Original Research Article

**The Mediating Effect of 21st Century Skills on the Relationship Between Learning Environment and Self-Directed Learning**

**ABSTRACT**

**Aims:** This study aims to examine the relationship among 21st-century skills, the learning environment, and self-directed learning among Senior High School students. Specifically, it seeks to determine the significant association between 21st-century skills, the learning environment, and students’ capacity for self-directed learning.

**Study Design:** This research employed a quantitative, non-experimental design.

**Place and Duration of the Study:** The study was conducted during the academic year 2024–2025 among Senior High School students from Padada National High School, Sulop National High School, Perfecto Sagarino National High School, and Molopolo National High School in Davao del Sur, Philippines.

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**Methodology:** A total of 325 students from public senior high schools in Davao del Sur, Region XI, Philippines, participated in the study. Stratified random sampling was used to select the participants. Data were collected using a structured survey questionnaire.

**Results:**The results reveal that 21st-century skills serve as a vital link between the learning environment and self-directed learning, enhancing students’ overall learning experiences. These skills are essential for preparing learners to meet academic and real-world challenges, including global demands. The findings further suggest that without these skills, students may struggle to achieve self-directed learning, even in a supportive learning environment. Ultimately, the study concludes that 21st-century skills act as a key integrative factor in building a strong foundation for meaningful learning, intrinsic motivation, and autonomous learning.

***Keywords:*** *education, secondary, 21st-century skills, learning environment, self-directed learning, mediation, Philippines, SDG #14*

**1. INTRODUCTION**

One of the problems faced by Senior High School students is the lack of skills in self-directed learning. Crowe emphasizes that despite its importance in daily learning and in adapting to the rapid changes in education, many students are still not adequately prepared for this type of learning [1]. Self-directed learning is essential to success beyond the classroom, but not all students possess the knowledge to take initiative, maintain discipline, and manage their own learning. In addition, Loyens, van Meerten, Schaap, and Wijnia (2023) emphasize that self-directed learning is highly associated with time management, which is one of the aspects often underdeveloped among students. Because of this, it becomes a hindrance to academic development, and most studies focus only on the outcomes of self-directed learning, indicating a lack of deeper understanding [3]. Self-directed learning is important in preparing students for lifelong learning and for facing the challenges of the modern age.

The learning environment, such as access to tools, teacher support, and classroom design, greatly affects learning. Furthermore, one of the essential aspects of self-directed learning is the integration of technology into the classroom; access to digital tools and resources helps students organize their learning and conduct independent research. Nguyen, Nguyen, and Vo (2025) highlight that technology empowers students to explore their own interests and take control of their learning. Similarly, the social and physical environment is necessary for developing students’ ability to become independent learners [4].

In the study of Kanyopa and Makgalwa (2024), they pointed out the importance of determining whether the environment provides enough support for the development of self-directed learning, because without it, teachers will find it difficult to cultivate such skills. A positive and structured environment is key to developing discipline and readiness for self-directed learning among students [5]. Chen and Wang demonstrated that various aspects of the learning environment, such as technology, teacher support, and classroom design, affect students' self-directed learning. Their study emphasized that the desire and ability of students to manage their own learning increase in an optimal learning environment. Studies also show that strong investment in technology and learning environment design is needed to further strengthen self-directed learning [6].

In addition, teacher support plays a significant role in enhancing self-directed learning. Students’ participation in self-directed learning activities improves through positive feedback and teacher encouragement. Miao and Ma (2023) showed that active teaching and teacher guidance create a supportive environment that motivates students to take responsibility for their own learning [7]. Likewise, self-directed learning is improved through student-centered activities and constructive feedback. Huang and Wang (2023) found that teacher support and constructive feedback enhance students’ engagement, self-efficacy, and ultimately their capacity for self-directed learning [8]. There is a strong relationship between the learning environment and 21st-century skills in the development of self-directed learning. Research shows that students’ ability to apply 21st-century skills improves when the learning system is effective. These skills are important to prepare students to thrive in a complex and interconnected world. Dorresteijn (2024) emphasize that an effective learning environment is one that integrates these skills into the curriculum and provides opportunities for students to work collaboratively and solve problems. This not only improves students’ knowledge but also strengthens their self-directed learning in response to global challenges [9].

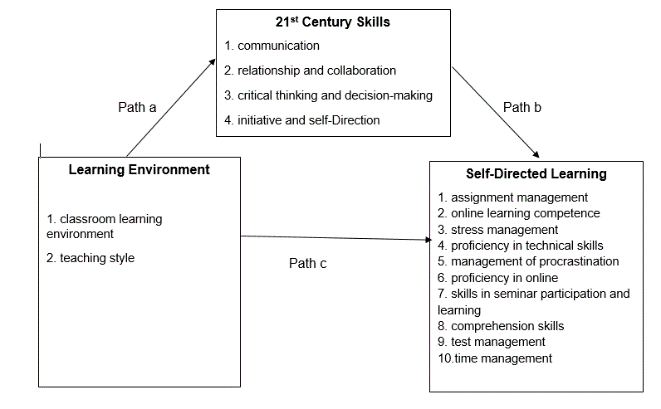
According to studies, students’ positive perception of the environment and teacher support helps develop their desire to learn. Munna and Kalam (2021) highlight that effective teaching and a supportive learning process contribute significantly to student’s motivation and engagement [10]. Moreover, self-directed learning results in deeper insight and self-confidence in problem-solving and goal-setting in life. Robinson and Persky (2020) emphasize that developing self-directed learners fosters critical thinking, independence, and confidence in achieving personal and academic goals [11]. Additionally, students with a high level of self-directed learning demonstrate decision-making skills both inside and outside the school, showing initiative and the ability to apply knowledge to society (Loeng, 2020) [12]. The development of self-directed learning is significantly influenced by students’ character and their use of 21st-century skills such as critical thinking (Ağaoğlu & Demir, 2020). With the continuous changes in academia, it is important for students to be prepared and knowledgeable in facing these challenges.

According to Muttohari and Sutiman (2021), 21st-century skills are essential for solving problems and for developing creative and critical thinking. Therefore, students must broaden their skills to achieve positive learning outcomes. A dynamic learning environment with collaboration and technology is essential in cultivating these skills [14].

Self-directed learning is significantly connected to 21st-century skills. It emphasizes autonomy and the ability to set goals, find resources, and monitor one's progress [15]. Karatas and Sebek (2020) also supported that students are more motivated in self-directed learning when encouraged to enhance their 21st-century skills. It is evident that self-directed learning is a complex process, which is why it is important for teachers to identify the factors that influence it [16].

This study aligns with Constructivist Theory as discussed by Suhendi & Purwarno (2018), which suggests that people learn from their own experiences and interactions. It focuses on the freedom of learners to learn based on their own discoveries [17]. Siemens’ Connectivism also reinforces the importance of linking information and creating solutions to problems, which is crucial in developing students’ deep thinking. Herlo (2017) supports this by emphasizing how Connectivist principles enhance learners’ ability to process complex information and foster deep learning [18]. Furthermore, 21st-century skills are a combination of cognitive learning and technology that serve as sources of knowledge. Sumardi, Rohman, and Wahyudiati (2020) emphasize that these skills prepare students to face global challenges through critical thinking [19]. Finally, Bandura’s Self-Efficacy Theory emphasizes that people are capable of facing life’s challenges. In the context of education, students are capable of discovering and developing their own ways of learning with the help of an environment and skills that support effective learning (Bandura and Adams,1977) [20].

This research used four steps to determine the mediating effect of self-directed learning on 21st-century skills and the learning environment of students, and to identify the type of mediation that occurred.



**Fig. 1. Conceptual framework of the study**

Specifically, this study aims to determine the level of students' 21st-century skills based on the following dimensions—communication; interpersonal relationships and collaboration; critical thinking and decision-making; and initiative and self-direction. It also aims to determine the level of students' self-directed learning; describe the relationship between 21st-century skills and the learning environment, 21st-century skills and self-directed learning, and self-directed learning and the learning environment; and identify the mediating effect of self-directed learning and the learning environment on students' 21st-century skills.

Path (c) showed the effect of 21st-century skills on the students' learning environment. Meanwhile, path (a) showed the direct effect of 21st-century skills on the mediating variable, self-directed learning. Furthermore, path (b) showed the direct effect of the mediating variable, self-directed learning, and in the final step, path (c') showed the indirect effect of 21st-century skills on the learning environment through the mediating variable, self-directed learning.

This study assumes that there is a significant relationship between the learning environment and 21st-century skills in shaping students’ competencies. Likewise, it is expected that there is a mediating effect of 21st-century skills on self-directed learning and the learning

environment. In the data analysis, the null hypothesis at 0.05 level of significance was used to measure its degree of importance.

**2. MATERIALS AND METHODS**

**2.1 Respondents**

This study focused on Grade 11 and Grade 12 students in Senior High School from the four largest public schools in the districts of Padada, Sulop, and Kiblawan in the province of Davao del Sur for the academic year 2023–2024. Out of a total population of 2,066 students enrolled in the Filipino subject, 325 participants were selected using the Raosoft calculator, with a 95% confidence level and a 5% margin of error, following rigorous sampling standards to ensure reliability. Stratified random sampling was employed to ensure proportional representation: 90 students from Padada, 188 from Sulop, and 47 from Kiblawan, based on official enrollment data from the Learners Information System (LIS). The participants shared common characteristics: they were between 16–18 years old, enrolled in the Filipino subject, and currently studying in public Senior High School programs. Students from Grades 7 to 10 were excluded from the study to focus specifically on the abilities and motivation of Grade 11 and 12 students. Participation in the study was conducted voluntarily, without coercion or any form of compensation. Students who voluntarily withdrew from participation were respectfully acknowledged.

The study was conducted in three municipalities in the province of Davao del Sur, known for having a large population of school-aged youth from both urban and rural communities. The research sites were selected because the researcher resides in the area and due to the high number of Senior High School students enrolled in these municipalities.

**2.2 Research Instrument**

This study used questionnaires as instruments for collecting data on each variable. First, “21st century-based soft skills: Spotlight on non-cognitive skills in a cognitive-laden dentistry program” [21]. It has 40 items and 4 indicators including communication, relationship and collaboration, critical thinking and decision-making, and initiative and self-direction, adapted from Marjorie Quieng, Pearly Lim, and Maria Rita Lucas [21]; Second, the learning environment with 18 items and two indicators: classroom learning environment and teaching styles, adapted from Jessica Faulkner, Kelly Bradley, Janet Lumpp, and James Bradley [22]. Lastly, self-directed learning with 25 items under eight indicators: assignment management, online learning ability, stress management, technical knowledge proficiency, procrastination management, effectiveness in online discussion, participation and learning in seminars, comprehension skills, test management, and time management from Henry Khiat [23]. The level of 21st-century skills and the learning environment was interpreted using a four-point scale from “Strongly Disagree” to “Strongly Agree.” Meanwhile, self-directed learning was interpreted using a five-point scale from “Strongly Disagree” to “Strongly Agree.” To ensure content validity and reliability, the instruments were reviewed by five experts and obtained an overall mean of 4.49 and were subjected to pilot testing. Cronbach’s Alpha analysis showed high reliability in each section: 0.93 for 21st-century skills, 0.89 for the learning environment, and 0.93 for self-directed learning.

**2.3 Research Design and Methodology**

This study utilized a quantitative descriptive-correlational design to examine the mediating effect of 21st-century skills on the relationship between the learning environment and the self-directed learning of Senior High School students. Data were gathered from Grade 11-12 students of four public schools using stratified random sampling. Data analysis was conducted with the help of a statistician using mean, Pearson r, regression analysis and path analysis.

Further, the aim of this study is to provide practical insights for improving instructional design aligned with the learning environment to better develop 21st-century skills and self-directed learning. Teachers, administrators, and curriculum designers may use the results of this study to enhance educational programs. Overall, the study was conducted according to ethical standards, with no fabricated data and no conflicts of interest.

Ethical standards were strictly followed. The instruments were reviewed by experts, translated into Filipino, and approved by the University of Mindanao Ethics Review Committee (UMERC-2024-477). Formal permission was obtained from the university and the participating schools. Data collection was done voluntarily and with the informed consent of the participants, and they were allowed to withdraw at any time if they wished.

The researcher ensured data privacy, anonymity, and confidentiality. All data were securely stored and disposed of in accordance with ethical standards.

**3. RESULTS AND DISCUSSION**

**3.1 Level of Learning Environment Among Students**

Table1 presents the level of the learning environment experienced by the participants in the study. Overall, the mean of 3.27 and a standard deviation of 0.43 indicate a high level, suggesting that the respondents agreed the learning environment was frequently demonstrated. The highest mean was observed in the aspect of teaching style, with a value of 3.32, indicating that this was consistently practiced by teachers in their classes. Meanwhile, the classroom learning environment obtained a mean of 3.23, which, although slightly lower, still falls under the high level, signifying frequent implementation. The overall result suggests that the respondents appreciated their learning environment—an encouraging indication that teachers were able to deliver knowledge effectively and foster a peaceful, productive classroom setting. This implies that when effective teaching styles and conducive classroom climates are implemented properly, students are more likely to achieve their goals and engage in self-directed learning. Furthermore, the high mean for students' perception of their learning environment supports the conclusion that a positive atmosphere has a beneficial impact on academic performance.

This finding aligns with earlier studies that emphasize the role of the learning environment in influencing emotional engagement and academic success (Karam & Al Kassab, 2023) [24]. It reinforces the idea that a supportive environment boosts student motivation and collaboration, leading to improved performance in academic tasks and better attainment of learning outcomes. The referenced literature confirms that environmental factors such as quality of teaching, student participation, and instructional style significantly affect student performance. Therefore, nurturing a positive and supportive learning environment is vital to academic achievement.

Additionally, the study highlighted that the quality of interaction between teacher and student significantly impacts academic performance (Savira,2024) [25]. A positive teacher-student relationship builds trust and strengthens the foundation of learning. When students receive consistent support and guidance from teachers, they tend to become more active in class, acquire knowledge more effectively, and develop greater self-confidence (Kassab, Rathan, Taylor & Hamdy) [26].

Moreover, consistent with the findings of Limpot and Maglangit (2), the quality of the classroom climate significantly contributes to students’ academic motivation and engagement. The authors highlight that a supportive and stimulating classroom environment—characterized by mutual respect, openness, and active participation—promotes learners’ enthusiasm for academic tasks. They suggest that creating positive learning spaces fosters emotional security and encourages active involvement, which are essential for cultivating student motivation and enhancing academic performance ([27].

Finally, Galang and Basco stated that a meaningful learning environment includes both the physical aspect of the classroom and the social and emotional support provided by the school. They also showed that an educational system that provides adequate support to students contributes to improved learning and academic success, thereby increasing the level of their academic performance [28].

**3.2 Level of Self-Directed Learning Among Students**

Based on Table 2, the selected students recorded an overall mean of 3.41 with a standard deviation of 0.63, which corresponds to the descriptive interpretation of “High.” This indicates a high level of self-directed learning, particularly in homework management, which garnered a mean of 4.04. The result demonstrates that the students have strong abilities in organizing, implementing, and complying with assigned tasks, reflecting diligence, discipline, and responsibility as learners. Following this, time management recorded a mean of 4.00, indicating their ability to prioritize, adhere to schedules, and complete tasks on time. The results further show that the students acted responsibly in using their time, which is essential for academic success.In stress management, the students recorded a mean of 3.87, indicating their ability to face and control stress-inducing situations. This confirms that aside from managing their time, they also possess emotional resilience, which is crucial for maintaining motivation and a positive outlook amidst academic challenges.

Skills in seminar participation recorded a mean of 3.78, demonstrating their active engagement and continuous learning both inside and outside the classroom. Meanwhile, test management had a mean of 3.28, which falls under the moderate level. This suggests that some students lack preparation, emotional regulation, and time management during examinations, hence the need for guidance to improve this aspect of assessment. In terms of online learning ability, a mean of 3.21 was recorded, showing sufficient knowledge in using technology but also indicating a need for improvement in consistency, use of online tools, and proper time management. Technical skills yielded a mean of 3.14, suggesting that although students are capable of using technology, further enhancement is needed to maximize its use for academic tasks. The ability to participate in online discussions recorded a mean of 3.06, reflecting adequate skills in engaging and expressing themselves on digital platforms. However, it remains important for teachers to focus on strategies that can further enhance this skill. It was also discovered that comprehension ability recorded a mean of 2.96, implying a need to deepen students’ understanding of course objectives and assigned tasks. The lowest among all aspects was procrastination management, with a mean of 2.72. While students have some ability to manage procrastination, training in effective time management is still required to avoid its negative impact on learning.

Overall, a high level of stress contributes to increased procrastination. Research shows that as challenges and stress increase, the risk of procrastination also rises, which may lead to a decline in academic performance (Fostervold, Ludvigsen, & Strømsø, 2022) [29]. Furthermore, time management and self-control are associated with avoiding procrastination.

Mohan and Athira (2020) emphasize that students who are good at managing their time and themselves are less likely to develop procrastination as a habit. Thus, strategies that prevent non-compliance with academic tasks are crucial [30]. Self-directed learning requires self-monitoring and self-management to be effective. Active student’s participation in every step of their education is important, hence the need for motivation to learn effectively. With proper time and task management, students can improve their learning and understanding of lessons (Simon & Al Ghailani, 2023) [31]. This is supported by findings that emphasize the importance of goal setting, evaluating one’s own progress, and selecting appropriate strategies. In addition, self-reflection and self-assessment help sustain learning even in the face of challenges (Brandt,2020) [32]. This is further supported by the study of Linkous, which states that students who use self-monitoring strategies, such as evaluating and correcting their performance, demonstrate higher motivation and achievement. This type of self-assessment promotes responsibility and critical thinking, which makes them more effective in achieving academic goals (Linkous,2020) [33].

**Chart 1. List of scale used, description, and interpretation of the data collected in the three variables of the study**

|  |  |  |
| --- | --- | --- |
| **Scale** | **Description** | **Interpretation** |
| 4.20-5.00 | Very High | This indicates a very high level, suggesting that the relationship with the students' learning environment is consistently demonstrated or manifested; |
| 3.40-4.19 | High | This indicates a high level, suggesting that the relationship is frequently observed; |
| 2.60-3.39 | Moderate | This indicates a moderate level, suggesting that the relationship is occasionally observed; |
| 1.80-2.59 | Low | This indicates a low level, suggesting that the relationship is rarely observed; |
| 1.00-1.79 | Very Low | Very low, indicating that the relationship with the learning environment is never observed. |

**Table 1. Level of Learning Environment Among Students**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Indicator SD Mean Description

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Classroom Learning Environment 0.46 3.23 High

Teaching Style 0.48 3.32 High

**Overall 0.43 3.28 High**

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**Table 2. Level of Students' Self-Directed Learning**

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Indicator SD Mean Description

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Assignment Management 0.71 4.04 High

Online Learning Competence 0.99 3.21 High

Stress Management 0.95 3.87 High

Proficiency in Technical Skills 1.00 3.14 Moderate

Management of Procrastination 1.23 2.72 Moderate

Proficiency in Online Discussion 1.14 3.06 High

Skills in Seminar Participation

and Learning 0.91 3.78 High

Comprehension Skills 1.06 2.96 Moderate

Test Management 0.89 3.28 Moderate

Time Management 0.75 4.00 High

**Overall 0.63 3.41 High**

**Table 3. Level of 21st Century Skills of the Students**

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Indicator SD Mean Description

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Communication 0.41 3.33 High

Relationship and Collaboration 0.45 3.40 Highest

Critical Thinking and Decision-Making 0.44 3.25 High

Initiative and Self-Direction 0.45 3.31 High

**Overall 0.38 3.32 High**

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**Table 4. Analysis of the Relationship Among Variables**

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**Pair Variable Correlation coefficient P value Decision on Ho**

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IV and DV Learning Environment 0.403 0.000 Reject

and Self-Directed Learning

IV and MV Learning Environment 0.705 0.000 Reject

and 21st Century Skills

MV and DV 21st Century Skills and 0.405 0.000 Reject

Self-Directed Learning

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**a. Level of 21st Century Skills of the Students**

Table 3 presents the mean scores of the items related to the 21st century skills of the students, showing an overall mean of 3.32 with the descriptive interpretation of “High.” This indicates that the students effectively utilize 21st century skills. Based on the data, the highest mean score (3.40) was recorded in the area of relationship-building and collaboration, suggesting that this contributes to establishing strong interpersonal connections, especially in academic activities. This was followed by communication, with a mean score of 3.33, which affirms that students demonstrate a high level of comprehension, critical thinking, and effective interaction. This also reflects their ability to strengthen relationships through interpersonal skills, particularly in communicating with teachers during the teaching and learning process.

Next, initiative and self-direction garnered a mean score of 3.31, showing that students are capable of setting personal goals in their daily routines and academic pursuits. This suggests that students are keeping up with the demands of the time in promoting both personal and academic success. Meanwhile, critical thinking and decision-making registered the lowest mean score of 3.25, but it still falls within the high range. This shows that students possess the ability to deeply understand and make sound decisions, especially in situations that require broad and analytical thinking in their studies.

Table 3 addresses the third objective of the study, which pertains to 21st century skills. Ekizer and Yıldırım (2023) emphasized that these competencies are essential in responding to the challenges of learning and enhancing educational outcomes if continuously developed by students [34]. Furthermore, González-Pérez and Ramírez-Montoya (2022) emphasized that 21st century skills are vital in shaping knowledge, competencies, and behaviors needed to adapt to the challenges of the digital age, employment, and social interaction. These skills also contribute to a broader understanding of learning within and beyond the school and aim to make students valuable members of society. It is expected that students who possess these skills will have the capacity to face life’s challenges effectively [35].

**3.3 Analyzing the Relationship Between Variables**

Table 4 presents the analysis of the relationships among three pairs of variables: Learning Environment and Self-Directed Learning, Learning Environment and 21st Century Skills, and 21st Century Skills and Self-Directed Learning. The results indicate that each pair of variables has a significant relationship based on the correlation coefficients and p-values obtained from the study. First, the correlation between the Learning Environment and Self-Directed Learning yielded a coefficient of 0.403. This shows a positive relationship between the two variables— as the quality of the learning environment improves, students’ self-directed learning also increases. This relationship is significant, as indicated by a p-value of 0.000, which is lower than the set significance level (p < 0.05), leading to the rejection of the null hypothesis (H₀). Second, the correlation between the Learning Environment and 21st Century Skills showed a coefficient of 0.705. This indicates that a positive learning environment significantly contributes to the development of 21st century skills. This relationship is also significant based on the p-value of 0.000, thus rejecting the null hypothesis for this pair as well. Lastly, the correlation between 21st Century Skills and Self-Directed Learning had a coefficient of 0.405. Although slightly lower than the previous pairs, it still shows a positive relationship. This suggests that as students strengthen their self-directed learning, their 21st century skills also improve. The relationship is significant, as indicated by a p-value of 0.000, resulting in the rejection of the null hypothesis.

In summary, the analysis confirms that the variables are significantly related to each other. This indicates that a conducive learning environment and strong 21st century skills play crucial roles in shaping students’ self-directed learning. These findings provide important insights for teachers and educators in designing more effective teaching strategies that enhance students' academic success.

Neves da Silva et al. (2022) emphasized that a positive classroom environment plays a vital role in student motivation, performance, and skills development in the context of 21st century education. It shows that a supportive learning setting strengthens students’ initiative and self-directed learning, as well as the development of their competencies [36].

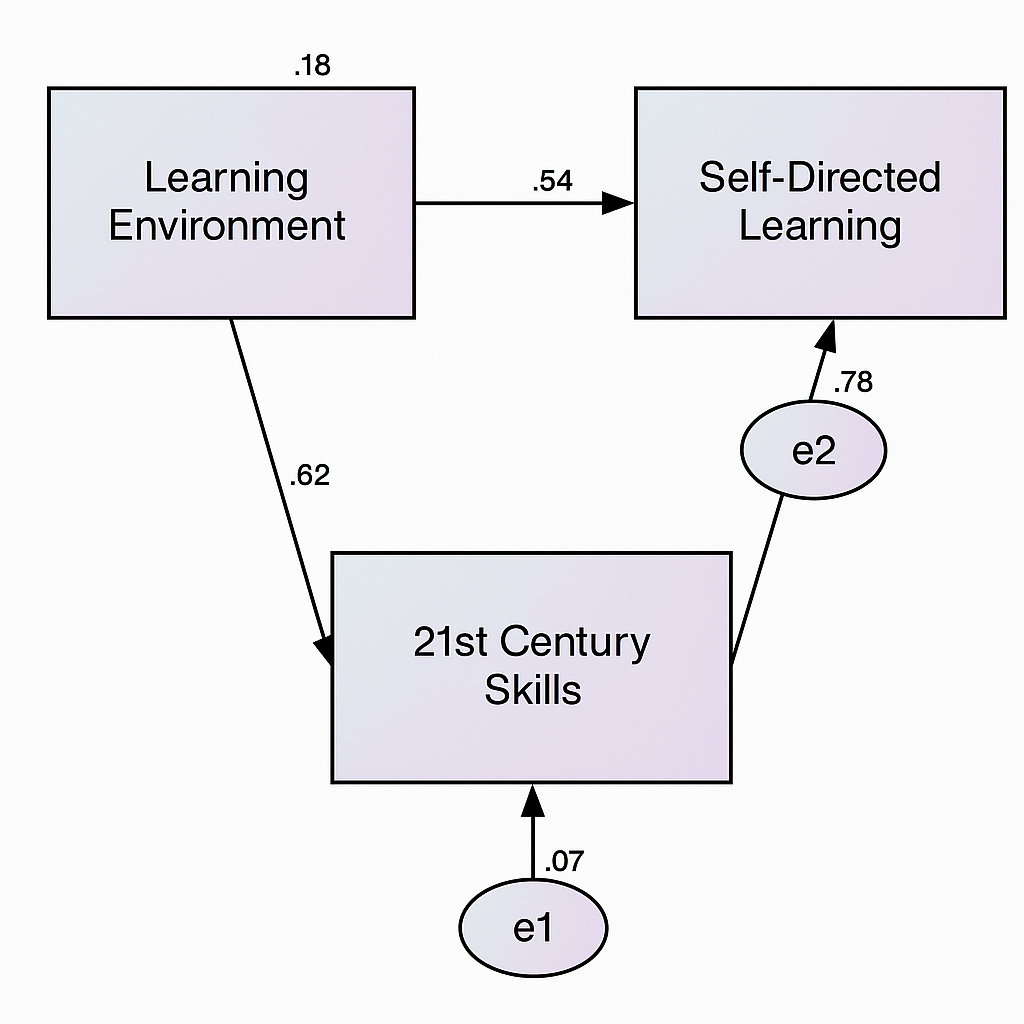
Moreover, a higher level of self-directed learning has a direct impact on academic performance. Studies show that the ability of students to study independently not only improves their academic results but also helps in nurturing 21st century skills essential in achieving their goals (Sighn and Kinaujia, 2025) [37].

**Analyzing the Mediation of Three Variables**

IV= LEARNING ENVIRONMENT

DV= SELF-DIRECTED LEARNING

MV= 21ST CENTURY SKILLS



**Fig. 2. Mediation model**

**Chart 2-PARTIAL MEDIATION (WITH SIGN UNCHANGED)**

|  |  |  | Estimate | S.E. | C.R. | P | Label |
| --- | --- | --- | --- | --- | --- | --- | --- |
| OVMV | <--- | OMIV | .624 | .035 | 17.896 | \*\*\* |  |
| OMDV | <--- | OVMV | .627 | .183 | 3.421 | \*\*\* |  |
| OMDV | <--- | OMIV | .537 | .162 | 3.312 | \*\*\* |  |

**b. Analyzing the Mediation of Three Variables**

Table presents the regression analysis examining the effect of the learning environment on students' self-directed learning, considering 21st-century skills as a mediating variable. Based on the results, the total effect of the learning environment on self-directed learning—prior to including 21st-century skills—was significant (B = 0.540, β = 0.705, p < 0.001). This indicates a positive relationship between the learning environment and students’ self-directed learning. Regarding the relationship between the learning environment and 21st-century skills, the results show a strong connection between the two variables. Regression analysis revealed that the learning environment has a significant effect on students' 21st-century skills (B = 0.624, β = 0.403, p < 0.001). This suggests that as the learning environment becomes more robust and effective, students' 21st-century skills are also more likely to develop. Meanwhile, the direct effect of 21st-century skills on self-directed learning was not as strong, although it remained significant (B = 0.627, β = 0.405). This implies that although 21st-century skills positively influence self-directed learning, they are not the strongest direct predictors of this outcome. Instead, the learning environment appears to exert a greater direct influence, while 21st-century skills serve as a mediator that deepens the relationship between the two variables.

Furthermore, the results of the mediation analysis examining whether 21st-century skills mediate the relationship between the learning environment and self-directed learning. The analysis utilized the Sobel z-test, which determines whether a variable serve as a mediator. According to the results, the Sobel z-value of 3.38 and a p-value less than 0.05 indicate a significant mediating effect of 21st-century skills. This suggests that these skills strengthen the connection between the learning environment and self-directed learning. A well-established learning environment enhances the development of these skills, which in turn contributes to more effective self-directed learning among students. These findings also underscore the importance of nurturing such skills to further improve students' capacity to learn independently. Moreover, the analysis demonstrated that 21st-century skills influence the relationship between the learning environment and self-directed learning. In other words, even if the environment is conducive to learning, the absence of 21st-century skills may hinder the full development of self-directed learning. The outcome still depends on the extent of the student’s knowledge and skill in applying these competencies. Having adequate 21st-century skills plays a crucial role in shaping a student’s ability to learn independently (Tan and Chan,2021) [38]. Furthermore, it has been emphasized that a modern, collaborative, and technology-integrated learning environment that embraces inquiry-based learning becomes more effective when it incorporates 21st-century skills. This approach makes the teaching and learning process more meaningful and interactive. Additionally, students are more likely to apply sound decision-making and problem-solving when they possess skills that enhance personal growth. Researchers stress the expansion of these skills to develop holistic learners who are capable of managing their own learning processes.

In summary, the study’s results revealed that 21st-century skills serve as a bridge between the learning environment and self-directed learning, enriching students’ overall learning experiences. These skills are vital for preparing students to face challenges both inside and outside the classroom, and to meet global demands. The findings suggest that without these skills, self-directed learning may not be fully realized even with a supportive learning environment (Johnson and Davis,2023) [39]. Ultimately, 21st-century skills serve as the essential link that connects a strong foundation for learning, intrinsic motivation, and the ability to learn independently.

**4. CONCLUSION**

Based on the results of the study, students demonstrated a high level of learning environment quality, indicating that their learning becomes more effective when classroom and non-classroom management is well implemented. The findings also showed that the variables had significant correlations, leading to the rejection of the null hypothesis. The learning environment had a significant relationship with self-directed learning (r = 0.403, p ≤ 0.000). Likewise, the learning environment showed a strong and significant relationship with 21st-century skills (r = 0.705, p ≤ 0.000). Finally, 21st-century skills also had a significant relationship with self-directed learning (r = 0.405, p ≤ 0.000).

Overall, the results reveal that 21st-century skills partially mediate the relationship between the learning environment and self-directed learning. This implies that 21st-century skills serve as a bridge that connects the learning environment to the enhancement of students’ self-directed learning.

The findings support the Constructivist Theory of Piaget and Vygotsky, as cited in the study by Suhinde and Purwarno (2018), which emphasizes the importance of learning through personal experience, imagination, and interaction with the environment. The results highlight that a positive learning environment plays a crucial role in the development of self-directed learning. Furthermore, the findings align with Siemens and Downes’ (2004) Connectivism Theory, which underscores the importance of a learner’s ability to connect information, technology, and people in nurturing self-directed learning. This is also supported by Bandura’s (1997) Self-Efficacy Theory, which posits that students with clear goals are better able to develop self-directed learning due to their confidence in their own capabilities.

To further enhance self-directed learning, it is recommended to strengthen students' confidence in using technology, in response to the demands of modern education. Students should be given opportunities to expand their knowledge in using basic tools such as Microsoft Word, internet research, and presentation software. Adequate time and training should also be provided to help them become proficient and confident in the use of technology. It is also important to develop students' problem-solving skills by providing activities focused on critical thinking, such as situational problem-solving tasks, case analysis, and collaborative learning.

In terms of teaching style, it is recommended that teachers observe student activities more actively to provide immediate guidance and motivation. This can be done through class roaming and questioning, offering timely feedback, and maintaining strong connections with students. Additionally, to address low levels of skill proficiency, interventions such as workshops on time management and avoiding procrastination are recommended. Students should be trained to set clear goals and create schedules for their activities

**ETHICAL APPROVAL AND CONSENT**

Overall, the study was conducted in accordance with ethical standards, with no fabricated data and no conflicts of interest. Ethical guidelines were strictly followed. The research instruments were reviewed by experts, translated into Filipino, and approved by the University of Mindanao Ethics Review Committee (UMERC-2024-477). Formal permission was also obtained from the university and the participating schools.

Data collection was carried out with the voluntary and informed consent of the participants, who were also allowed to withdraw from the study at any time if they wished.

The researcher ensured data privacy, anonymity, and confidentiality. All data were securely stored and properly disposed of in accordance with ethical standards.

**COMPETING INTERESTS**

The authors declare no competing interests.

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