adapting to independent learning, these issues were reduced in the second cycle. This suggests that continuous practice and structured support are essential for developing SDL skills.

Discussion

The findings of this study demonstrate that the implementation of structured instructional strategies goal-setting, inquiry-based learning (IBL), and problem-based learning (PBL)—significantly enhanced self-directed learning (SDL) among Grade 10 science students. The results indicate a clear shift from teacher-dependent learning to increased student autonomy, engagement, and reflective thinking. This section interprets these findings in relation to existing theories and empirical studies.

One of the most significant outcomes of the study was the improvement in students' goal-setting abilities. The increase in mean scores for goal-setting suggests that students developed the ability to plan and take ownership of their learning. This finding strongly aligns with Zimmerman's (2000) Self-Regulated Learning (SRL) theory, which identifies goal-setting as a critical component of the forethought phase. When students are able to set clear learning goals, they become more focused and motivated to achieve them. Similarly, Locke and Latham (2002) argue that specific and challenging goals enhance performance and persistence. In this study, goal-setting activities provided students with a structured framework to organize their learning, which contributed to increased independence and accountability.

The improvement in students' motivation further supports the effectiveness of SDL strategies. The findings revealed that students became more interested and actively engaged in science lessons, particularly during inquiry-based and problem-based activities. This observation is consistent with Self-Determination Theory (Deci & Ryan, 1985), which emphasizes the importance of autonomy in enhancing intrinsic motivation. When students were given opportunities to explore concepts, ask questions, and solve problems, they demonstrated higher levels of curiosity and enthusiasm. This suggests that shifting from teacher-centered to student-centered approaches can significantly improve learners' motivation and engagement.

Inquiry-based learning played a crucial role in promoting active participation and critical thinking. The results showed that students became more involved in classroom activities and demonstrated improved understanding of scientific concepts. These findings are consistent with previous research indicating that IBL enhances conceptual understanding and inquiry skills (Uus et al., 2022). By engaging students in questioning, experimentation, and analysis, IBL created a learning environment where students could construct knowledge actively rather than passively receiving information. This supports the principles of constructivist learning theory, which emphasizes the importance of active learning and knowledge construction (Piaget, 1952; Vygotsky, 1978).

Similarly, problem-based learning contributed to the development of students' problem-solving and collaborative skills. The improvement in collaboration and independence observed in the study indicates that students were able to work together to solve real-world problems while taking responsibility for their learning. This finding aligns with Wale and Bishaw (2020), who reported that PBL enhances critical thinking and learner autonomy. The use of real-life problems in science lessons enabled students to connect theoretical knowledge with practical applications, making learning more meaningful and relevant.

Another key finding of the study was the significant improvement in students' self-monitoring and reflection skills. Reflection is a critical component of both SDL and SRL, as it allows learners to evaluate their performance and identify areas for improvement (Zimmerman, 2000). The increase in reflection scores indicates that students became more aware of their learning processes and developed the ability to assess their progress. This was further supported by qualitative data, where students expressed that reflection activities helped them understand their strengths and weaknesses. These findings are consistent with Tekkol and Demirel (2018), who found that self-monitoring and reflection are essential for effective self-directed learning.

Despite these positive outcomes, the study also identified several challenges in implementing SDL strategies. During the initial phase of the intervention, students experienced difficulties adapting to independent learning. They were accustomed to teacher-centered instruction and required guidance to engage in self-directed activities. This finding is consistent with Bandara (2021), who noted that students in Sri Lankan classrooms often lack prior exposure to SDL practices. Additionally, teachers face challenges such as limited time, heavy curricular demands, and resource constraints, which can hinder the implementation of student-centered approaches (Nawastheen et al., 2020).

However, the reduction of these challenges in the second cycle suggests that SDL skills can be developed gradually through structured support and continuous practice. The action research approach used in this study was particularly effective in addressing these challenges, as it allowed the teacher to reflect on the initial implementation and make necessary adjustments. This highlights the importance of flexibility and adaptability in teaching practices when introducing new instructional strategies.

The findings of this study also have important implications for science education in Sri Lanka. They demonstrate that even within the constraints of an exam-oriented system, it is possible to integrate SDL strategies into classroom teaching. By incorporating goal-setting, inquiry-based learning, and problem-based learning, teachers can create a more engaging and learner-centered environment that promotes autonomy and critical thinking.

Furthermore, the study contributes to existing literature by providing empirical evidence on the combined effect of multiple SDL strategies in a secondary school context. While previous research has often focused on individual strategies, this study demonstrates that integrating multiple approaches can produce more comprehensive improvements in students' learning behaviors.

In conclusion, the findings confirm that structured instructional strategies are effective in enhancing self-directed learning among Grade 10 science students. The study highlights the importance of creating learning environments that support autonomy, encourage inquiry, and promote reflection. By adopting such approaches, educators can help students develop the skills necessary for lifelong learning and success in an increasingly complex world.

Conclusion

This study investigated the effectiveness of structured instructional strategies in enhancing self-directed learning (SDL) among Grade 10 science students in Sri Lanka. The findings clearly demonstrate that the integration of goal-setting, inquiry-based learning, and problem-based learning significantly improves students' ability to take responsibility for their learning. Students showed notable progress in key SDL domains, including motivation, goal-setting, self-monitoring, and reflection, indicating a shift from teacher-dependent learning to greater autonomy and engagement.

The study also highlights that SDL does not develop spontaneously but requires deliberate instructional support and structured opportunities within the classroom. The use of action research enabled continuous refinement of teaching strategies, which contributed to improved student outcomes in the second cycle. Although initial challenges such as student resistance, time constraints, and limited resources were observed, these were gradually reduced through guided practice and adaptation.

From a practical perspective, the findings suggest that science teachers can effectively promote SDL by incorporating learner-centered strategies into regular classroom teaching without compromising syllabus coverage. The study also supports the need for professional development programs that equip teachers with the skills to implement SDL-oriented practices.

In conclusion, fostering self-directed learning is essential for developing independent, motivated, and lifelong learners. Integrating structured SDL strategies into secondary science education can significantly enhance both academic performance and essential 21st-century skills. Future research should explore long-term impacts of SDL interventions and their application across different subjects and educational contexts.

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