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The Role of Technology Integration and Teacher Support in Enhancing Student Engagement: Exploring the Mediation of Self-Directed Learning

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Abstract: The article explores the interconnections among technology integration, teacher support, self-directed learning (SDL), and student engagement in higher education. Grounded in Self-Determination Theory (SDT), examines how autonomy, competence, and relatedness are fostered through these variables. The findings indicate that while technology integration and teacher support significantly influence SDL, their direct effect on student engagement is limited, suggesting the involvement of additional mediating factors. This study contributes to the growing body of literature by providing empirical evidence on the mediating role of SDL, highlighting its critical role in modern pedagogical practices. By addressing gaps in the understanding of these relationships, the research offers actionable insights for crafting holistic and effective educational strategies. Data from 135 participants were analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM), providing robust insights into these relationships. By shedding light on the intricate role of SDL as a mediator, the study underscores the importance of holistic approaches in crafting effective educational interventions. These findings offer valuable guidance for educators, policymakers, and institutions striving to enhance student engagement and optimize learning outcomes.
Keywords: Technology Integration, Teacher Support, Self-Directed Learning, Student Engagement, Educational Interventions.

1. Introduction

Technology has transformed traditional practices of education and changed historical paradigms of teaching and learning in ever ever-evolving world and the latest techniques are used to integrate students. The use of technology including whiteboards, virtual classrooms, adaptive learning, and social media in learning has altered learning from an endogenous mode to an exogenous mode of learning through activity and mission. A major determinant of engagement has been revealed to be the integration of technology that supports a customized approach to instructional delivery and enhances collaboration as well as access to a variety of learning resources. This change has attracted much

literature and institutional interest, including analyzing how technology could support learning better (OECD, 2019).

The application of technologies in learning does not intrinsically mean better learning experiences. The effectiveness of its implementation in educational practices largely depends on other factors, such as teacher assistance—particularly emotional, instructional, and technical support—which remains critical in anchoring student success. Teachers provide guidance and scaffolding that enable students to navigate learning challenges, interpret information, and achieve mastery of concepts. Instructional and technical support creates the element of trust and companionship which is very vital, unlike emotional support which creates a sense of belonging and security as well as instructional and technical support that makes students guarantee that they can use technology to advance their learning. The synergy between these components enables the students to feel engaged and motivated, to go out and discover, to learn cooperatively and perform tasks that are purposeful when dealing with educational technology tools, and to receive directions from the teacher.

A critical component in this educational dynamic is self-directed learning (SDL). It is therefore important to clearly define that self-directed learning means the capability of a student to engage himself or herself in planning, executing, and assessing learning activities on his/her own (Garrison, 1997). It is not merely a skill but a mindset that emphasizes autonomy, accountability, and motivation. Theoretical literature suggests that when a learner is placed in an environment with access to the tools required for learning, there is a high propensity for them to become a facilitative learner. This, in turn, enhances their engagement, motivation, and academic achievement (Deci & Ryan, 1985). Technology is capable of offering the resources that SDL needs while the teachers' support encourages the students both emotionally and cognitively to succeed in such a learning environment.

This paper argues that this triad of technology integration as an element of instructional design, teacher training, and student-centered learning offers a remarkable chance for enhancing pedagogy practices. To wit, knowing how all of these elements work and make up the whole in helping students get engaged is important in figuring out the problems that come with modern learning. Even with all the varieties of technological aids available in the modern environment, schools and similar establishments may encounter various problems in their striving for effective interaction and increased rates of learning progression. These challenges draw attention to the fact that appreciable measures of the interactivity of the technology and teacher support are needed to promote SDL and, in turn, motivate learning engagement. This is where this study seeks to operate since it will attempt to address the research objectives.

1.1 Research Problem and Justification

Although the use of technologies in teaching and learning has become almost pervasive, the resultant improvement in learning achievement and learners' participation remains variable. Once the classroom is furnished with these technologies does not in any way improve the quality of learning. Findings indicate that technology integration into learning environments is contingent on its purpose and how well-supported it is to enhance the instructional goals teachers have set (Bellemare et al., 2016). and if students are not guided appropriately by teachers, these tools can either remain mere add-ons or can remain ineffective in capturing the students' attention span. At the same time, another form of support from teachers, emotional, instructional, and technical has been

acknowledged to be crucial in practice and research for a very long time. The article shows how teachers help students meet their emotional and cognitive requirements by being committed to creating a nurturing learning climate. However, despite substantial research on teacher support, its interplay with technology integration and its influence on self-directed learning (SDL) remain underexplored. As SDL emphasizes students' autonomy and initiative in managing their learning processes, understanding how teacher support enhances students' capacity to engage in SDL is critical (Deci & Ryan, 1985).

This creates a large gap within the existing educational research literature regarding the mediating effect of SDL in the connection between technology implementation, teachers' encouragement, and students' participation. While most other research explores these variables in one single study, hence there is limited understanding of how these variables interrelate with one another; for example, how technology may influence engagement. For instance, while technology integration has been shown to support collaborative learning, its effectiveness may be amplified or diminished depending on the presence and quality of teacher support (Helmefalk, Palmquist & Rosenlund, 2023). In addition, more research is needed on the capacity of SDL as a connector among the use of technology, teacher support, and students' interest. It is therefore important to close this research gap in order to provide information to policy-makers, educators, and institutions on how to best design interventions which include technology support for teachers to optimize students' engagement. The practices of education that would encompass these interrelated factors might add value to an understanding of how learning environments might be enhanced. This paper aims to contribute to this knowledge by examining the multiple interconnections between technology use in the classroom, teachers' facilitation, SDL, and students' motivation, along with providing empirical data that may help improve the principles of education.

1.2 Objectives of the Study

This study aims to:

1. Examine the direct effects of technology integration and teacher support on Self-directed learning and student engagement.
2. Investigate the mediating role of self-directed learning in the relationship between technology integration, teacher support, and student engagement.
3. Provide empirical evidence to guide educators in leveraging technology and support mechanisms to enhance student engagement.

2. Literature Review and Hypothesis Development

2.1 Technology Integration (TI) in Education

The influence of technology in teaching-learning systems that has promoted teaching technologies that allow for interactivity increases and personalization of teaching. Findings have always pointed towards its ability to foster reasoning, cooperative learning and students' engagement when well implemented within classroom settings. According to Means et al. (2013), integration of technology in classroom improves the student's ability to interact during learning especially where technology is applied intensively such as in technology-infused subjects where improved response and personalized learning environment may be evoked. Tools such as learning management systems (LMS), virtual simulations, and adaptive learning platforms have emerged as key enablers in this context (Bellemare et

al., 2016). Some collaborative learning tools include Moodle and Blackboard, electronic course structures that grant access to course content, tests or quizzes, and forums for discussion of topics; virtual simulations have turned out to be most useful where practical skills are difficult to practice, in fields such as medicine or engineering, for instance (Stahl, 2023). Thus, technologies of adaptive learning advance this concept and enable focused content delivery depending on the progress of each learner, which was identified to increase academic outcomes and conceptual knowledge conversion (Gligorea et al., 2023).

However, these advantages show that the use of technology in class depends on the ability to adopt apparatuses to the goals of concept instruction. Technology should therefore be viewed as an addition to conventional approaches to learning rather than as the principal strategy (Ertmer & Ottenbreit-Leftwich, 2010). Moreover, teacher competence is influential because their beliefs about the subject, IT competence, and acquaintance with pertinent theories define the degree of success. It has been acknowledged that organized learning for professional development concerned with technological literacy has been found to be essential in getting the maximum from technological applications in the learning context (Budyaningsih & Fikroh, 2023). Most importantly, what technology offers us in terms of engagement is highly dependent on such factors as mapping of technology use with learning objectives, sufficient teacher education, and technical backing. Efforts in other studies are aimed more at analyzing the success of the particular tools, yet, they do not raise such important questions as the level of institutional support, availability of resources, and resistance from teachers. These gaps highlight the importance of research that looks at the factors that define technology adoption and the sum total of each factor on students. Based on the synthesis of the literature, this study hypothesizes:

Hypothesis 1: Technology integration has a positive direct effect on student engagement.

2.2 Teacher Support (TS) and Its Impact on Student Engagement (StEng)

Teacher support (TS) encompasses emotional, instructional, and technical dimensions, all of which significantly influence student engagement. The literature review shows how the teacher-student relationships that are positive influence the motivation, self-esteem, and participation of students in class. Wentzel (1998) assert that there is a positive perception between teacher support and/with intrinsic classroom motivation, thus enhancing enactment. This support not only helps in improving grades but also brings a much-needed positive impact into a student's life and makes him or her feel valuable.

2.2.1 Emotional Support

Emotional support is a cornerstone of TS, providing students with a sense of belonging and psychological safety. Pianta, Hamre and Allen (2012) emphasize the role of positive teacher-student relationships in creating a nurturing environment that fosters student engagement in classroom activities. It makes the learners feel wanted and safe to explore in the tests discussions and other activities in school. While highly effective, the literature often fails to address variability in the effectiveness of emotional support across diverse educational and cultural contexts, which may limit its generalizability.

2.2.2 Instructional Support

Instructional support for learning principally refers to supportive interactions with

specific, necessary, and concrete methodologies that teach students about the features of learning goals. Hattie (2009) highlights the profound impact of high-quality feedback and well-presented material on student engagement and learning outcomes. Of the various forms of support described by Wood, Bruner and Ross (1976), scaffolding is most effective in paring, as this fosters the students into attempting and achieving the task, bit by bit. Nevertheless, there is a gap within the knowledge of whether higher or lower level of instructional support influences learners of different academic achievement levels, which can serve as a viable research direction.

2.2.3 Technical Support

Technical support has become increasingly critical in modern learning environments, particularly those integrating technology. Teachers proficient in educational technology foster engagement by enabling students to access digital resources and learning platforms, allowing for personalized and self-paced learning. Graham (2006) asserts that teacher facilitation of technology use significantly influences student motivation in internet-based and blended learning environments. However, while the literature highlights the importance of technical support, it often overlooks institutional barriers such as insufficient training or lack of resources, which can hinder effective implementation.

2.3 Relevance and Limitations of the Literature

Existing studies provide robust evidence for the importance of teacher support in student engagement. However, most focus on isolated dimensions (e.g., emotional or instructional support) without addressing their interplay. Furthermore, limited attention has been paid to contextual factors, such as socio-economic or cultural influences, that may mediate the effectiveness of TS. Future studies could explore how the combined effects of TS dimensions contribute to student engagement across diverse educational settings. Based on the above discussion, it is hypothesized that:

Hypothesis 2: Teacher support positively influences student engagement.

2.4 Technology Integration and Its Impact on Self-Directed Learning

Technology Integration (TI) has profoundly reshaped the educational landscape, playing a crucial role in fostering Self-Directed Learning (SDL). Through the application of e-learning platforms, mobile technologies, and a collaborative virtual environment, TI enables learners to effectively search, assimilate, and utilize information through SDL as postulated by Bhat (2023). Technology-supported learning offers a learning environment in which the learner is able to follow personalized learning environments based on learning preferences and learning paces (Nazempour & Darabi, 2023). Further, OERs and CMEs let learners engage in topics not covered in their curriculum and welcome more autonomy and motivation. That is why, even though it is clear that TI can contribute to supporting SDL it is critical to indicate that its potential should be systematically implemented. Technology skills must be to benefit from the tools provided by the system. Without this skills base, technology can be counterproductive or it can be used in suboptimal ways. Contemporary references while rich in discussing the advantages of TI tend to overstate the disadvantage of accessing, navigating, and garnering institutional support for SDL as one of the most promising approaches to learning.

Hypothesis 3: Technology Integration (TI) positively influences learners' readiness for Self-Directed Learning (SDL).

2.5 Teacher Support and Its Impact on Self-Directed Learning

Teacher Support (TS) is instrumental in ensuring that technology is effectively harnessed for SDL. In addition to the role of providing tools, teachers also serve as mentors who encourage students to use plans as well as resources and assess their work—an area regarded as important in SDL. Teachers facilitate student's learning environment and hence help the students to develop confidence in readiness to carry out independent learning. Furthermore, learners benefit from purposefully arranged cooperative learning by a teacher in developing critical thinking, talking, and problem-solving identified to support SDL (Zaheer et al., 2022). Although the technology offers the platform in which the learning takes place, TS ensures the learners benefit from its possibilities. Incorporation of feedback and the use of inquiry-based methods encourages the students to shift from the role of mere vessels for containing knowledge to learners. However, existing literature fails to account for variation in teachers' ability to perform in terms of support giving, which in the study displays a strong correlation with SDL results. Essentials of training, resources, and teaching methods that differentiate educational programs and teachers continue to be the factors that require future research. This study posits that TS not only enhances SDL but also ensures the effective integration of technology to support learner autonomy.

Hypothesis 4: Teacher Support (TS) enhances the effectiveness of Technology Integration (TI) in promoting Self-Directed Learning (SDL).

2.6 Self-Directed Learning (SDL) as a Mediator

Self-Directed Learning (SDL) has emerged as a cornerstone of contemporary education, emphasizing autonomy and lifelong learning. Garrison (1997) defines SDL as a learner-driven process involving the planning, selection, and evaluation of one's learning activities. This learner-centered approach contrasts with traditional teacher-directed methods by placing responsibility and motivation squarely on the student, fostering deeper academic engagement and achievement. SDL is grounded in Adult Learning Theory, as articulated by Knowles (1975), which positions autonomy as a fundamental attribute of effective learning. This autonomy allows learners to dictate the pace, style, and context of their educational journey, enhancing both motivation and engagement. Zimmerman (2002) further highlights that SDL strengthens self-efficacy, or students' confidence in their ability to achieve independently, positively influencing their affective and cognitive engagement.

The mediating role of SDL is particularly significant in understanding the interplay between technology integration, teacher support, and student engagement. SDL allows the learners to utilize opportunities available in the external world in order to interact with content in a higher order. For example, in their study, Venkatesh, Thong and Xu (2012) explained that technology provides students with the opportunities to take charge of their activities with learning resources which leads to effective and purposeful learning processes. Similarly, assignment and feedback in SDL is used to tap into teacher support to encourage motivation and continued learning engagement as postulated by Schunk (2005). Engagement in these areas contributes significantly to SDL's offerings, but its advantages cover academic performance as well. As Zimmerman (2002) has mentioned,

self-regulation which is the main process of SDL helps the students to make a plan, measure progress, and reflect and decide on the strategies used enabling enhanced concentration, recall, and affective investment in learning. Furthermore, SDL fosters determination and tenacity, preparing students for success in meeting adversity and exerting continuous effort.

2.7 Critical Appraisal and Limitations

Across all of the defined research areas, the presence of SDL is established as a key factor in the educational process, and the relationship is supported by numerous strands of research. However, in the existing research, much attention was paid to the positive outcomes of SDL while few or no studies looked at how contextual or demographic factors may moderate the effectiveness of SDL. First, the contribution of factors such as cultural leaders, institutional culture, and socioeconomic status as well as the availability of resources for the development of SDL capabilities is still debatable. However, even though SDL is usually favorable, its effectiveness may be contingent upon the involvement of the teachers, and the kind of technology used. Subsequent studies could explore these contextual differences in order to elucidate the contemporary theorization of SDL as a mediator, especially within pluralistic learning environments. This would enable the development of more targeted interventions to maximize SDL's impact on student engagement and achievement. Thus, based on existing literature, it is hypothesized that:

Hypothesis 5: Self-directed learning mediates the relationship between technology integration and student engagement, as students use technology to independently engage with content in ways that enhance their learning experience.

Hypothesis 6: Self-directed learning mediates the relationship between teacher support and student engagement, as students apply teacher feedback and support in self-regulated ways that increase motivation and participation.

2.8 Student Engagement: Theoretical Perspectives

Student engagement encompasses behavioral, emotional, and cognitive participation in academic activities, contributing significantly to academic performance (Fredricks, Blumenfeld & Paris, 2004). Of the three categories of academic self-regulation, the behavioral purpose embraced attendance, completion of assignments, and class participation that have a positive relationship with performance as described by Appleton, Christenson and Furlong (2008). It also entails tenacity in matters of self-completion which research pointed as a predictor of students' performance (Skinner & Belmont, 1993). Interest is part of motivation, a positive attitude, or enjoyment of education which requires affective aspects to enable the Ss to notice and care about what is being taught Emotional Engagement (Fredricks et al., 2004; Pianta et al., 2012). Academic relevance refers to giving priority to content understanding, problem-solving, and effort, which forms diffuse yet long-lasting, cognitive skills (Appleton et al., 2008; Pintrich, 2003). Conceptual paradigms offer understanding of these aspect of engagement. Self-Determination Theory (SDT) emphasizes the role of intrinsic motivation driven by autonomy, competence, and relatedness, which fosters deeper engagement and improved outcomes (Deci & Ryan, 1985). Vygotsky's Social Constructivist Theory (1978) highlights the role of social interactions and scaffolding, where teachers support tasks students cannot complete

independently. This theory then associates cognitive and emotional involvement with collaboration on learning: engagement is not solitary, cultural and social, as learning is fundamentally performed through interaction.

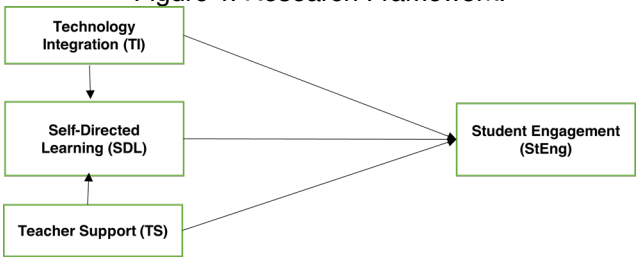
2.9 Gaps in Existing Research

Although the advantages of technology integration and teacher support are well-documented, their combined influence on student engagement, particularly through the lens of self-directed learning (SDL), remains insufficiently examined. Of course, previous research has paid a great deal of attention to these factors separately, although they rarely investigate the interdependence of these variables and the degree to which SDL can both moderate and mediate these relationships (Helmefalk et al., 2023). This gap leaves significant questions unanswered regarding the dynamics of these relationships and their impact on fostering student engagement. Moreover, contextual factors such as cultural norms, institutional practices, and differences in educational settings are seldom considered, despite their potential to influence these interactions. This highlights the importance of multi-index research designs that incorporate both the interdepended nature of these variable and the contexts that they exist in.

2.10 Self-Determination Theory and Its Relevance to the Study

Self-Determination Theory (SDT), proposed by Deci and Ryan (1985), emphasizes the importance of intrinsic motivation and the fulfillment of basic psychological needs—autonomy, competence, and relatedness—in fostering optimal human functioning. In the educational context, SDT provides a robust framework for understanding how external inputs, such as technology integration and teacher support, can enhance intrinsic motivation and student engagement. By enabling autonomy through technology and fulfilling the need for relatedness via teacher support, SDT aligns with the mediating role of self-directed learning (SDL) in this study. Within the article, SDL is an aspect of the SDT, which is described by the autonomy perspective taken by the students during the learning process. Technology integration allows for learner control and autonomous access to materials, making their learning independent, at the same time teachers' assistance is needed to provide enough support to develop their competency, and to monitor their interest. The study's emphasis on examining how these elements synergistically enhance student engagement resonates with SDT's assertion that supportive environments catalyze intrinsic motivation, ultimately driving deeper engagement and academic success. Based on the above discussion, the following research framework is proposed:

Figure 1: Research Framework.



3. Methodology

3.1 Research Design

This study adopts a quantitative research design to examine the relationships among technology integration, teacher support, self-directed learning, and student engagement. The quantitative approach is suitable for testing hypotheses and establishing causal relationships through statistical analysis (Creswell, 2014).

3.2 Population and Sampling

The study sample target teachers of higher secondary schools who are in the classroom teaching their students. This population was chosen because these teachers are at the forefront of implementing technology in classrooms and providing the necessary instructional and emotional support to students, making them uniquely positioned to offer insights relevant to the study objectives. A purposive sampling method was employed to ensure that participants had relevant experience with technology integration and teacher support practices. Purposefully, this method was chosen to reach persons who might provide better and especially, context-stuffed answers regarding the investigated variables as per the target population of experienced educators. Purposive sampling allows researchers to select participants based on predefined criteria, enhancing the study's relevance and ensuring the data collected is directly applicable to the research questions (Campbell et al., 2020). The selected participants had to meet the following criteria: They had to have taught for at least two years in the secondary school education sector, and they should be willing to use technology in their knowledge areas. Such teachers were only employed to that we only selected participants in the study with at least five years experience in teaching to reduce biasness from teachers with other forms of teaching experience aside from Junior secondary school experience where this study was focused on were excluded other relevant personnel. For these reasons all the self completion questionnaires were excluded because in a case of lost values or discrepancies they mislead the result.

3.2.1 Sample Size Determination

The sample size determination adhered to the guidelines established for partial least squares structural equation modeling (PLS-SEM). Specifically, Hair et al. (2017) recommend a minimum sample size of 10 times the number of indicators for the most complex construct in the model. Given the complexity of the constructs and the number of indicators used in this study, the final sample size of 135 participants was deemed adequate to achieve statistical power and produce robust, reliable results.

3.2.2 Potential Bias and Mitigation Strategies

While purposive sampling offers focused insights, it is susceptible to selection bias, which may limit the generalizability of the findings. To address this, participants are selected from the various schools with varying technological endowment and different priority placed on technological development. It is also about increasing the number of participants of different backgrounds, so that the data would not be as distorted as in other cases. A

possible threat to internal validity could be self-selection bias whereby only teachers who are most comfortable with the use of technology might have volunteered. In response to this, recruitment focused on how the study can assist educators with or without computer skills. Further, the pre-screening process helped to ovoid any misunderstandings about the questions that were asked to avoid rigmarole. Hajesmaeel-Gohari et al. (2022) notes that the use of questionnaires made the responses more reliable. By so doing, the study can be assured of internal and external validity within the study's parameters and thus provide reasonable recommendations on teacher support and the use of technologies in education.

4. Data Collection

Data were collected using structured interview questionnaires designed based on validated scales from prior studies. The questionnaire included specific items adapted to measure the variables of technology integration, teacher support, self-directed learning, and student engagement. Each variable was assessed using a definite number of items to ensure robust measurement and alignment with established instruments:

1. Technology Integration: Six items were adapted from the Technology Integration Questionnaire (TIQ), which have been widely utilized to evaluate the extent and effectiveness of technology use in educational contexts.
2. Teacher Support: Four items were drawn from the Teacher Support Scale (TSS) by Torsheim, Aaroe and Wold (2003), focusing on assessing emotional and instructional support provided by teachers.
3. Self-Directed Learning (SDL): Five items were derived from the Self-Directed Learning Readiness Scale (SDLRS) by Guglielmino (1977), which measures students' capacity for autonomous learning.
4. Student Engagement: Six items were adapted from the Student Engagement Instrument (SEI) by Appleton et al. (2008), capturing behavioral, emotional, and cognitive dimensions of engagement.

To tailor the items to the study context, slight modifications were made while maintaining the original constructs' validity and reliability. Responses were gathered on a 5-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). A pre-screening process was conducted to resolve ambiguities and refine the tool, ensuring its accuracy and appropriateness. This step helped to enhance participants' understanding of the questions and the reliability of their responses.

5. Demographics

Table 1 presents the demographic distribution of participants in this study. Out of a total of 135 respondents, 85 participants (62.96%) were female, while 50 participants (37.04%) were male. The cumulative percentage indicates that the female respondents formed a larger portion of the sample. This gender composition reflects the diverse representation within the population under study. Understanding these demographics is crucial for contextualizing the findings, as gender-based differences may influence perceptions, behaviors, or responses related to the research topic. The results of this demographic analysis will be considered when interpreting the overall study outcomes.

Table 1: Demographic Presentation.

SEX	Number	%	Cumulative %
M	50	37.04%	37.04%
F	85	62.96%	100%
Total	135	100%	100%

6. Data Normality Assessment

Figure 2: Histogram.

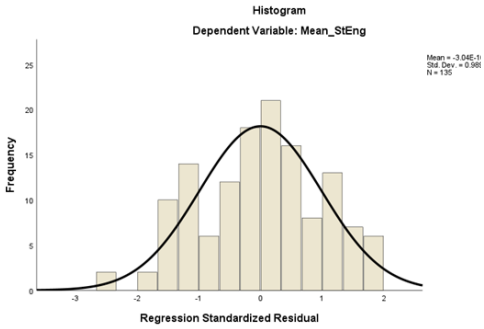
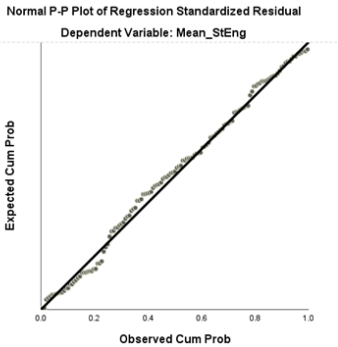


Figure 3: p-p plot.



Figures 2 and 3 represent the normality tests of regression analysis for Mean_StEng (Mean Student Engagement. The bin on the left is the histogram of the regression standardized residuals, which can be seen as normally distributed. The fact that these graphics are aligned with a bell shape implies that the residuals are equally distributed; thus satisfying the basic assumption of regression analysis. The second diagram is a Normal P-P Plot of standardized residuals which involves a comparison of the cumulative frequency of the observed data with the cumulative frequency of expected data under normal conditions. The flat pattern of the data points along the diagonal line indicates that the residuals are highly symmetrical, and thus conform to the normal distribution hypothesis for data. Such outcomes of the tests raise the suitability of the regression model to explain the relations between the variables in the study as it complies with the normality premise.

7. Assessment of Measurement (outer) Model

Figure 4: Measurement Model.

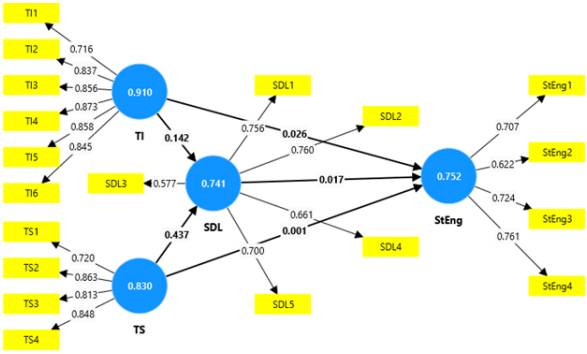


Table 2: Construct Reliability and Validity-Overview.

	CA	CR (rho_a)	CR (rho_c)	AVE
SDL	.741	.760	.822	.582
StEng	.752	.719	.797	.697
TI	.910	.914	.931	.693
TS	.830	.851	.886	.661

Table 2 outlines the reliability and validity metrics for the study's constructs: Self-Directed Learning (SDL), Student Engagement (StEng), Technology Integration (TI), and Teacher Support (TS). Cronbach's alpha coefficients for all constructs are above 0.7 thus indicating good internal reliability (Taber, 2018). Also, composite reliability (rho_c) values are above 0.7, which endorses the reliability of the constructs. Moreover, the average variance extracted (AVE) of all the constructs is higher than 0.5; this implies that the constructs have enough convergent validity to justify that the constructs explain sufficient variance of the indicators (Cheung et al., 2024). These results can thus attest to the reliability of the measurement model for the next level of structural analysis.

8. Assessment of Structural Model

Figure 5: Structural Model.

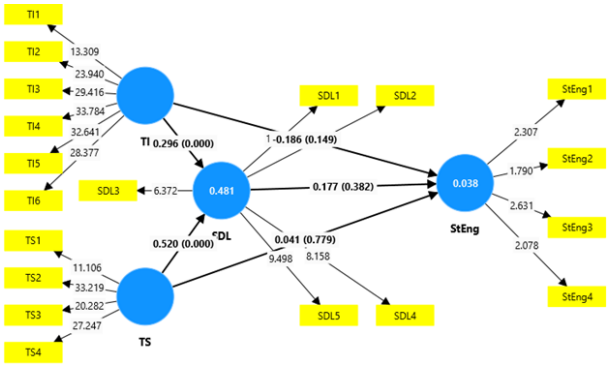


Table 3 Path Coefficients and Significance Testing.

	Sample (O)	Mean	Standard Deviation	T statistics	P values
SDL -> StEng	.177	.133	.203	.873	.382
TI -> SDL	.296	.300	.081	3.638	0
TI -> StEng	-.133	-.137	.112	1.188	.235
TS -> SDL	.520	.524	.068	7.685	0
TS -> StEng	0.133	0.125	0.129	1.027	0.304

The results of Table 3 indicate that technology integration significantly influences self-directed learning (O = 0.296, T = 3.638, p = 0), and teacher support also has a strong positive effect on self-directed learning (O = 0.52, T = 7.685, p = 0). However, self-directed learning does not significantly impact student engagement (O = 0.177, T = 0.873, p = 0.382). Neither technology integration (O = -0.133, T = 1.188, p = 0.235) nor teacher support (O = 0.133, T = 1.027, p = 0.304) has a statistically significant direct effect on student engagement. Hence hypotheses 1 & 2 are not supported. These findings suggest that while technology integration and teacher support play crucial roles in enhancing self-directed learning, their influence on student engagement may occur indirectly or be mediated by other factors. The mediation analysis as presented in Table 4 shows that the indirect effects of technology integration on student engagement through self-directed learning (O = 0.052, T = 0.812, p = 0.417) and teacher support on student engagement through self-directed learning (O = 0.092, T = 0.865, p = 0.387) are not statistically significant. These results suggest that self-directed learning does not serve as a meaningful mediator between either technology integration or teacher support and student engagement, indicating that their effects on student engagement may occur through other pathways or factors. Hypotheses 5 & 6 are not supported in this study.

Table 4: Mediating Effects

	Sample	M	Std Dev	T_Stats	P_values
TI -> SDL -> StEng	.052	.039	.065	.812	.417
TS -> SDL -> StEng	.092	.069	.106	.865	.387

Table 5: Coefficient of Determination

	R-square	R-square adjusted
SDL	.481	.474
StEng	.038	.019

The R-square values are presented in Table 5, which gives information regarding the variance attributed to a model's predictors. For Self-Directed Learning (SDL), the R-square value of 0.481 indicates that technology integration and teacher support collectively explain 48.1% of the variance in SDL. That is why adjusted R-square for SDL equals to 0, 474, which considered the number of the predictors in the equation and hence is somewhat lowest and more rigorous estimate. In contrast, the R-square value for Student Engagement (StEng) is 0.038, showing that only 3.8% of the variance in StEng is explained by the predictors. The adjusted R-square in the model of StEng is 0.019, which shows that the model has only a slight ability to explain the variation of this variable. It is especially notable that the

effect of the predictors on SDL is stronger than on StEng.

9. Discussion of the Findings

The findings of this investigation provides an understanding of the effects of technology incorporation, teacher encouragement, and autonomy concerning students' engagement. Previous research corroborates the findings that Technology Integration (TI) significantly influences Self-Directed Learning (SDL). Recent previous literature also pointed out that the teaching effectiveness of technology encourages autonomous learning behaviors since students are in a position to use those technologies to explore knowledge that would otherwise they would search for personally. The result of the direct effect modeled in this study ($\beta = 0.296$, $t = 3.638$, $p < 0.001$) is consistent with Bellemare et al. (2016), who opined that if the technology used in university teaching is aligned with teaching practice, then engagement outcomes are likely to be enhanced.

Teacher Support (TS) also demonstrated a substantial direct effect on SDL ($\beta = 0.52$, $t = 7.685$, $p < 0.001$). Torsheim et al. (2003) pointed out earlier that students' self-regulation and self-organization promotion depend on affective and directive support by the teachers. Furthermore, Wentzel (1998) established that supportive teacher-student relationships are crucial in motivating students and building their academic resilience, reinforcing the observed effects of TS on SDL. However, the study did not find a significant direct effect of TI and TS on Student Engagement (StEng) (TI -> StEng: $\beta = -0.133$, $t = 1.188$, $p = 0.235$; TS -> StEng: $\beta = 0.133$, $t = 1.027$, $p = 0.304$). This outcome suggests that engagement requires more than just external resources or support; it necessitates intrinsic motivation and active participation, consistent with Self-Determination Theory (Deci & Ryan, 1985). Fredricks et al. (2004) observed that engagement is a complex concept that is depicted by the behavioral, emotional, and cognitive processes, meaning more than just the technological or instructional variables.

The mediation analysis further revealed that SDL did not significantly mediate the relationship between TI and StEng ($\beta = 0.052$, $t = 0.812$, $p = 0.417$) or TS and StEng ($\beta = 0.092$, $t = 0.865$, $p = 0.387$). Thus, unlike other researchers, like Garrison (1997), who pointed at the fact that SDL is a figure that mediates students' learning processes and enables them to take charge of their learning processes, the current analysis reveals that this process is multifaceted. Zimmerman (2002) argued that SDL's impact depends heavily on contextual factors and the extent to which students are empowered to actively participate in their education. The study shows that if technology and teacher support must be incorporated into SDL, technology has a lower coefficient of determination for Student Engagement ($R^2 = 0.038$) Nonetheless the contribution to SDL ($R^2 = 0.481$) demonstrates the need for the use of technology and teacher support in the promotion of autonomy. This accords with Ertmer and Ottenbreit-Leftwich (2010), who stressed the importance of designing for the effective technological transformation of learning in service of student outcomes.

The findings of this study also provide insights into the relationships among technology integration, teacher support, self-directed learning (SDL), and student engagement, advancing the study's research objectives while highlighting theoretical complexities. The significant impact of technology integration and teacher support on SDL aligns with the principles of Self-Determination Theory (SDT), which emphasizes the role of autonomy and competence in fostering intrinsic motivation (Deci & Ryan, 1985). However, the

lack of a significant direct effect of these variables on student engagement challenges traditional expectations that external resources alone can drive engagement (Fredricks et al., 2004). This suggests that engagement is a multidimensional construct requiring not only external inputs but also internal processes, such as intrinsic motivation and active participation, which may be influenced by factors beyond the scope of this study. Existing literature, such as Bellemare et al. (2016), emphasizes that the effectiveness of technology integration depends on its alignment with instructional objectives, a nuance that further supports the current findings. Similarly, the role of teacher support in facilitating SDL, as established by Torsheim et al. (2003), reinforces its critical function in shaping students' capacity for autonomy and regulation. These results underscore the importance of designing educational strategies that integrate technology and teacher support to promote SDL while recognizing that engagement may be mediated by other psychological or contextual factors.

10. Implications for Theory and Practice

From a theoretical perspective, this study contributes to the growing body of literature by incorporating Self-Determination Theory (SDT) into the exploration of student engagement. By focusing on SDL as a mediator, the study provides empirical evidence supporting the autonomy and competence dimensions of SDT, which emphasize the importance of fostering intrinsic motivation through external support mechanisms. The findings challenge existing paradigms that rely heavily on external inputs to drive engagement, showing that intrinsic motivation and active participation play a critical role in shaping student engagement. These results expand our understanding of engagement as a multidimensional construct, highlighting the need for both internal and external factors to work in synergy. For educators and policymakers, these results underline the need to design holistic strategies that not only integrate technology effectively but also emphasize robust teacher-student interactions. Teachers should be equipped with the necessary skills to align technology with pedagogical goals and provide adequate emotional and instructional scaffolding to maximize engagement outcomes. Moreover, institutional efforts should focus on creating supportive learning environments that enhance students' SDL capabilities through structured training and guidance.

11. Future Recommendations and Limitation

Subsequent studies should explore additional contextual variables that may affect the utility of technology and the kinds of teacher support that help to improve students' engagement. Such an analysis could uncover the moderators of these variables in different cultural and institutional contexts. Further, more extended research designs that compare LDL with SDL methods in the long run and investigate the influence of the method used on the learners' achievement and motivation are suggested. Practical applications of these findings can guide the development of more effective technology integration strategies, ensuring they align with pedagogical goals and support student engagement in diverse educational settings. However, a limitation of this study is its focus on a specific context, which may not fully generalize to other educational systems or cultural environments. It is on the same note that future research could extend the analysis of mediators past the facets of intrinsic motivation to include other psychological factors that would indeed provide

more light on the subject of student engagement. Schools, colleges, and universities should also incorporate faculty training on technological incorporation into their teaching approach and knowledge to enhance the implementation process as well as adoption of SDL culture. Future studies should also address the limitations of this research by incorporating longitudinal data and considering a wider range of educational contexts to provide more comprehensive insights.

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