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EXAMINING SELF-DIRECTED LEARNING READINESS AS A MEDIATOR BETWEEN PROJECT-BASED LEARNING AND PHYSICS PROBLEM SOLVING SKILLS OF GRADE 10 STUDENTS

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ABSTRACT

This study investigated the mediating role of self-directed learning readiness in the relationship between project-based learning and physics problem-solving skills among Grade 10 students in public schools in Mati City, Davao Oriental. A quantitative research design utilizing descriptive and correlational approach was employed. The study involved 193 Grade 10 students from four public secondary schools. The study used mean, standard deviation, Pearson correlation, and Sobel test to analyze project-based learning, self-directed learning readiness, and problem-solving abilities in physics, addressing various research questions on their relationships and mediation effects. Findings indicated high levels of engagement in project-based learning, physics problem-solving skills, and self-directed learning readiness among the participants. Statistical analysis revealed significant relationships between project-based learning and physics problem-solving skills, self-directed learning readiness and physics problem-solving skills, and project-based learning and self-directed learning readiness. Moreover, self-directed learning readiness was found to significantly mediate the relationship between project-based learning and physics problem-solving skills. These results highlight the importance of fostering both project-based learning and self-directed learning readiness to enhance students' problem-solving skills in physics.

Keywords: *Science, Physics, Education, Project-Based Learning, Problem-Solving Skills, Self-Directed Learning Readiness, Grade 10 Students, Descriptive And Correlational, Mediation Analysis, Mati Philippines*

Chapter 1
THE PROBLEM AND ITS SETTING

Background of the Study

Recent studies have highlighted the importance of problem-solving skills in Physics, which encompass systematic observation and critical thinking essential for achieving desired outcomes. These skills involve data collection, interpretation, conceptual thinking, logical reasoning, strategic planning, analytical skills, and decision-making (Rahman, 2019). Developing these abilities is crucial for students, as it not only fosters effective learning but also enhances cognitive skills (Astuti et al., 2021). However, many students perceive Physics as a challenging subject due to its reliance on mathematical proficiency, which contributes to a belief that the subject is less accessible (Gunawan et al., 2020).

In Indonesia, a study indicated that 52.93% of high school students displayed low problem-solving skills in Physics (Jua, 2020). Furthermore, English pupils have experienced a notable decline in problem-solving performance, dropping from 8th to 14th in the TIMSS rankings for secondary science (TIMSS, 2019). Similarly, the Dominican Republic reported low percentages of students achieving high levels in science-related problem-solving skills (OECD, 2019). In Nigeria, only 30% of students passed Physics, which includes problem-solving and spatial reasoning for the senior secondary school certificate examination (SSSCE), indicating low enrollment and substantial failure rates (Bada & Jita, 2020).

In Lamut, Ifugao, students reported experiencing anxiety during Physics problem-solving lectures (Pasigon, 2022). A survey in a private university in Manila revealed that 12th Grade STEM students struggled to complete Physics worksheets, demonstrating inadequate understanding of problems, difficulty identifying principles, and challenges in relating standard units to specific quantities (Alonzo & Mistades, 2021). Globally, TIMSS data showed that 13% of learners in the Philippines performed below the minimum standard, with 87% failing in Science due to problem-solving difficulties (TIMSS, 2019).

A school in Mati City reported that only 37 out of 102 students passed their science examination, which included problem-solving questions. This declining proficiency trend has persisted for five years across junior high levels. Similarly, another school in Mati Northwest noted similar concerns regarding students' problem-solving skills in Math and Science, leading to increased enrollment in summer classes for struggling students.

Examining the literature, research indicates that the Project-Based Learning (PBL) approach positively impacts students' problem-solving abilities (Mettas & Constantinou, 2008). Learners taught using PBL strategies demonstrated significantly better self-directed learning skills than those taught through traditional methods (Bagheri et al., 2013).

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However, there remains a lack of literature exploring the relationship between self-directed learning preparedness, PBL, and problem-solving skills (PSS). This study aims to fill this gap by examining how self-directed learning preparedness influences the relationship between PSS and PBL.

The research responds to the urgent need for investigating problem-solving skills, which hold global significance in education. The pandemic exacerbated challenges, including financial strain and mental health issues, hindering students' critical-thinking abilities (Lim et al., 2022). As schools return to normal, the study seeks to provide insights beneficial to the Department of Education, administrators, teachers, and students, with findings presented at local and international research forums.

Ultimately, enhancing problem-solving skills in science, math, and Physics may lead to a more competent STEM workforce. Improved abilities equip students to tackle real-world issues and advance technology. This research hopes to cultivate adept problem solvers whose scientific expertise can significantly benefit society.Statement of the Problem

The purpose of this study is to determine whether there are any direct connections between SDLR and PSS and PBL. In addition, it attempts to determine if self-directed learning preparedness functions as a mediator in a PBL-performance relationship with respect to enhancing the potential of Grade 10 students in the Mati City Division to solve physics-related issues.

Review of Related Literature

Physics Problem-Solving Skills

Problem-solving in Physics involves understanding situations, identifying issues, evaluating data, and implementing plans to achieve desired results (Fissore et al., 2021). Teachers play a critical role in helping students develop these skills through various instructional strategies and assessment tools (Cordova et al., 2024). As problem-solving becomes a key 21st-century skill, educational approaches increasingly focus on equipping students with these abilities (Kennedy & Sundberg, 2020). Effective instruction in problem-solving, particularly in Physics, is crucial given the low passing rates in the subject (Ince, 2018).

Research suggests that skilled problem solvers excel at recognizing key concepts and executing solutions (Punzalan, 2023). However, novice students often struggle with the planning phase, indicating a need for targeted support in this area (Tan, 2021). In the Philippines, 7th-grade students face challenges in learning Physics problem-solving and critical thinking skills, often struggling to apply mathematical concepts effectively (Sulatra, 2022). Contextualized instructional materials can enhance students' critical thinking and problem-solving capabilities (Febriana, 2018).

A practical approach to teaching problem-solving, such as Woods' model, emphasizes real-life applications and the importance of understanding misconceptions (Funke et al., 2018; Rahman, 2019). Effective problem-solving strategies include analysis, synthesis, and evaluation, which are essential for navigating complex Physics problems (Mazorodze & Reiss, 2019). The Polya technique, a structured four-step problem-solving process, enhances analytical reasoning and decision-making skills (Gray, 2018).

Moreover, project-based learning (PBL) fosters self-directed learning and strengthens problem-solving skills in real-world contexts (Boss & Krauss, 2022). Strong problem-solving abilities enable students to identify and address challenges during project execution, promoting self-regulation and confidence (Asepmepa, 2023).

Project-Based Learning (PBL)

PBL is an instructional approach that engages students in active learning through exploration of complex questions or challenges (Hontz, 2022). Students collaborate to research and develop solutions, reinforcing their understanding through hands-on experiences (Boss, 2022). PBL cultivates critical thinking, creativity, and collaboration, ensuring students can apply their knowledge in real-world situations (Dabbagh, 2019).

Historically rooted in progressive education movements, PBL emphasizes interdisciplinary connections and real-world relevance (Nollmever & Torres, 2022). Inquiry forms the core of PBL, motivating students to investigate topics they find meaningful (Almulla, 2020). This approach promotes collaboration, allowing students to work together and learn from each other (Safarini, 2019).

Despite its benefits, implementing PBL presents challenges, including resource allocation, curriculum alignment, and teacher training (Meng et al., 2023). Successful PBL experiences require careful planning and management to ensure that projects maintain relevance and authenticity (Boss, 2022).

Self-Directed Learning Readiness (SDLR)

Self-directed learning readiness refers to an individual's motivation and confidence in taking responsibility for their learning (Premkumar, 2018). It involves the ability to locate and utilize various resources and requires self-management skills (Karatas, 2021). Creating self-directed learners necessitates a shift in teaching roles, from traditional instruction to a more facilitative approach, allowing students to take charge of their learning (Robinson & Persky, 2020).

Theoretical frameworks guiding SDLR include Malcolm Knowles' andragogy, which emphasizes autonomy in adult learning, and Bandura's Social Cognitive Theory, highlighting the role of self-efficacy (Collier, 2022). Successful self-directed learners exhibit strong metacognitive abilities, enabling them to manage their learning processes effectively (Karatas & Arpaci, 2021).

Self-management skills, including time management and resource utilization, are critical for successful SDLR (Dumoulin et al., 2021). These skills contribute to character development and academic success, enhancing students' problem-solving abilities and social interactions (Lou & Noels,

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2019). Additionally, a strong desire for learning drives students to seek knowledge and build their problem-solving skills (Dumoulin et al., 2021).

Challenges remain in fostering SDLR, with many students requiring support in developing self-management abilities (Brandt, 2020). Effective teaching strategies that incorporate feedback and encourage independence can enhance students' readiness for self-directed learning (Wang, 2021).

Chapter 2
METHOD

Research Design

This study utilized a quantitative, descriptive correlational non-experimental design to gather and evaluate numerical data related to project-based learning, preparedness for self-directed learning, and physics problem-solving skills. The quantitative approach, as outlined by Trochim and Donnelly (2008), emphasizes the use of statistical methods to quantify variables and identify trends. Descriptive research, supported by Gay et al. (2011) and Fraenkel et al. (2012), helped gauge the frequency of phenomena and generate hypotheses based on student participation and skills. Correlational methods examined the relationships among project-based learning, self-directed learning, and physics problem-solving abilities, aiming to describe the interplay among these variables.

Research Respondents

The study targeted Grade 10 students enrolled in the academic year 2024-2025 from four public secondary schools in the Division of the City of Mati. A total of 386 students was identified as the population, with a sample size of 193 determined through stratified sampling to ensure representation of demographic subgroups. This sample included allocations from each school: School A (75), School B (52), School C (21), and School D (45). Random selection from each school was conducted using Microsoft Excel to minimize bias.

Research Instruments

This study utilized three modified survey questionnaires to evaluate project-based learning, physics problem-solving skills, and readiness for self-directed learning. All instruments were reviewed and validated by experts, with pilot testing and item analysis conducted for contextualization.

Polya Problem-Solving Survey (PPSS): This instrument assesses students' solutions to physics problems based on Polya's (1945) methodology. It comprises 23 items across four dimensions: understanding, planning, implementation, and reflection. The reliability coefficient for the PPSS is 0.882, indicating strong dependability. Respondents rated each item on a 5-point Likert Scale, where 1 signifies strong disagreement and 5 indicates strong agreement.

Self-Directed Learning Readiness Scale (SDLRS): Developed by Guglielmino in 1977, this tool measures an individual's readiness for self-directed learning, focusing on self-management, self-discipline, and self-assessment. The SDLRS is organized into three subcategories: self-control (15 items), desire for learning (12 items), and self-management (13 items). Internal consistency was assessed using the Cronbach's alpha coefficient, which is 0.890. Respondents evaluated each item using a 5-point Likert scale, with 1 representing strong disagreement.

High-Quality Project-Based Learning Student Survey (HQPBLSS): Created by Evans (2018), this survey evaluates the quality of the project-based learning environment. It includes parallel questions on six criteria: intellectual challenge and achievement, authenticity, public product, cooperation, project management, and reflection. Responses were scored on a 5-point Likert scale, with a Cronbach's alpha value of 0.805 for internal consistency across the areas

Data Gathering Procedure

The data collection process was conducted systematically through several key steps:

Seeking Permission to Conduct the Study: The researcher initially sought approval from the St. Mary's College of Tagum, Inc. Research Ethics Committee to examine and evaluate the research protocol. After obtaining the necessary approval, a letter of support from the Graduate School Program Dean was secured. Subsequently, the researcher submitted both the letter of recommendation and the permission letter to the City of Mati Division's Office of the Schools Division Superintendent for formal authorization. Upon receiving this approval, the researcher distributed the letters to the principals of the selected schools.

Random Selection of Research Respondents: To minimize bias, participants were randomly selected from each school and grade level using the random function in Microsoft Excel. Grade 10 advisers acted as gatekeepers for selecting respondents. An orientation session was organized for the enumerators to explain the study's goals and procedures, emphasizing the importance of respondent confidentiality. Enumerators were required to sign a confidentiality agreement before proceeding. After the orientation, the gatekeepers provided the researcher with names and contact details of Grade 10 students. Using a master list, the researcher assigned random numbers to each name via Excel's RAND function, then sorted and filtered the list to select participants corresponding to the predetermined sample size.

General Orientation and Seeking Consent: The Grade 10 advisers served as gatekeepers in obtaining consent. During the orientation, the researcher explained the study's objectives and methods, adhering to a privacy protocol to protect participant identities. Only essential information was collected, and the importance of maintaining anonymity was stressed. Enumerators signed a confidentiality agreement, and the adviser provided only names and contact information of the students. Consent forms were distributed to gatekeepers, and after parental consent was obtained, participants filled out Informed Assent Forms. The completed forms were returned to the enumerators and encoded securely, allowing the ethics commission to review the consent documents.

Administration and Retrieval of the Questionnaire: Once informed consent and assent forms were collected from at least

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50% of the sample size, the researcher distributed the questionnaires to the enumerators. These included the High-Quality Project-Based Learning Student Survey (HQPBLSS), Self-Directed Learning Readiness Scale (SDLRS), and Polya Problem-Solving Survey (PPSS). As the questionnaires were distributed face-to-face, all responses were collected on the same day. The researcher ensured that no personal information was requested from the respondents to protect their confidentiality and anonymity. Data was shared with the Research Ethics Committee and other regulatory bodies only when necessary, ensuring compliance with data protection regulations.

Checking, Collating, and Processing of Data: The researcher collected the responses and entered them into a Microsoft Excel document that was accessible only to them. For additional security, the data was uploaded to Google Drive in a password-protected ZIP file and saved in a password-protected Excel file, ensuring it contained no identifying information. Responses were examined and coded two weeks after collection. The researcher analyzed the findings with assistance from the graduate school's statistician. Both electronic and physical data copies were securely stored, with electronic data saved in a password-protected Excel spreadsheet and hard copies preserved in a locked filing cabinet. After retaining the data for the required duration, it was securely deleted to maintain confidentiality.

This systematic approach ensured that the data gathering process adhered to ethical standards and maintained the integrity of participant confidentiality.

Chapter 3
RESULTS AND DISCUSSION

This chapter presents the findings of the study in a structured format, including analyses, implications, and relevant literature citations. The discussion focuses on how the findings relate to the research objectives.

Extent of Student's Project-Based Learning in Terms of Intellectual Challenge and Accomplishment

The findings on students' project-based learning regarding intellectual challenge reveal a mean of 4.19 (SD = 0.86), categorized as highly extensive. The highest mean score was for "I focus on the important content and concepts" at 4.39 (SD = 0.90), indicating consistent engagement. Conversely, the lowest mean was for "I investigate a challenging problem" at 3.97 (SD = 0.87), suggesting opportunities for enhancing critical thinking. These results imply that while students engage with essential content, educators should provide more chances for exploring challenging problems.

Research supports these findings, indicating that project-based learning correlates positively with students' intellectual challenge and achievement (Sudjimat & Permadi, 2021; Yu, 2024). Almulla (2020) emphasized the necessity of effective teacher facilitation in project-based learning for successful outcomes.

Extent of Student's Project-Based Learning in Terms of Authenticity

In terms of authenticity, students scored a mean of 4.20 (SD = 0.71). The item "I reflect on the real learning" had the highest average mean of 4.42 (SD = 0.62), indicating a strong manifestation of authenticity. However, "I make choices about my topic" had a slightly lower mean of 4.09 (SD = 0.79), revealing limitations in student autonomy. Educators should provide more choices in topics and activities to enhance student investment.

Research by Boss and Krauss (2020) and Kishpaugh (2021) emphasizes the importance of authenticity in project-based learning, confirming the high levels of reflection observed.

Extent of Student's Project-Based Learning in Terms of Public Product

Students demonstrated a mean of 4.01 (SD = 0.74) regarding public products. The highest mean was for "I share my work-in-progress" at 4.19 (SD = 0.51), while "I engage in dialogue with my audiences" had a lower mean of 3.74 (SD = 0.89). This suggests proficiency in sharing work but indicates a need for improvement in audience engagement. Educators should facilitate more opportunities for meaningful dialogue.

These findings align with previous research indicating that public product skills foster deeper learning and accountability (Robertson, 2023; Yang et al., 2021).

Extent of Student's Project-Based Learning in Terms of Collaboration

Collaboration scored a mean of 3.82 (SD = 0.92). The highest mean was for "I learn to be a more effective team member" at 4.01 (SD = 0.89), while "I collaborate online with students in other schools" had the lowest mean of 3.36 (SD = 0.92). This highlights strength in team collaboration, yet indicates a need for enhanced online collaboration experiences.

Research supports these findings, indicating that project-based learning strategies correlate with increased student cooperation (Melguizo-Garín et al., 2022; De Vivo, 2022).

Extent of Student's Project-Based Learning in Terms of Project Management

Students scored a mean of 4.32 (SD = 0.78) in project management. The highest mean was for "I follow the appropriate steps" at 4.45 (SD = 0.96), while "I learn to use project management processes" scored 4.18 (SD = 0.72). While students excel in following procedures, further instruction on project management tools is needed.

Research indicates that project-based learning enhances students' project management skills (Albar & Southcott, 2021; Martinez, 2022).

Extent of Student's Project-Based Learning in Terms of Reflection

Reflection had an overall mean of 3.94 (SD = 0.91). The highest mean was for "I learn to assess and suggest improvements" at 4.28 (SD = 0.86), while "I pause to think about what I am doing" scored 3.70 (SD = 0.94). This indicates strong self-assessment skills but highlights the need for integrating more reflective practices.

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Research supports that effective project-based learning encourages meaningful reflection (Miller et al., 2021; Wood & Pranjol, 2024).

Summary on the Extent of Student's Project-Based Learning

Overall, project-based learning among students is highly manifested, with a mean of 4.08 (SD = 0.82). The highest mean was in project management, while the lowest was in collaboration. This suggests that while project management skills are strong, collaboration might need development.

Research indicates that effective project management and reflection are crucial for success in project-based learning (Torres et al., 2021; Mursid et al., 2022).

Level of Student's Physics Problem-Solving Skills

The study assessed students' physics problem-solving skills through various phases: understanding, planning, implementing, and reflecting.

1. **Understanding**: Mean of 4.06 (SD = 0.90). Students excel in recognizing problem goals but need to improve problem comprehension.
2. **Planning**: Mean of 3.96 (SD = 0.89). Strong in organizing information, but systematic planning requires further attention.
3. **Implementing**: Mean of 4.28 (SD = 0.74). High proficiency in identifying main ideas before solving problems, though action plan clarity needs improvement.
4. **Looking Back**: Mean of 4.10 (SD = 0.89). Strong proficiency in reviewing solutions but suggests a need for greater self-awareness regarding problem-solving capabilities.

Research indicates that effective problem-solving skills in physics are linked to understanding problem goals and systematic planning (Parker, 2022; Maries & Singh, 2023).

Level of Student's Self-Directed Learning Readiness

Students exhibited strong self-directed learning readiness, with overall means as follows:

1. **Self-Management**: Mean of 3.96 (SD = 0.87). High preference for planning learning, but management skills require enhancement.
2. **Desire for Learning**: Mean of 4.26 (SD = 0.81). Demonstrates eagerness for new ideas but indicates limited self-reflection.
3. **Self-Control**: Mean of 4.13 (SD = 0.81). Strong preference for setting personal goals, but logical reasoning skills need improvement.

Research shows that self-management and reflection are essential for effective self-directed learning (Brandt, 2020; Zhu et al., 2020).

Relationship Between Project-Based Learning, Physics Problem-Solving Skills, and Self-Directed Learning Readiness

Statistical analysis revealed strong correlations:

- Project-based learning and physics problem-solving skills: r = 0.671, r^2 = 0.450.
- Project-based learning and self-directed learning readiness: r = 0.521, r^2 = 0.271.
- Self-directed learning readiness and physics problem-solving skills: r = 0.595, r^2 = 0.354.

These findings indicate that project-based learning significantly enhances both problem-solving skills and self-directed learning readiness.

Mediating Effect of Self-Directed Learning Readiness

Mediation analysis confirmed that self-directed learning readiness mediates the relationship between project-based learning and physics problem-solving skills. The Sobel test indicated a significant effect (Sobel z-value = 4.798, $p < 0.000002$), confirming that self-directed learning readiness significantly influences this relationship.

Research supports these findings, indicating that self-regulated learning enhances problem-solving skills (Zhu et al., 2020; Bahar et al., 2024).

Conclusion

The results indicate that project-based learning significantly contributes to enhancing students' physics problem-solving skills and self-directed learning readiness. Educators should focus on incorporating more project-based learning opportunities and fostering self-directed learning practices to improve students' engagement and skill development in both areas.

Chapter 4
SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This chapter presents the summary of the major findings of the study, conclusions, and proposed recommendations.

Summary of Findings

The major findings are as follows:

1. The extent of students' project-based learning has an overall mean of 4.08, described as highly extensive, with a standard deviation of 0.82. Project management scored the highest mean of 4.32, followed by Authenticity at 4.20. Other indicators included Intellectual Challenge and Accomplishment at 4.19, Public Product at 4.01, Reflection at 3.94, and Collaboration at 3.82.
2. The level of students' physics problem-solving skills obtained an overall mean of 4.10, described as high, with a standard deviation of 0.86. The highest indicator was Implementing at 4.28, followed by Look Back at 4.10, Understanding at 4.06, and Planning at 3.94.
3. The level of self-directed learning readiness had an overall mean of 4.12, described as high, with a standard deviation of 0.83. Desire for Learning scored the highest at 4.26, followed by Self-Control at 4.13, and Self-Management at 3.96.
4. A low, positive, and significant relationship was found between project-based learning and physics problem-solving skills ($r = 0.671$; $p < 0.05$). Similar relationships were identified between project-based learning and self-directed learning readiness ($r = 0.521$; $p < 0.05$), and

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between self-directed learning readiness and physics problem-solving skills ($r = 0.595$; $p < 0.05$).

5. Self-Directed Learning Readiness ($z = 4.798$, $p < 0.05$, ratio < 0.80) significantly mediates the relationship between project-based learning and physics problem-solving skills.

Conclusion

The findings led to the following conclusions:

1. Project-based learning is evident, demonstrating various learner behaviors such as intellectual challenge and collaboration.
2. Students often exhibit physics problem-solving skills through understanding, planning, and implementing strategies.
3. Self-directed learning readiness is frequently manifested, indicating self-management and desire for learning.
4. A strong correlation exists between project-based learning and physics problem-solving abilities, suggesting that improvements in one will enhance the other.
5. Self-directed learning readiness mediates the relationship between project-based learning and physics problem-solving skills.

Recommendations

Based on the findings, the following recommendations are made:

1. Enhance Project-Based Learning: Educators should implement project-based learning to improve students' problem-solving abilities, self-confidence, and independence, preparing them for self-directed learning.
2. Incorporate PBL Activities: Educators can design engaging PBL activities, such as creating simple roller coasters or exploring physics in everyday life, providing guidance and feedback to foster teamwork.
3. Training for Educators: The Department of Education and school administrators must offer training programs to help teachers effectively implement project-based learning and support self-directed learning.
4. Future Research: Further studies should examine the long-term effects of project-based learning and self-directed learning preparedness on students' performance and comprehension of scientific concepts across various educational contexts.
5. These recommendations aim to enrich teaching practices and enhance student learning outcomes in science education.

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