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Enhancing Self-Directed Learning, Academic Self-Efficacy, and Student Performance in Science, Technology, and Society under Modular Distance Learning

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Abstract

Understanding the factors influencing academic performance is particularly crucial in the context of the COVID-19 pandemic, especially under modular distance learning (MDL) conditions. This descriptive-correlational study investigates the relationships among self-directed learning skills, academic self-efficacy, and student performance in the Science, Technology, and Society (STS) course during the implementation of MDL. A total of 550 university students were purposively selected from an initial population of 694 enrolled in STS courses at West Visayas State University – Calinog Campus, Iloilo, Philippines, during the academic years 2020–2021 and 2021–2022. Data were collected through Google Forms, using pilot-tested instruments measuring self-directed learning and academic self-efficacy. Final course grades were used to determine STS performance. Descriptive and inferential statistical methods were applied, with a significance level set at $\alpha = 0.05$. Findings revealed that the majority of respondents demonstrated high levels of self-directed learning skills and academic self-efficacy. In terms of performance, most students achieved "satisfactory" to "very satisfactory" grades, with a smaller number attaining "outstanding" and "highly outstanding" outcomes—highlighting adaptability and resilience in a modular learning environment. Moreover, significant positive correlations were found among self-directed learning skills, academic self-efficacy, and academic performance. These results underscore the importance of integrating strategies that promote self-regulated learning and academic confidence into teaching practices, curriculum design, and policy formulation. The findings contribute to the development of targeted interventions aimed at improving student outcomes, particularly in higher education institutions implementing module-based or flexible learning modalities in the post-pandemic educational landscape.

Introduction

In 2020, the Philippines faced significant challenges due to the widespread disruptions caused by the COVID-19 pandemic, affecting key sectors such as the economy, healthcare, culture, and education. The global health crisis had a profound impact on educational systems worldwide, leading to the widespread closure of schools, universities, and colleges (United Nations, 2020). The higher education sector in the Philippines was

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particularly affected, as noted by Toquero (2020). In response to these challenges, educational institutions worldwide were compelled to transition from traditional in-person instruction to online, distance, or remote learning modalities (Masha, et al.,, 2020). In the Philippines, the Commission on Higher Education (CHED), in accordance with directives from the Inter-Agency Task Force for COVID-19, issued Memorandum Orders mandating the suspension of face-to-face classes, including on-the-job training and internships (CHED, 2020). Many public and private educational institutions were unprepared for this abrupt transition, necessitating the adoption of blended or fully remote learning approaches. To guide this transition, CHED introduced Memorandum Order No. 4 in 2020, outlining policies for Higher Education Institutions (HEIs) to implement flexible learning; a framework encompassing various instructional modalities for distance education. In alignment with the recommendations of the United Nations Educational, Scientific, and Cultural Organization (UNESCO), HEIs were granted autonomy to select the most suitable and effective learning approaches for their students, whether online, offline, blended, or a combination thereof (Antonio, 2022; Magsambol, 2020).

In response to these challenges, the university found it necessary to adapt its teaching and learning methods to the "new normal." The university developed a blended learning policy to serve as the foundation for the administration and faculty at West Visayas State University (WVSU) in implementing a variety of teaching modalities. In the first semester of the Academic Year 2020-2021, the university made the decision to embrace remote learning due to the escalating COVID-19 cases in the province, which posed significant risks to both faculty and students. This remote learning approach included the option of modular instruction, online classes, or a combination of both. The WVSU-Calinog Campus (WVSUCC), as one of the satellite campuses, chose to implement modular instruction throughout the Academic Year 2020-2021 and continued with this approach for certain courses in the Academic Year 2021-2022, particularly for the STS course. This decision was largely influenced by the fact that a majority of students lacked internet access and the necessary facilities for online classes.

One of the most engaging courses that empower students to critically assess the societal impacts of the pandemic is Science, Technology, and Society (STS), which helps students make ethical decisions and actively engage in class discussions and public discourse. It is a general education course exploring the interplay between scientific and technological advancements and their social, cultural, and political contexts (CHED, 2013). STS educates students that science goes beyond rigid procedures, empowering them to contribute to societal well-being through scientific knowledge and active democratic engagement (Autieri et al.,, 2016). Since the onset of the COVID-19 pandemic, science has become more crucial to everyday life than ever before (Ball, 2021). Moreover, science, technology, and global innovation have been pivotal in addressing the pandemic and the resulting unprecedented socio-economic crisis (Paunov et al., , 2021). The STS course helps cultivate scientific literacy, enabling individuals to synthesize ideas, formulate and defend arguments, and adapt concepts in the face of new information (Croce & Firestone, 2020). Education must prepare students for the volatile, uncertain, complex, and ambiguous (VUCA) world and address emerging societal challenges (Johansen & Euchner, 2013; Panthalookaran, 2022), most especially in the pandemic times.

The pandemic brought significant changes to STS education, with the transition to online and modular learning disrupting the traditional classroom environment and limiting interactive discussions and hands-on activities essential for exploring the connections between science, technology, and society. Thus, to address this, the university developed and distributed printed or digitized modules for the course NSCI 110: Science, Technology, and Society (STS), taking into consideration the students' geographic locations and their access to internet connectivity. The adoption of Modular Distance Learning (MDL) was also motivated by the students' reported sense of disconnection from society and their social circles, attributed to the quarantine measures during the COVID-19 pandemic and the closure of educational institutions (Killian, 2020). MDL is a learning modality that is particularly suitable for areas with limited internet access. As stated by Abude (2021), modular learning, which utilizes Self-Learning Modules (SLM), proves to be extremely convenient for the majority of regular Filipino students. This approach has been proven to be efficient and effective for students' learning, irrespective of whether the subject matter is easy or challenging (Malik, 2012). It offers benefits to both teachers and students, with students learning at their own pace and teachers able to adapt to various teaching settings (Valencia, 2020).

In light of the ongoing pandemic, which had a significant impact on the teaching and learning processes, students' primary objective remains to attain improved academic performance. However, it is undeniable that the learning environment also influenced various aspects of each student as an individual learner due to the abrupt changes in learning methods. The Philippine university students facing challenges such as unstable internet, insufficient resources, power interruptions, unclear content, excessive activities, limited support, communication issues, home responsibilities, financial strains, and health struggles during the COVID-19 crisis (Rotas & Cahapay, 2020). Laguador (2021) noted concerns among college students about achieving learning outcomes through flexible modalities, particularly in laboratory-intensive classes, alongside challenges in instructional delivery and teacher communication. There were various difficulties in modular distance learning for university students, according to Bustillo and Aguilos (2022), which includes internet connectivity issues, inadequate resources, unclear task instructions, excessive workload, poor learning environments, and mental health concerns. The pandemic required the swift implementation of various learning modalities, such as MDL, to ensure educational continuity, compelling institutions to engage in extensive planning and strategizing (Betlen, 2021; Nolasco, 2022). Universities and colleges should conduct strategic scenario analyses for various outcomes in curriculum, student engagement, and technology to ensure educational continuity during and beyond the pandemic. They must adopt flexible teaching modalities by updating curricula, training faculty, and enhancing infrastructure. These strategies should be continually assessed and adapted to address changing conditions in times of crisis (Dayagbil et al., 2021). By addressing these challenges through rigorous research and proactive interventions, educational institutions can mitigate disparities, promote equity in access to education, and ensure that students receive the necessary support to thrive academically and personally amidst evolving learning modalities and global uncertainties.

According to Saiz-Linares, et al.,(2019), learners grapple with an array of personal, intellectual, and social factors across different situations. Specifically, the sudden transition from traditional face-to-face classes to modular instruction has affected certain non-cognitive aspects of students, including their self-directed learning skills and self-efficacy in relation to their studies. These variables represent crucial psychological concepts and resources that are pivotal for students' academic success and may significantly impact college students' persistence in light of the challenges they have encountered during the pandemic.

Self-directed learning (SDL) encompasses individuals' capacity to independently seek and apply resources, information, and skills, facilitating adaptation to new environments and effective problem-solving (Herlo, 2017; Tan et al., 2011). It underscores learners' responsibility for managing their own learning, integrating both motivation and ability for self-direction (Brockett & Hiemstra, 2018; Nasri & Mansor, 2016). SDL is strongly linked with academic achievement, as evidenced by research demonstrating its positive impact on student performance and success. (Bodkyn, 2015; Cazan & Schiopca, 2014; John & Michael, 2018; Kan'an & Osman, 2015; Lounsbury et al., 2004; Oducado, 2021; Saeid & Eslaminejad, 2016; Tekkol & Demirel, 2018; Triastuti, 2016). Self-directed learning skills are crucial in the educational context, especially during crises like the COVID-19 pandemic, as they empower students to independently manage and adapt their learning processes in the face of disruptions. Xu et al. (2020) emphasized that, similar to modular learning setups, online teaching formats without in-class components require students to independently complete numerous learning tasks as arranged by their schools and teachers. Therefore, the ability to learn independently is particularly important during the pandemic. Self-directed learning skills were crucial for students to adapt, solve problems, manage time, personalize learning, stay engaged, and develop critical skills for lifelong adaptability. Additionally, Mahlaba (2020) highlighted the importance of SDL during the pandemic, as it allows students to engage in the global knowledge production economy while "salvaging the academic year."

Academic self-efficacy, described by Elias and MacDonald (2007), refers to an individual's belief in their ability to achieve educational goals through strategic actions, driving dedication and effort (Pintrich, 2003). It influences task selection and persistence, with those attributing failures to effort rather than ability (Kurbanoğlu & Akın, 2010), showing increased perseverance and effective task completion strategies (Bandura, 1997; Jung & Lee, 2018; Li et al., 2020; Schunk & Ertmer, 2000). This self-belief enhances academic performance (Tian, et al., 2018), intertwining with motivation (Arik, 2019) and impacting students' choices, efforts, and emotional responses in learning contexts (Bandura, 1997).

Academic self-efficacy plays a crucial role in education, especially during crises like the COVID-19 pandemic, influencing students' confidence in overcoming challenges and achieving academic success. Research by Irawan et al.,(2020) and Irfan et al. (2020) indicates that limited teacher-student interaction in online classes due to pandemic-related barriers has hindered students' ability to ask questions and express ideas, leading to increased anxiety. Therefore, activating students' self-belief and determination is essential for overcoming these obstacles and boosting motivation and confidence in learning (Aure & Jugar, 2017; Casinillo & Casinillo, 2020). Particularly in the pandemic era, where learning environments may not be optimal, self-efficacy has emerged as a significant factor in online education settings (Hodges, 2008; Shen et al., 2013; Zimmerman & Kulikowich, 2016), helping learners navigate new experiences associated with online learning. Moreover, students in online settings require enhanced self-direction and self-regulation for academic success (Goulão & Menedez, 2015), aligning with Pajares (2009) assertion that efficacious learners persist longer despite challenges.

While studies have explored modular distance learning and academic performance, limited research has focused on psychological factors such as self-directed learning skills and academic self-efficacy, particularly during the COVID-19 pandemic. No prior research has comprehensively examined the factors affecting university students' performance in an STS course within modular distance learning. This study aims to fill this gap by investigating the relationship between self-directed learning skills, academic self-efficacy, and STS performance. This research seeks to evaluate these skills and their impact on STS performance, enhancing college students' success in module-based learning environments. The findings will guide educational strategies to nurture self-directed learning and academic confidence, promoting overall academic success.

Objectives

This research investigated the self-directed learning skills, academic self-efficacy, and performance in Science, Technology, and Society (STS) of students enrolled at a state university located in the province of Iloilo, Philippines. The study was designed with two primary objectives:

1. To determine the level of self-directed learning skills, academic self-efficacy and STS performance of the respondents in a Modular Distance Learning (MDL).

2. To determine the relationships among the self-directed learning skills, academic self-efficacy, and Science, Technology and Society (STS) performance of the respondents in a Modular Distance Learning (MDL).

Hypothesis

In view of the foregoing statements, the following null hypothesis was formulated: There is no significant relationship among self-directed learning skills, academic self-efficacy, and Science, Technology and Society (STS) performance of the respondents in a Modular Distance Learning (MDL) modality.

Literature Review

Self-Directed Learning (SDL) in Distance Education

Amid the pandemic, SDL in Distance Education in the Philippines highlights the effectiveness of student-driven approaches for university students. It emphasizes the importance of student autonomy in setting goals, tracking progress, and using tailored online resources, proving crucial for effective learning amid pandemic challenges. Knowles (1975) defines SDL as learners actively identifying their learning needs, selecting resources, employing strategies, and independently monitoring progress. This promotes autonomy in learning management, empowering students to establish goals, utilize suitable materials, and assess academic progress effectively. It is also defined as the pursuit of performance, information, or capabilities by individuals using resources independently, anytime and anywhere, as asserted by Herlo (2017). This independence underscores the essential skill of adapting to new environments and situations, enabling individuals to promptly seek and apply resources for problem-solving and improvement in various contexts, as noted by Tan et al. (2011). Brockett and Hiemstra (2018) emphasize SDL as a reliance on one's initiative to resolve challenges and achieve better outcomes. Nasri and Mansor (2016) categorize SDL as a process, purpose, and methodology, where learners take responsibility for identifying learning gaps and setting objectives, managing tasks and resources autonomously, and integrating knowledge across disciplines and learning environments, as highlighted by Khiat (2017). Moreover, it involves assessing learning requirements, setting learning objectives, choosing and applying suitable learning methods, and assessing learning achievements independently or with assistance (Levett-Jones, 2005).

Modular or online teaching formats that lack in-person components require students to autonomously complete a variety of learning tasks by following the school and teacher's guidelines. Factors influencing SDL are diverse and include both external and internal dimensions. External factors such as support from loved ones, educators, resources, peer connections, and parenting advice, along with internal factors like physical health, leisure time, personal interests, maturity, and cognitive abilities, all play significant roles in academic success (Nyambe et al.,2016). Weinstein and Mayer (1986) underscore the importance of effective learning strategies in acquiring knowledge, while studies demonstrate the effectiveness of methods like peer teaching and collaborative assignments in enhancing learning among self-directed learners (Bryan, 2015; Douglas & Morris, 2014). In modular learning environments, strategies to enhance SDL include fostering learner autonomy, employing interactive platforms, integrating self-assessment tools, and providing personalized feedback mechanisms. SDL, as defined by Wijaya et al., (2020), involves independently setting goals, accessing resources, implementing strategies, and evaluating outcomes (Wongsri et al., 2002). However, challenges highlighted by Adnan and Anwar (2020) such as resource constraints in academic institutions and among marginalized students, limited internet access, and technological barriers, hinder organizational responsiveness and student engagement in learning (Zhong, 2020), particularly affecting economically disadvantaged students.

Numerous studies have explored the correlation between SDL and academic success, emphasizing its pivotal role in educational outcomes. Lounsbury et al. (2004) underscored SDL's close association with academic achievement, while Cazan and Schiopca (2014) identified it as a reliable predictor of learners' academic success. Khiat (2015) further illustrated SDL's influence on student performance, and Tekkol and Demiral (2018) provided evidence of its significant impact on university students' academic achievements. Saeid and Eslaminejad (2016) established correlations between SDL, academic achievement, and readiness for learning, whereas Kan'an and Osman (2015) emphasized SDL's importance in science education success. Further, Malison and Thammakoranonta (2018) and Suknaisith (2014) highlighted students' satisfaction with SDL and its positive effects on learning attributes such as self-discipline, self-management, and motivation. Additionally, Oducado (2021) demonstrated that SDL is essential for academic success in nursing education, revealing that self-esteem, perseverance, and SDL skills enhance nursing students' performance. A similar result was observed in online EFL courses (Torun, 2020), underscoring the significance of proactive learning, self-management, and self-control in achieving academic success. Thus, the capacity to learn autonomously was critical during the COVID-19 pandemic (Xu et al., 2020). SDL skill was an influential indicator of educational achievement (Tio et al., 2016).

Academic Self-Efficacy in Modular Distance Learning (MDL)

In MDL settings, academic self-efficacy denotes students' confidence in achieving academic success through remote learning. This includes their ability to set and achieve goals, utilize online resources effectively, and tackle challenges independently. Given the limited face-to-face interaction in MDL, strong academic self-efficacy is pivotal in motivating students to persevere, manage their studies efficiently, and navigate diverse technological and educational requirements. During the pandemic, MDL became vital in the country due to restrictions on in-person classes. This shift significantly influenced university students' academic self-perception and outcomes, particularly their academic self-efficacy, as defined by Bandura (2004). This belief in their ability to excel in academic tasks shapes their approach to goals and challenges (Luszczynska & Schwarzer, 2005), impacting their learning choices and effort (Bandura, 1977, 1982, 1989; Schunk, 1989a, 1989b; Zimmerman et al., 1992). Enhanced self-efficacy, linked to perceived capabilities in academic contexts (Zimmerman, 2000), correlates with greater motivation, persistence, and problem-solving skills (Puzziferro, 2008; Zhang et al., 2018), influencing students' commitment and academic comprehension (Hill, 2002). This trait, described by Blanco et al. (2011), shapes students' ambitions and achievements across diverse academic goals, encompassing attention to challenges, communication skills, and strategies for meeting academic standards (Fuenmayor & Villasmil, 2008; Herrera, 2013; Valdivieso et al., 2013). Research suggests that high self-efficacy is associated with greater willingness to attempt and perform tasks, thereby influencing academic outcomes (Bandura & Locke, 2003; Farnsworth et al., 2004; Qadoos et al., 2020; Schunk, 1991). Thus, predicting academic performance alongside cognitive abilities (Abid et al., 2019; Murphy & Alexander, 2000).

The sudden transition to emergency remote teaching during the pandemic prompted concerns about its impact on students' perceived self-efficacy in achieving academic success, given their lack of preparation for such rapid changes (Abreu, 2020). Academic self-efficacy among college students strongly influences their academic performance and goals, affected by stressors such as task overload and the pandemic, as evidenced by research demonstrating its enhancement of study skills, cognitive abilities, motivation, and predictive value for academic success in diverse educational settings. Stressors like task overload, work pressure, evaluations, and the pandemic have been shown to decrease self-efficacy, with 29% of highly stressed students reporting low self-efficacy levels (Navarro-Mateu et al., 2020). Emphasizing the role of emotions, De la Fuente et al. (2019) demonstrated that higher levels of positive emotionality enhance academic success in conjunction with academic self-efficacy.

The connection between academic self-efficacy and performance is pivotal in educational research, highlighting its substantial influence on student achievement. Research by Alyami et al. (2017), Doménech-Betoret, et al. (2017), Putwain et al. (2012), Valdebenito (2017b), and Veresova and Foglova (2016) demonstrates how academic self-efficacy relates to motivation, learning outcomes, scholarship accessibility, and academic persistence. Tian et al. (2018) additionally illustrate improvements in academic self-efficacy and performance through interventions such as group hope therapy. Academic self-efficacy plays a crucial role in academic success, correlating with improved study skills and cognitive abilities for better academic organization (Delgado et al., 2019). Studies by Ahmadi (2020), Colom (2012), and Robiños et al. (2020) highlight its positive association with academic performance and engagement in specific subjects. High self-efficacy predicts better academic outcomes consistently across studies (Ahmad & Akbar, 2020; Tenhet, 2013; Walker & Greene, 2009), influencing academic aspirations indirectly (Ahmadi, 2020) and promoting effective learning strategies (Afifah & Indriwardhani, 2021; Agustiani et al., 2016).

Science, Technology, and Society (STS) Education in MDL Settings

The STS course in MDL framework embodies a modern educational paradigm that examines the complex connections among scientific progress, technological developments, and their societal consequences within a versatile and inclusive learning setting. This method empowers students to independently explore STS topics, adjusting their learning to suit various schedules and preferences. Nonetheless, MDL introduces distinct challenges, such as fewer chances for interactive and collaborative learning, which are pivotal for understanding STS's interdisciplinary essence. Overcoming these obstacles is crucial to fully harnessing MDL's potential benefits in fostering critical thinking and ethical decision-making abilities essential for addressing multifaceted global issues.

The University of the Philippines (UP) mandates the STS course for undergraduates. Following UP's lead, the CHED included it in the revised general education curriculum, making it mandatory for all colleges and universities nationwide (Vallejo, 2013). The course examines the connections between technological and scientific developments and the social, cultural, political, and economic settings in which they develop and evolve (CHED, 2013). This interdisciplinary course examines how science and technology influence society, which is crucial for human development. It emphasizes that socio-political, cultural, economic, and philosophical factors shape scientific and technological advancements. The course aims to develop students' reflective knowledge for ethical decision-making and fulfilling lives and contains required lessons on understanding the environment and the changing climate.

In the pandemic context, university students learned the STS course via modular instruction, utilizing both printed and digital modules that included comprehensive content, exercises, and assessments. This self-paced method facilitated independent study management amidst pandemic challenges, with instructors providing support through online consultations and messaging. Assessments, which included online submissions and quizzes, were accompanied by continuous feedback and emotional support crucial for maintaining effective learning. While MDL offers flexibility and accessibility in STS course, its limited interactive and collaborative aspects pose challenges for grasping interdisciplinary concepts fully. Addressing these limitations is essential to optimize MDL's impact on improving STS course outcomes and preparing students for complex societal dynamics.

Employing MDL for the STS course offers benefits like flexibility and accessibility, yet also poses challenges such as restricted interactive and collaborative learning opportunities, highlighting the importance of

finding a balance to enhance educational outcomes in this interdisciplinary field. It has revolutionized STS education, offering flexibility and accessibility that accommodate diverse student needs (Bernard et. al, 2014; McKnight et al, 2016). However, MDL's reliance on remote formats diminishes opportunities for interactive and collaborative learning crucial in understanding STS's interdisciplinary nature (Vaughan et al., 2013). The absence of face-to-face interactions and hands-on experiences may hinder students' grasp of complex interactions between science, technology, and society (Liu et al., 2007; Pannekoek & Ally, 2008). Disparities in access to technology raise concerns about educational equity in MDL environments, emphasizing the need for innovative pedagogical strategies and institutional support to address these challenges and provide effective STS education for all students (Hodges et al., 2020). Future research should continue to explore strategies for enhancing the effectiveness of MDL in STS education while mitigating its limitations.

Conceptual Framework

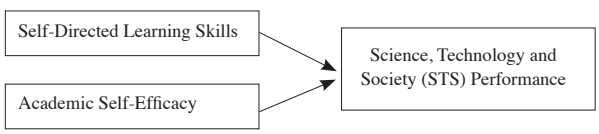

Figure 1 Conceptual Framework

Research Methodology

1. Population and Samples

This study utilized a descriptive-correlational research design using a quantitative approach via an online survey. The choice of this methodology became necessary due to the limitations enforced during the General Community Quarantine, which limited traditional data collection methods. The primary focus of data collection was among students from various departments, including education, agriculture, business and management, and information technology, at the West Visayas State University-Calinog Campus. Data was gathered over the academic years 2020-2021 and 2021-2022. Specifically, the actual data collection took place from August 2020 to May 2022, during which participants were recruited and survey responses were gathered, aligning with the implementation of modular instruction as an educational delivery method during that particular period.

In this study, the researchers utilized purposive sampling to determine the number of respondents. In order to be included in the analysis, participants had to meet specific inclusion criteria, which were as follows: 1) enrolled and have taken NSCI 110 (Science, Technology & Society), this criterion ensures that all respondents share a common foundation of knowledge, providing a consistent basis for analyzing and comparing self-directed learning skills, academic self-efficacy, and STS performance. It helps establish clear and relevant relationships among these variables within the MDL context; 2) have at least 18 years of age at the time of the study, this describes that respondents who are 18 years or older are legally adults, implying maturity and independence essential for self-directed learning and reliable self-assessment. Their age ensures they can engage meaningfully with the study's objectives, and 3) willing to take part in the survey. This criterion respects respondents' autonomy, allowing them to choose participation. Willing participants are more likely to provide thoughtful and honest responses, essential for assessing self-directed learning skills, academic self-efficacy, and STS performance.

Initially, all 694 students who were enrolled in and had taken the subject were invited to participate in the survey. However, the final analysis incorporated the responses of only 550 students who satisfied the inclusion criteria. This resulted in a response rate of 79.25% (550 out of 694). It is worth noting that while some researchers consider a 50% response rate as acceptable, it is important to recognize that online surveys typically achieve lower response rates than their paper-based counterparts, as discussed by Nulty (2008) and Moralista and Oducado (2020).

2. Research Instruments

While the research instruments, specifically self-directed learning skills and academic self-efficacy, were previously established as valid and reliable, they were subjected to pilot testing to ensure their suitability for the present context and the targeted respondents. This pilot testing was conducted using Google Forms, the same method employed for the final data collection procedures.

A research instrument adapted from Ayyildiz and Tarhan (2015) was employed to evaluate the self-directed learning skills of the participants. This scale included 20 items created to evaluate the self-directed learning skills of the respondents. Responses were collected using a 5-point Likert scale, with choices spanning from 5 for "strongly agree" to 1 for "strongly disagree," indicating the degree to which respondents agreed or disagreed with

each statement. Within the framework of this study, the overall Cronbach's alpha coefficient for the scale was computed at 0.92, signifying its reliability.

The assessment of academic self-efficacy was conducted using a scale adapted from the Motivated Strategies for Learning Questionnaire (MSLQ) by Duncan and McKeachie (2005). In particular, this scale focused on self-efficacy related to learning and performance, a subcategory within the MSLQ. It comprised 8 items created to assess students' academic self-efficacy within the scope of modular distance learning. Participants were directed to assess each item using a 5-point Likert-type scale, with numeric values spanning from 1 (representing the lowest level) to 5 (representing the highest level). In this study, the overall Cronbach alpha coefficient for the scale was calculated at 0.91, indicating its reliability.

The assessment of Science, Technology and Society (STS) performance involved evaluating the final grades achieved by the respondents during specific semesters when modular instruction was implemented as a response to COVID-19 restrictions. Participants were requested to disclose their final grades in the questionnaire, provided they had granted permission by signing a waiver that allowed the researchers to collect this data.

3. Data Collection

The survey itself was conducted using Google Forms. The survey link was distributed among the respondents through their university e-mail accounts, group chats and other social media platforms. Students from each year level and section enrolled in the subject were assigned STS course chat groups to ensure easy communication and accessibility as survey respondents. The researcher sent reminders at different times to accommodate various time zones and daily schedules, maximizing response rates. To maintain neutrality and inclusivity, the survey introduction and questions were carefully worded to avoid leading responses.

To adhere to current health protocols and COVID-19 guidelines, in-person, pen-and-paper administration was avoided to minimize face-to-face interactions. All actions in this study adhered to the principles delineated in the Declaration of Helsinki. Before the study began, all participants provided online, voluntary, and informed consent. They were informed about the survey's purpose and the importance of their participation. Consent was obtained prior to their engagement with the questionnaire. Clear instructions were provided, and participants were given the option to decline participation at their discretion. The researcher ensured that any concerns or questions from participants were appropriately addressed before, during, and after the questionnaire administration. Additionally, respondents were assured that all collected information would be kept strictly confidential and used solely for academic research purposes.

4. Data Analysis

The data collected via Google Forms were acquired and then analyzed using SPSS version 23. Categorical variables for respondents' profiles and STS performance were presented in terms of frequencies and percentages. To describe the data, measures such as means and standard deviations were calculated. The means were used to describe the level of self-directed learning skills and academic self-efficacy, while standard deviations were utilized to determine the homogeneity or heterogeneity of the respondents' responses in self-directed learning skills and academic self-efficacy. Spearman's rho was employed to examine correlations among the variables. This investigation used a non-probability sampling technique, and data obtained for these variables were found to be non-normally distributed. Thus, this non-parametric test of relationship was used. While the study generally used a significance level of $\alpha = 0.05$, a tighter threshold of $\alpha = 0.001$ was used specifically for the Spearman rho correlations to ensure the findings were as reliable as possible.

For assessing the participants' levels of self-directed learning skills and academic self-efficacy, the researchers applied a scale and interpretations based on the Nearest-Integer Response from Normally-Distributed Opinion (NIRNDO) Model for Likert Scale, as developed by Pornel (2011).

For Self-Directed Learning Skills:

Mean	Interpretation
4.50 - 5.00	Very High
3.50 - 4.49	High
2.50 - 3.49	Moderate
1.50 - 2.49	Low
1.00 - 1.49	Very Low

For Academic Self-Efficacy:

Mean	Interpretation
4.50 - 5.00	Very High
3.50 - 4.49	High
2.50 - 3.49	Moderate
1.50 - 2.49	Low
1.00 - 1.49	Very Low

In order to determine the degree to which academic self-efficacy, self-directed learning abilities, and STS performance are related, the researchers applied Spearman's rho. This evaluation classified the intensity and orientation of the relationship based on the criteria set forth by Dancey and Reidy (2004).

Spearman rho	Correlation
> + 0.70	Very Strong Relationship
+ 0.40 – 0.69	Strong Relationship
+ 0.30 – 0.39	Moderate Relationship
+ 0.20 - 0.29	Weak Relationship
+ 0.01 – 0.19	No or Negligible Relationship

Results

The Respondents

Since this investigation applied purposive sampling technique, all students taking the STS course during that time were considered as participants. However, only 550 students who satisfied the inclusion criteria were qualified to be participants out of 694 total populations of the target respondents.

Table 1 data indicate that out of the 550 qualified participants in the study, 140 (25.50%) were male, and 410 (74.50%) were female. Regarding age, 253 (46.00%) were 21 years old or older, whereas 297 (54.00%) were 20 years old and younger. When it came to the number of siblings in their families, 398 (72.40%) had five or fewer, and 152 (27.60%) had six or more. In terms of their location, 508 (92.40%) were from barangay-based areas, while 42 (7.60%) resided in town-based locations. In their evaluation of modular learning instruction, 65 (11.82%) respondents reported being very satisfied, 237 (43.09%) were satisfied, 146 (26.55%) were dissatisfied, and 102 (18.55%) were very dissatisfied.

Table 1 Distribution of the Respondents

Category	Frequency (F)	Percentage (%)
Entire Group	550	100.00
Gender		
Male	140	25.50
Female	410	74.50
Age		
21 yrs old and above	253	46.00
20 yrs old and below	297	54.00
No. of Siblings in the Family		
5 or less	398	72.40
6 or more	152	27.60
Location		
Barangay-Based	508	92.40
Town-Based	42	7.60
Modular Distance Learning Satisfaction		
Very Satisfied	65	11.82
Satisfied	237	43.09
Dissatisfied	146	26.55
Very Dissatisfied	102	18.55

Self-Directed Learning Skills

Table 2 illustrates the self-directed learning skills levels of the respondents. The statement "I think that taking an active role in learning is important. "received the highest weighted mean (M = 4.41, SD = 0.67) among all the statements describing the self-directed learning skills of the respondents. The statement "I'm having

Table 2 Respondent's Profile in Terms of Self-Directed Learning Skills

Indicator	Mean	SD	Verbal Interpretation
1. When learning a new topic, I make notes on the most significant aspects.	4.29	0.67	High
2. I feel that I am capable of learning a lesson, in spite of how hard the situation is.	3.99	0.70	High
3. Instead of using the internet to have a nice time, I should be using it for educational reasons.	4.06	0.74	High
4. I use a variety of learning methodologies, each of which is tailored to the characteristics of the subject matter I am studying.	3.98	0.76	High
5. I'm having trouble applying what I've learned in the lessons to my everyday activities.	3.46	0.95	Moderate
6. Making plans helps me to arrange my study time.	4.34	0.70	High
7. When reading texts, I highlight the key points.	4.13	0.77	High
8. If I am able to make connections between new ideas and previous information, the learning has been effective.	4.16	0.72	High
9. Whenever I am driven to study, any distracting elements do not cause me to deviate from my course of action.	3.69	0.89	High
10. When I am learning a new topic, I pay close attention to the establishment of relationships between ideas.	4.06	0.83	High
11. After each learning experience, I consider what I can do to improve my performance.	4.27	0.76	High
12. I take ownership of my learning.	4.10	0.71	High
13. I always evaluate my performance in the exercises/ homework that I have accomplished.	4.05	0.73	High
14. To learn a new topic quickly, I must first master related prior courses.	3.99	0.80	High
15. I find some time for learning while preparing a new day.	4.00	0.73	High
16. When I begin to learn anything new, I go through my previous knowledge that serves as the foundation for the new subject.	4.13	0.71	High
17. When I solve a problem, I may come up with different solutions.	3.92	0.80	High
18. I think that taking an active role in learning is important.	4.41	0.67	High
19. The important thing is not what I learn, but whether I've got a passing grade.	3.33	1.26	Moderate
20. I keep myself motivated by realizing the outcome I will achieve at the completion of a learning experience.	4.34	0.79	High
Overall	**4.03**	**0.50**	**High**

trouble applying what I've learned in the lessons to my everyday activities." obtained the lowest weighted mean (M = 3.46, SD = 0.95) of all the accounts. The overall weighted mean of 4.03 and a standard deviation of 0.50 indicate that the respondents have "high" level of self-directed learning skills.

Academic Self-Efficacy

As shown in Table 3, the statement "I expect that by using this method of teaching/instruction, I will be able to improve my learning." had the highest weighted mean of 4.05 with standard deviation of .75. While the statement ''I am sure that I can understand the module's most difficult content." had the least weighted mean of 3.55 with a standard deviation of 0.83. To sum up, the overall weighted mean of 3.83 and an overall standard deviation of 0.62 indicates that the respondents have "high" level of academic self-efficacy.

Table 3 Respondent's Profile in Terms of Academic Self-Efficacy

Indicator	Mean	SD	Verbal Interpretation
1. I am confident that I will obtain a high grade.	3.88	0.76	High
2. I am confident that I can understand the most challenging topics covered in the module.	3.82	0.76	High
3. I am sure that I will be able to understand the fundamental concepts.	3.83	0.72	High
4. I am sure that I can understand the module's most difficult content.	3.55	0.83	High
5. I am positive that I will perform well on the module's learning assessments.	3.85	0.84	High
6. I expect that by using this method of teaching/ instruction, I will be able to improve my learning.	4.05	0.75	High
7. I am confident that I will be able to master the concepts presented in the course module.	3.76	0.81	High
8. Given some difficulty of this course, I believe I will perform well upon utilizing this delivery mode of learning.	3.90	0.84	High
Overall	**3.83**	**0.62**	**High**

Science, Technology and Society (STS) Performance

As shown in Table 4, the majority of respondents demonstrated a "satisfactory" performance in STS, accounting for 102 individuals, equivalent to 18.55%. This observation underscores a significant representation of individuals within this category, indicating an acceptable level of performance. It suggests that a considerable number of students effectively navigated the challenges of distance learning during the pandemic, meeting the fundamental requirements and expectations of their courses utilizing modular distance learning. Following this, 80 respondents, constituting 14.55% of the total, achieved a "very satisfactory" STS performance, indicating a high level of achievement. This category represents a significant portion of the dataset, indicating that respondents successfully adapted to the new learning environment and demonstrated exceptional dedication and academic achievement. Additionally, 78 respondents, representing 14.18% of the total, attained a "very good" STS performance, highlighting a substantial number of individuals who performed at an impressively high level. These respondents demonstrated a commendable level of adaptability and success in their STS subjects during the pandemic while utilizing modular instruction. Although their performance is notably high, it falls just slightly below the "very satisfactory" category.

In the "fair" category, which comprises 74 instances and accounts for 13.45% of the total, there was a moderate level of STS performance, reflecting a significant portion of the data. These respondents managed to adapt to the challenges of modular distance learning to a reasonable extent, indicating a substantial representation of individuals who coped reasonably well with the transition. Furthermore, 69 respondents, equivalent to 12.55%, demonstrated an "outstanding" STS performance, representing a larger proportion compared to the "highly outstanding" category. This group signifies a distinguished set of students known for their exceptional attributes and remarkable performance in their STS courses during the pandemic. Among the respondents, the "good" category, which encompasses 57 instances and constitutes 10.36% of the total, signifies a reasonable level of STS performance, although it falls short of the "very good" or "outstanding" categories. Lastly, 46 respondents, accounting for 8.36% of the total, achieved a "highly outstanding" STS performance. This implies that only a relatively small portion of the total falls within this category, possibly representing individuals with remarkable or exceptional STS

Table 4 Science, Technology and Society (STS) Performance Level of the Respondents

Level	F	%
Highly Outstanding	46	8.36
Outstanding	69	12.55
Very Good	78	14.18
Good	57	10.36
Very Satisfactory	80	14.55
Satisfactory	102	18.55
Fair	74	13.45
Passing	44	8.00
Total	**550**	**100.00**

performance during the challenging period of modular distance learning. In conclusion, 44 respondents, or 8.00%, were categorized under the "passing" category, representing a relatively small proportion of the respondent population who faced challenges in adapting to the demands of distance learning through modules during the pandemic.

Relationships among Self-Directed Learning Skills, Academic Self-Efficacy and Science, Technology and Society (STS) Performance of the Respondents

Table 5 shows that there was a significant positive relationship (rho = .528; p = .000) between self-directed learning skills and academic self-efficacy; between self-directed learning skills and STS performance (rho = .487; p = .000); and between academic self-efficacy and STS performance (rho = .515; p = .000). The computed p-values are significant at .001 alpha level. The null hypothesis assuming no significant relationships among self-directed learning skills, academic self-efficacy and Science, Technology and Society (STS) performance of the respondents was therefore, rejected. The study provided compelling evidence for rejecting the null hypothesis, indicating significant and strong positive correlations among self-directed learning skills, academic self-efficacy, and STS performance among the respondents. These findings imply that greater proficiency in self-directed learning skills and academic self-efficacy correlates with enhanced performance in STS domains. In other words, their ability to independently guide their learning process and their confidence in their academic abilities positively influence their effectiveness in understanding and navigating complex issues within the realms of science, technology, and societal interactions. Thus, higher levels of these skills and self-beliefs are indicative of enhanced performance in areas that require interdisciplinary knowledge and critical analysis of contemporary scientific and technological issues in society in the MDL framework during the pandemic period.

Table 5 Relationships among Self-Directed Learning Skills, Academic Self-Efficacy and Science, Technology and Society (STS) Performance of the Respondents

(N=550)

Variables	Self-Directed Learning Skills	Academic Self-Efficacy	STS Performance
Self-Directed Learning Skills	1		
Academic Self-Efficacy	.528***	1	
STS Performance	.487***	.515***	1

*** $p < 0.001$

Discussion

This outcome illustrates that the self-directed learning skills of the respondents do not fall into the "very high" category, nor are they considered "very low" or "low"; instead, they are rated as falling within the "high" to "moderate" range. This rating suggests that most students possess self-directed learning skills that range from moderate to high. When analyzing individual items separately, the majority of students received mean ratings that align with the interpretation of "high." Only two items received mean ratings that are interpreted as "moderate." Overall, "high" level self-directed learning skills of the students during the pandemic indicates that they successfully managed their own learning, adapted to remote education, and sustained academic progress despite the challenges. These results consistently adhere with the Garrison's Self-Directed Learning Theory (1997), which highlights learner autonomy in goal setting, progress monitoring, and adjustment. This theory suggests that learners actively engage in these processes to improve outcomes. Despite disrupted learning environments, students driven by academic self-efficacy remained actively engaged (Roberson et al., 2021). The shift to modular distance learning necessitated the development of self-directed learning skills, including independent action, goal setting, resource management, and outcome assessment (Wijaya et al., 2020; Wongsri et al., 2002). They adapted by creating personalized goals and using online platforms and resources (Mahlaba, 2020), demonstrating resilience and maximizing educational opportunities despite adversity. This discovery underscores that the respondents are highly motivated and capable of independent study, effectively managing their own learning. They identify their needs, set goals, choose methods, and assess outcomes, showing robust self-directed learning skills. This adaptability highlights their proficiency in autonomous learning, even during the challenges of pandemic-induced distance learning.

The result suggests that students' self-efficacy falls within a high range, not reaching the level of "very high," and also not descending into the realms of "very low," "low," or "moderate." Even when evaluating individual items separately, all students received similar mean ratings, all interpreted as "high." These results aligned with Bandura's theory of social cognition and self-efficacy (Bandura, 1977; 1999), stressing that academic self-efficacy was shaped by the students' belief in their capabilities and expected outcomes. Akhtar (2008) defines self-efficacy as the belief in overcoming

challenges and succeeding in tasks. Dullas (2018) emphasizes self-efficacy's role in confidence for task execution. High academic self-efficacy helped students stay motivated, adapt to new learning methods, and succeed despite challenges. Students' academic self-efficacy is shaped by their orientations, personal challenges, relationships, study strategies, and institutional assessments, and it serves as a predictor of academic performance, alongside cognitive abilities (Abid et al., 2019). Given this overall high self-efficacy rating, it can be inferred that these students possess significant levels of self-belief that can contribute positively to their achievements and overall well-being. The students believe that modular distance learning significantly benefits their education despite challenges. Their enthusiasm and high academic self-efficacy suggest confidence in their ability to excel and adapt, indicating resilience, initiative, and likely academic success amid the pandemic.

In terms of STS performance, the result illustrates how students adjusted and fared during the pandemic while engaging in modular distance learning in STS education. The most prevalent pattern was observed in the "satisfactory" category, indicating that a significant portion of students effectively managed their coursework and achieved at an acceptable level. Additionally, the data highlights remarkable achievements in both the "very satisfactory" and "outstanding" categories, with a smaller group of students falling into the "highly outstanding" category. As stated by Johansen & Euchner (2013) and Panthalookaran (2022), education must prepare students for the volatile, uncertain, complex, and ambiguous (VUCA) world and address emerging societal challenges, especially in these pandemic times. These findings suggest that during the pandemic, students showed adaptability and success in STS education through modular distance learning. Most students achieved satisfactory levels, effectively handling their coursework. Additionally, a significant number attained very satisfactory and outstanding results, highlighting exceptional performance among a smaller cohort. These results emphasize students' resilience and ability to succeed academically in STS education despite challenging circumstances.

The outcome reveals a substantial, positive link between self-directed learning skills and academic self-efficacy. This discovery is in line with the research of Coros and Madrigal (2021), Lew and Park (2015), Meng et.al (2019), and Turan and Koç (2018), all underlining the noteworthy connection between self-directed learning and academic self-efficacy. Additionally, Saeid and Eslaminejad. (2016) looked at the connection between students' self-directed learning, self-efficacy, and learning enthusiasm. Research findings indicated a robust relationship between self-directed learning and self-efficacy, which was corroborated by Phan et al. (2021). This shows that encouraging the development of self-directed learning skills can strengthen students' confidence in their academic abilities. This relationship implies that educational strategies focusing on self-directed learning may also enhance students' academic self-efficacy, thereby potentially boosting their academic performance and resilience in educational settings.

It was discovered that a significant and strong positive correlation exists between self-directed learning skills and performance in STS, particularly adhered with the research results of Kan'an and Osman (2015) which underscores the importance of self-directed learning for success in science education. Students who achieved higher academic success were also found to possess notably higher levels of self-directed learning skills, as shown in the study by Tekkol and Demirel (2018). Therefore, it is suggested that self-directed learning plays a significant role in contributing to higher academic achievement in science subjects. Consequently, integrating self-directed learning components into teaching and fostering the growth of self-directed learning abilities among students can be highly advantageous and rewarding for their academic success in science. These findings are consistent with the broader notion that self-directedness is positively linked to academic achievement, as seen in studies by Bodkyn (2015), Cazan and Schiopca (2014), Oducado (2021), Saeid and Eslaminejad (2016), Torun (2020), and Triastuti (2016). This result implies that enhancing self-directed learning abilities can potentially lead to improved academic outcomes in STS education. This finding further suggests that educational strategies focusing on developing and nurturing students' self-directed learning skills could be effective in enhancing their performance and success in STS education.

Academic self-efficacy strongly correlates with STS performance. This result consistently explains the arguments raised by Ahmadi (2020) noting that academic self-efficacy enhances academic performance and student aspirations in university settings. High self-efficacy increases willingness to attempt tasks and improves academic outcomes (Ahmad & Akbar, 2020; Qadoos et al., 2020). Research confirms that self-efficacious

students excel academically, demonstrating better focus and success (Fong & Yuen, 2016); Njega et al., 2019). This relationship is particularly notable in science education, where high self-efficacy enhances performance and motivates greater effort (Arik, 2019; Juan et al., 2017). Boosting self-efficacy improves problem-solving and overall academic performance (Hayat et al., 2020; Zhou et al., 2019), suggesting its critical role in achieving better academic outcomes (Doménech-Betoret et al., 2017; Musa, 2020; Talsma et al., 2021). This suggests that enhancing students' belief in their academic capabilities could improve their performance in STS subjects. Educators and policymakers could focus on strategies like creating supportive learning environments, fostering goal-setting skills, and promoting perseverance in tackling challenges. These initiatives are expected to enhance academic results and promote overall student success in STS education.

The study's findings highlighting significant relationships among self-directed learning skills, academic self-efficacy, and STS performances within the MDL framework. This was supported by the study conducted by Yao (2021) showing correlations among students' academic self-efficacy, self-directed learning skills, and problem-solving abilities. This result indicates that efforts focused on cultivating self-directed learning skills and boosting academic self-efficacy may enhance STS academic achievements. Further, it emphasizes the significance of promoting self-directed learning and self-efficacy within the modular learning environments to improve student performance in STS education.

The study underscores the importance for educators, policymakers, and stakeholders to prioritize the development of self-directed learning skills and academic self-efficacy to improve STS performance. Academic staff and faculty should prioritize integrating self-directed learning into MDL curricula to empower students in managing their learning independently, thereby enhancing STS academic outcomes. Shifting to facilitation and guidance rather than traditional instruction methods, they should incorporate strategies to develop students' self-directed learning skills and academic self-efficacy. Regular monitoring of students' progress and assessing readiness for supporting self-directed learning through professional development are crucial steps. Admissions officers could consider using self-directed learning skills to inform student screening and support academic and professional competency development. University officials and administrators are encouraged to develop supportive policies that promote flexible educational practices in STS education and allocate resources for technology infrastructure crucial for MDL. Stakeholders, including parents, community and industry partners, should support initiatives that foster self-directed learning and academic self-efficacy in STS education, ensuring equitable access to digital resources and enhancing overall educational resilience in challenging times. Overall, these findings underscore the effectiveness of self-directed learning and academic self-efficacy in improving STS academic performance within MDL frameworks with or without the pandemic. Lastly, educators, policymakers, and stakeholders must collaborate to foster environments that support these skills and strategies, enhancing educational outcomes and preparing students for future scientific, technological, and societal challenges.

Broadly speaking, this study established the direct influence of self-directed learning skills and self-efficacy on STS performance. It underscores the interplay of cognitive and non-cognitive factors in determining students' academic outcomes. Emphasizing the development of self-directed learning skills and academic self-efficacy is crucial for enhancing STS performance. By empowering students to evaluate their progress and take ownership of their learning, self-directed learners can achieve academic success. Additionally, self-efficacious students demonstrate resilience in pursuing ambitious goals, overcoming challenges, and adjusting strategies as needed. Consequently, this research underscores the significant role of self-directed learning skills and self-efficacy in shaping STS performance.

Suggestions

Since the findings of this study align with its objectives and results in all respects, further research should be conducted to ascertain whether similar or different results with regards to STS education when employing modular distance learning. Researchers could also explore other non-cognitive factors that would predict STS performance of students within the MDL framework. Experimental research may be done to be able to employ strategies to enhance self-directed learning skills and academic self-efficacy and how they would affect specific outcomes such as the STS performance of students. Research could be expanded to other academic disciplines and settings. To gain deeper insights, qualitative research methods utilizing in-depth interviews or focus group discussions could further

explore the challenges and benefits of MDL from the students' perspectives. Furthermore, studies on faculty, institutional impacts, and policy effects should be undertaken to investigate the role of faculty support and institutional policies in facilitating effective MDL. These efforts will help assess the influence of educational policies on the implementation and success of MDL, identifying best practices and policies that enhance student learning outcomes during and post-pandemic. By exploring these areas, future research can build on the insights gained from this study to further understand and enhance the academic success of students in various learning environments, particularly in times of crisis.

Further, enhancing students' self-directed learning skills and academic self-efficacy is crucial for universities, achieved through structured guidance, online resources, and workshops aimed at fostering self-reliance and proficiency. Introducing interventions and hybrid learning models that blend traditional and modular approaches can accommodate diverse learning styles, enhancing students' adaptability and non-cognitive skills. These efforts are essential for supporting students' mental health and overall well-being, especially during challenging times like a pandemic, thereby promoting positive outcomes in science education.

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