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Predicting integrated biology-technical-vocational skills through self-regulation in career-oriented pedagogy

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ABSTRACT

This study addresses the critical issue of enhancing students' integrated biology-technical-vocational skills, essential for career readiness, by investigating the predictive role of self-regulation within a career-oriented pedagogical framework. Self-regulation, encompassing decision-making, goal orientation, impulse control, and self-direction, is recognized as vital for both academic achievement and career preparedness. Despite its importance, there is a gap in the literature regarding its influence on the development of integrated skills. To bridge this gap, the study employs a quasi-experimental design, utilizing analysis of variance (ANOVA) and simple linear regression on data from a representative sample. The findings reveal that self-regulation significantly predicts the acquisition of these integrated skills. The study concludes that enhancing self-regulation through targeted educational interventions is crucial for fostering students' career-oriented skills. These insights contribute to educational psychology by highlighting the importance of self-regulation in skill development, offering practical implications for improving academic and vocational outcomes. Future research should further explore these relationships and their practical applications in educational settings.

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1. INTRODUCTION

Self-regulation is a multifaceted construct encompassing decision-making, goal orientation, impulse control, and self-direction, crucial for the academic success and career readiness of students [1]–[3]. Extensive literature emphasizes it is significance in fostering academic achievement, critical thinking, and adaptability to the evolving demands of the job market [4]–[10]. The ability to self-regulate the learning processes of an individual has been linked to improved learning outcomes and increased engagement in educational settings [11]–[13]. Moreover, self-regulated learning plays a pivotal role in technical-vocational education and training (TVET), supporting the development of skills essential for employment and career advancement [14]–[18]. Despite these insights, there remains a gap in the literature regarding the specific role of self-regulation in predicting integrated biology-technical-vocational skills among students.

Integrating biology with technical and vocational skills is increasingly recognized as essential for preparing students to meet the diverse challenges of modern careers [19]–[22]. Integrated skills encompass domain-specific knowledge and practical competencies, crucial for success in various occupational fields [23], [24]. This study seeks to address the gap in understanding by exploring whether and how self-regulation influences the development of these integrated skills. Understanding this relationship is vital for designing effective educational interventions that enhance the readiness for both academic pursuits and vocational challenges of students [25], [26]. By examining the predictors of integrated skills development, educators can better tailor instructional strategies to foster holistic student development aligned with the demands of the 21st-century workforce [27].

The significance of this study lies in its potential to contribute empirical evidence to educational psychology and vocational education. By elucidating the role of self-regulation in predicting integrated biology-technical-vocational skills, the study aims to provide insights that can inform educational practices and policies. It addresses the need for a more nuanced understanding of how self-regulation impacts skill acquisition and application in interdisciplinary contexts [28]. This research is particularly timely given the increasing emphasis on science, technology, engineering, and mathematics (STEM) education and the integration of vocational training into academic curricula [29]. By identifying the mechanisms through which self-regulation influences skill development, educators can better equip students with the competencies needed to thrive in a rapidly evolving global economy [30].

Despite the growing body of research on self-regulation and its educational implications, gaps remain in understanding it is specific impact on integrating biology with technical-vocational skills. Existing studies often focus on general academic outcomes or specific vocational disciplines, overlooking the interdisciplinary nature of modern career demands [31]. Few studies have comprehensively explored how self-regulation influences the acquisition and application of integrated skills across diverse educational contexts and career paths [32], [33]. Additionally, while there is recognition of the importance of self-regulation in academic settings, there is a need for empirical evidence linking specific self-regulatory behaviors to the development of practical competencies essential for career success [34], [35]. This study aims to address these gaps by examining the predictive role of self-regulation in fostering integrated biology-technical-vocational skills among students.

Albeit, this study aims to advance our understanding of how self-regulation influences the development of integrated biology-technical-vocational skills among students. By addressing the identified gaps in the literature and exploring the research question through rigorous methodology, the study seeks to provide evidence-based insights that can inform educational practices and policies. Likewise, this study investigated the following research question: how does self-regulation predict integrated biology-technical-vocational skills among students?

2. METHOD

2.1. Design

This study utilized a quasi-experimental design to investigate the impact of career-oriented pedagogy (COP) on the development of biology-technical-vocational integrated skills mediated by self-regulation in students. The quasi-experimental design facilitated comparisons between a treatment group exposed to COP and a control group non-career-oriented pedagogy (NCOP), allowing for insights into the effectiveness of the intervention in enhancing targeted skills. This design also accounted for pre-existing differences among participants, strengthening the internal validity of the study.

2.2. Participants

The sample size of 70 students was chosen to ensure sufficient statistical power for detecting significant effects while maintaining a representative sample, consistent with Honra *et al.* [35] recommendation for medium effect sizes, where a sample of approximately 30 participants is adequate. The instruments were validated by a panel of experts and demonstrated strong reliability, with Cronbach's alpha values of 0.85 for the self-regulation scale and 0.82 for the integrated skills assessment, indicating validity and reliability for measuring the impact of COP on students' self-regulation and integrated skills development. Ethical considerations were paramount; informed consent was obtained from all participants, ensuring their voluntary involvement, and confidentiality was maintained throughout the study to protect student privacy and data integrity.

2.3. Intervention

The COP intervention aimed to integrate technical and vocational skills development in biology education. The COP activities included inquiry-based learning modules, reflective journal writing, vocational skills workshops, and other structured learning experiences. These activities were designed to enhance the self-regulation of students by promoting decision making, goal orientation, impulse control, and self-directed learning behaviors. The intervention spanned two months or equivalent to one grading period in a school year to allow sufficient time for participants to engage with and benefit from the COP activities.

Figure 1 illustrates the progression of lesson developments across the COP and NCOP groups following a 5E instructional model throughout the study period. The 5E model includes the engagement, exploration, explanation, elaboration, and evaluation phases. It visually depicts how lessons in the COP group are structured to integrate career-focused curricula and vocational skills training, emphasizing active student engagement and practical application. In contrast, the NCOP group adheres to traditional academic pathways with standard instructional methods and content delivery. This comparative overview highlights the differential impact of career-oriented instructional strategies on student learning outcomes within the context of the 5E instructional framework.

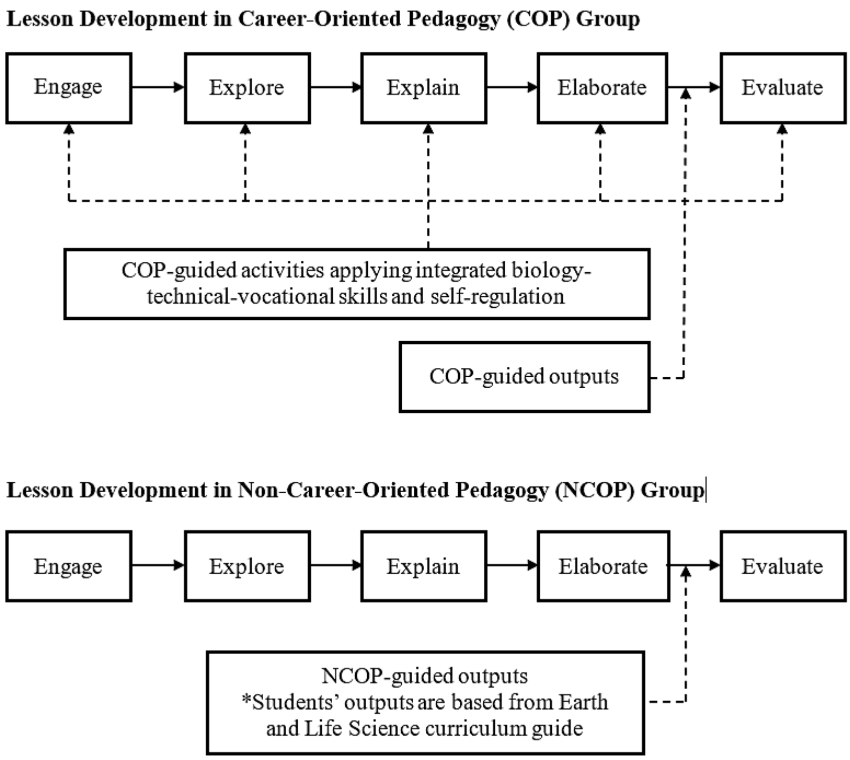

Figure 1. Lesson developments in COP and NCOP groups

2.4. Instruments

To measure the effectiveness of the intervention, several instruments were utilized. These included validated self-regulation [5] and integrated biology-technical-vocational skills (researcher-made) scales selected for their reliability and validity in assessing the targeted constructs. These instruments ensured robust data collection aligned with the objectives of the study and provided comprehensive insights into the skill development of the participants.

2.5. Data collection and analysis procedures

Data collection involved pretest and posttest assessments of the mentioned scales to capture self-regulation and integrated biology-technical-vocational skills. Pretest assessments established baseline measures, while posttest assessments evaluated outcomes following the intervention. Data analysis utilized simple linear regression analysis and one-way analysis of variance (ANOVA) to examine the impact of COP on how the self-regulation of students predicted their integrated biology-technical-vocational skills development. Statistical significance was set at $p<0.05$ to determine the effectiveness of the intervention and establish correlations between self-regulation and integrated biology-technical-vocational skills outcomes.

3. RESULTS AND DISCUSSION

To assess whether students' self-regulation predicts their integrated biology-technical-vocational skills, a simple linear regression analysis was conducted. The mean posttest scores from the biology-technical-vocational skills questionnaire (BTVSQ) were used as the dependent variable. The mean posttest ratings from the self-regulation questionnaire (SRQ) served as the predictor.

Table 1 shows that self-regulation positively predicts the integrated biology-technical-vocational skills among COP-exposed students, with a correlation coefficient (R) of 0.696, indicating a strong positive relationship. The model explains 48.5% of the variance in these skills (R^2=0.485), and after adjusting for sample size, it accounts for 46.9% (adjusted R^2=0.469). The standard error of 0.062 reflects the average deviation of the observed values from the regression line based on a sample size of 35.

Table 1. Regression analysis of self-regulation predicting integrated biology-technical-vocational skills

Model	R	R^2	Adjusted R^2	*SE*
1	0.696	0.485	0.469	0.062

Note: N=35

In addition, the coefficients in Table 2 show that the constant (intercept) is not statistically significant (β=0.920, *SE*=0.479, *t*=1.922, *p*=0.063), as indicated by its *p*-value exceeding 0.05. In contrast, self-regulation significantly and positively influences integrated biology-technical-vocational skills (β=0.762, *SE*=0.137, *t*=5.572, *p*=0.021), with a strong t-value and a highly significant *p*-value. This suggests that higher levels of self-regulation in biology predict increased proficiency in integrated biology-technical-vocational skills among COP-exposed students, emphasizing the importance of self-regulation in enhancing these integrated competencies.

Table 2. Coefficients for regression model predicting integrated biology-technical-vocational skills

Model		Coefficients	*SE*	*t*	Sig.
1	(Constant)	0.920	0.479	1.922	0.063
	Self-Regulation	0.762	0.137	5.572	0.021*

Note: *indicates p<0.05

Likewise, the ANOVA results in Table 3 indicate a highly significant regression model (*F*=13037.341, *p*=0.014), demonstrating that self-regulation significantly predicts integrated biology-technical-vocational skills among COP-exposed students. The regression model explains a substantial portion of the variance (R^2=0.485), supported by a large sum of squares for regression (419.539) compared to residuals (1.094). This robust statistical significance highlights the strong positive relationship between self-regulation and vocational skills, affirming that greater self-regulation in science enhances these integrated skills effectively.

Table 3. ANOVA results for regression model predicting integrated biology-technical-vocational vocational skills

Model		Sum of squares	*df*	Mean square	*F*	Sig.
1	Regression	419.539	1	419.539	13037.341	0.014*
	Residual	1.094	34	0.032		
	Total	420.633	35			

Note: *indicates p<0.05

Conversely, the integrated findings across Tables 1 to 3 highlight the significant role of self-regulation in predicting integrated biology-technical-vocational skills among COP-exposed students. Table 1 reveals a strong positive relationship between self-regulation and these skills, with substantial explanatory power (R^2=0.485). The coefficients in Table 2 demonstrate that self-regulation significantly influences these skills, while the constant shows no statistical significance. Furthermore, the ANOVA results in Table 3 confirm the overall significance of the regression model, highlighting that self-regulation strongly predicts integrated biology-technical-vocational skills among COP-exposed students. These findings emphasize fostering self-regulation to enhance integrated competencies in biology and technical-vocational education contexts.

This study highlights the importance of self-regulation in biology students, encompassing decision-making, goal orientation, impulse control, and self-direction. These skills are crucial for navigating career paths and addressing learning challenges effectively. They also align with research emphasizing their role in adapting to industry demands and enhancing employability [3], [7], [11], [15], [21].

The study revealed that students' readiness for learning facilitated the mastery of practical skills in biology and related fields. COP strategies, such as inquiry-based activities and reflective journal writing, fostered self-regulation and integrated biology-technical-vocational skills into students' learning experiences. These approaches were designed to enhance academic and professional competencies in line with industry requirements.

Self-regulation emerged as a significant predictor of students' proficiency in integrating biology with technical-vocational skills. This finding highlights the critical role of self-regulation in educational contexts, emphasizing the need to nurture this trait to enhance career-oriented competencies and overall academic outcomes. The study suggested that improving self-regulation enhances problem-solving, collaboration, communication, and metacognitive skills essential for success in dynamic professional environments [9], [13], [17], [24], [27]–[30].

Collaboration among students in COP settings was bolstered through structured roles and impulse control, facilitating effective teamwork and support-seeking behaviors. Reflective group dynamics promoted emotional regulation and rational decision-making, crucial for sustained professional engagement [23], [35]. Activities like debates and role-plays further encouraged students to regulate their learning experiences and develop interpersonal skills critical for career readiness.

Metacognitive skills were significantly enhanced through COP approaches, with activities such as learning journals fostering cognitive and metacognitive strategies. These methods promoted self-directed learning and goal setting, reinforcing the importance of social support in monitoring progress and achieving educational objectives [33]. Integrating such practices in COP improved students' ability to regulate their learning processes and adapt to diverse learning environments.

Effective communication skills, vital for vocational success, were nurtured through self-regulation practices within COP. Bilingual communication methods and reflective writing activities enhanced students' communicative competence, preparing them for professional interactions and demands [32]–[35]. These initiatives highlighted the role of self-regulation in cultivating versatile communication strategies essential for navigating varied workplace contexts and advancing career goals.

Consequently, one limitation of this study is the small sample size, which may affect the generalizability of the findings and reduce statistical power, making it challenging to detect significant effects [6]. A smaller sample size can increase the margin of error and result in less precise estimates of population parameters, limiting the ability to perform complex statistical analyses. However, the sample was carefully selected to ensure representativeness, and the specific context of the study might mitigate some concerns. Despite these limitations, smaller samples can still provide valuable insights, especially in exploratory or pilot studies [23], [25]. Future research should aim to include larger sample sizes to confirm the findings and enhance generalizability and robustness.

In essence, self-regulation is crucial for predicting the integration of biology-technical-vocational skills among students in COP environments. Educators can effectively enhance students' problem-solving, collaboration, metacognitive, and communication skills by fostering self-regulation through structured teaching methods and targeted activities. These findings emphasize the pivotal role of self-regulation in preparing students for successful careers and lifelong learning, advocating for tailored educational approaches that support comprehensive skill development in vocational contexts. This study fills existing gaps by providing empirical evidence and corroborating the significance of self-regulation in skill acquisition, suggesting areas for further research and practical application in educational settings.

4. CONCLUSION

Ultimately, this study explains the profound impact of self-regulation on the development of biology-technical-vocational integrated skills of students within COP environments. The findings consistently highlight that students who exhibit higher levels of self-regulation-manifested through decision-making, goal orientation, impulse control, and self-direction-are better equipped to excel in academic pursuits and practical vocational skills. These attributes enhance problem-solving abilities and collaborative efforts and bolster metacognitive awareness and effective communication in professional contexts. By integrating targeted strategies like inquiry-based learning and reflective practices, educators can effectively nurture self-regulation among students, preparing them comprehensively for the demands of evolving industries and competitive job markets.

Moving forward, it is recommended that educational institutions and policymakers prioritize the integration of self-regulation development within curricular frameworks, particularly in technical and vocational education. Incorporating structured activities that promote decision making, goal setting, and emotional management can significantly enhance the readiness of students for real-world challenges. Moreover, fostering a supportive learning environment that encourages collaborative learning, metacognitive reflection, and effective communication skills will further empower students to navigate complex professional landscapes confidently. Continuous professional development for educators on implementing these strategies effectively is also essential to ensure sustained growth and success among students in COP programs. In brief, by cultivating robust self-regulation skills, educational stakeholders can empower students to thrive academically and professionally in an increasingly competitive global economy.

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