



The high school path to self-directed learning: Navigating through learning ecosystem, modern teaching, achievement motivation, and the mindset roadmap

Suntonrapot Damrongpanit

Educational Evaluation and Research, Education Foundations and Development, Faculty of Education, Chiang Mai University, Muang, Chiang Mai, 50200, Thailand

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Abstract

This research investigated the influence of the Learning Ecosystem, Modern Teaching, Achievement Motivation, and Mindset on Self-directed Learning among students. It also examined the mediating role of mindset between the three factors and students' Self-directed Learning. The study involved 984 high school students in Thailand, with data collected through questionnaires having reliabilities ranging from 0.766–0.928. Partial least square structural equation modeling and serial mediation analysis were employed. The findings revealed that the Learning Ecosystem, Modern Teaching, and Achievement Motivation had significant positive direct effects on Self-directed Learning. Mindset played a crucial mediating role, where a Growth Mindset significantly enhanced the effects of the Learning Ecosystem, Modern Teaching, and Achievement Motivation on Self-directed Learning. In contrast, a Fixed Mindset had only a small direct effect on Self-directed Learning. The model variables could explain 64.6 percent of the variance in Self-directed Learning. These findings suggest important policy implications: promoting Self-directed Learning should focus on developing exploratory and experimental Learning Ecosystems, coupled with student-centered Modern Teaching using technology and fostering higher-order thinking. Cultivating Achievement Motivation and a Growth Mindset is crucial, as it will enable students to develop Self-directed Learning skills – an essential foundation for lifelong learning in today's rapidly changing world.

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Corresponding author.

E-mail address: suntonrapot.d@cmu.ac.th (Damrongpanit, S.).

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Introduction

Self-directed learning (SDL) is a crucial skill for learning in the present era, as knowledge and technology are rapidly changing. Learners, therefore, need SDL skills to adapt and develop themselves continuously throughout life (Rashid & Asghar, 2016). SDL is a systematic process where learners take the initiative, set goals, plan their learning, carry out learning activities, and evaluate their own learning outcomes, driven primarily by intrinsic motivation (Knowles, 1975).

Previous research highlighted SDL's pivotal role in learning outcomes. Learners with high SDL achieve better academically, demonstrate greater creativity, and stronger problem-solving abilities than those with low SDL (Alghamdi, 2021; Zhoc et al., 2020). Additionally, individuals with high SDL are likely lifelong learners, adapting flexibly to changes and engaging in continuous self-directed learning (Rashid & Asghar, 2016). In contrast, those lacking SDL rely on instructions, lack motivation, and may cease learning after a certain level (Ayyildiz & Tarhan, 2015). However, despite SDL being a significant goal of modern education, developing it is challenging due to numerous factors, including learners' motivation, beliefs, self-perception (Zhoc et al., 2020), as well as learning environment and teacher/peer support (Lee et al., 2014). These factors are interrelated and influence one another.

A review of the literature reveals that while many factors have been studied as influencing SDL, the findings remain conflicting in some aspects. For instance, while some research indicates that learners' intrinsic factors, such as motivation, beliefs, and self-perception, are crucial determinants of SDL (Ng, 2018), other studies have found extrinsic environmental factors, like the learning context, support from teachers, peers, and society, to be more significant (Lee et al., 2014). Conflicts also exist in research examining the influence of mindset on SDL, with some studies suggesting that a growth mindset, believing abilities can be developed, significantly positively impacting SDL (Aditomo, 2015), while others have not found such a relationship (Dweck, 2006). This diversity and conflicting nature of findings highlight the complexity and necessity of systematically studying these factors together to deeply understand the true mechanisms and interactions among them, leading to clearer conclusions about which factors and through what processes influence the development of learners' SDL.

Therefore, to address this knowledge gap, the present research aims to comprehensively study the influence of

components expected to play a crucial role in promoting SDL, including the learning ecosystem, modern teaching, achievement motivation, and learners' mindsets. The focus is on examining direct and indirect influences, as well as the mediating roles of each factor, to obtain a holistic picture of the intricate mechanisms underlying SDL development in learners. This will lead to effective and targeted approaches for improving educational practices to promote SDL.

Literature Review

From a broader perspective, self-directed learning (SDL) has been increasingly viewed not merely as an individual learning skill, but as a multidimensional capability emerging from the interaction between learners and their learning contexts. While classical perspectives emphasize autonomy, goal-setting, and intrinsic motivation as core elements of SDL (Knowles, 1975), contemporary research suggests that SDL develops dynamically through learners' continuous engagement with complex and supportive learning environments (Rashid & Asghar, 2016). Empirical studies consistently report that learners with higher levels of SDL demonstrate better academic achievement, creativity, and problem-solving abilities (Alghamdi, 2021; Zhoc et al., 2020). However, SDL does not develop uniformly among all learners. Those with lower SDL tend to rely heavily on external guidance and show limited motivation for sustained learning (Ayyildiz & Tarhan, 2015). This variation indicates that SDL cannot be fully explained by individual attributes alone, highlighting the need to examine how personal characteristics and contextual factors jointly contribute to the development of SDL in educational settings.

The learning ecosystem (ECO) is a concept describing the interrelated system of components that facilitate or hinder learning in a given context. It encompasses both learners' intrinsic factors and extrinsics such as curricula, teaching methods, technologies, and learning resources (Broadbent & Poon, 2015). An effective ECO is diverse, flexible, interconnected, and fosters participation, supporting learners in setting goals, taking actions, evaluating their learning, interacting with peers and experts (Baig, 2013), laying an essential foundation for lifelong learning. This study examines ECO's direct and indirect influences on SDL, including its mediating role.

Modern teaching practices have been consistently shown to influence learning outcomes not only through

direct instructional effects, but also indirectly through learners' motivational and psychological characteristics. Empirical evidence from Thailand by Damrongpanit (2019) demonstrated that modern teaching exerted both direct and indirect effects on students' academic achievement through non-cognitive mediators, particularly achievement motivation and self-efficacy. Using multilevel structural equation modeling, the study revealed that modern teaching practices significantly enhanced students' motivational dispositions, which in turn contributed substantially to learning outcomes, explaining over 60% of variance at the student level and nearly all variance at the classroom level.

These findings underscore the importance of viewing instructional quality as a contextual catalyst that operates through internal learner processes rather than as a purely instructional input. This mediational perspective provides a strong theoretical foundation for the present study, which extends prior work by examining growth mindset and achievement motivation as key psychological mechanisms linking modern teaching and the learning ecosystem to self-directed learning (SDL). In line with Damrongpanit's (2019) results, the current study conceptualizes modern teaching not as an isolated instructional practice, but as an enabling condition that shapes learners' motivational orientations and learning beliefs, ultimately fostering SDL in contemporary learning environments.

Empirical studies further support the role of achievement motivation in fostering self-directed learning. Hematian et al. (2017) demonstrated that goal-setting practices significantly enhanced students' self-directed learning and academic achievement, with achievement motivation serving as a key explanatory mechanism. These findings suggest that motivational processes strengthen learners' capacity to regulate their learning activities, providing empirical support for conceptualizing achievement motivation as an important mediating factor in the development of self-directed learning.

The relationship between mindset and self-directed learning (SDL) has been widely examined in educational research. A growth mindset, which views abilities as developable, is associated with stronger engagement in SDL behaviors than a fixed mindset that perceives abilities as innate (Duckworth & Yeager, 2015; Dweck, 2006). Empirical evidence indicates that SDL-related mindsets are positively related to learning enjoyment and strategy knowledge, and indirectly to academic achievement (Karlen et al., 2021). Learners who believe that their learning abilities can be developed tend to

experience more positive learning emotions, employ effective metacognitive strategies, and achieve higher academic outcomes. These findings are consistent with Bandura's (1986) Social Cognitive Theory, which emphasizes reciprocal interactions among personal factors, behavior, and environment. They also align with Constructivist perspectives that view learners as active constructors of knowledge through experience and reflection (Goldie, 2016), as well as McClelland's (1953) Motivation Theory, highlighting the role of achievement motivation in driving learning behavior.

However, while various factors have been studied regarding their impacts on SDL, findings remain conflicting in some aspects. For instance, some research indicates that learners' intrinsic factors are crucial determinants of SDL (Ng, 2018), while other studies have found extrinsic environmental factors to be more significant (Lee et al., 2014). Conflicts also exist in research examining the influence of mindset on SDL, with some studies suggesting a positive impact of growth mindset (Aditomo, 2015), while others have not found such a relationship (Dweck, 2006). This research aims to comprehensively study the influence of components expected to play a crucial role in promoting SDL, including the learning ecosystem, modern teaching, achievement motivation, and learners' mindsets. The focus is on examining direct and indirect influences, as well as the mediating roles of each factor, to obtain a holistic picture of the intricate mechanisms underlying SDL development in learners. This quantitative research using PLS-SEM is crucial for deeply understanding the holistic mechanisms promoting SDL, contributing insights into developing effective learning strategies to foster SDL in learners.

Based on the literature review, this study proposes five overarching hypotheses concerning factors influencing students' self-directed learning (SDL). Specifically, fixed mindset is expected to negatively influence SDL, whereas growth mindset, achievement motivation, modern teaching, and the learning ecosystem are hypothesized to exert positive effects on SDL (H1). Furthermore, the effects of modern teaching and the learning ecosystem on SDL are expected to be transmitted through learners' motivational and cognitive mechanisms, particularly achievement motivation and mindsets (H2–H4). Finally, this study proposes a serial mediation process in which the learning ecosystem and modern teaching influence SDL through a sequence of motivational and cognitive factors, including achievement motivation and learners' mindsets (H5).

Methodology

Participants

The participants for this research were 984 high school students from various schools in the northern region of Thailand. They were selected through a multi-stage sampling process to obtain a diverse and representative sample of the population. The researchers determined the sample size using power analysis based on 10 latent variables and 22 observed variables from the hypothesized model. The power ($1-\beta$) was set at 0.80, meaning there was only a 20 percent chance of failing to reject a false null hypothesis. The effect size (f^2) was set at 0.15, considered a medium effect. The significance level (α) was 0.05, allowing for a 5% margin of error (Cohen, 1992). The minimum required sample size calculated was 942 participants, and the actual data collected from 984 participants exceeded this threshold. The participants ranged in age from 11 to 15 years old, with cumulative GPAs ranging from 1.77 to 3.75. The sample consisted of 314 male students (31.9%) and 670 female students (68.1%), comprising 293 students (29.8%) in grade 10, 328 students (33.3%) in grade 11, and 363 students (36.9%) in grade 12.

Research Instrument

A 5-point rating scale questionnaire (1 = strongly disagree/never to 5 = strongly agree/always) was used to measure all observed variables. The instruments were validated by experts and pilot-tested prior to data collection. Discriminant validity was assessed using item-total correlation (Pearson's r_{XY}), and internal consistency reliability was evaluated using Cronbach's alpha (α).

Self-directed learning (SDL) was measured across multiple dimensions, including goal setting, planning, information seeking, method selection, skill development, and self-evaluation. The SDL construct comprised openness to learning, understanding one's potential, independence, perseverance, recognizing the value of learning, creativity, viewing problems as challenges, and applying SDL skills. Item-total correlations ranged from 0.416 to 0.777, and reliability was high ($\alpha = 0.973$).

Achievement motivation (ACM) was assessed through indicators of goal orientation, perseverance, desire for success, and enjoyment of learning, encompassing goal orientation, need for achievement learning, and learning enjoyment (item-total correlation

= 0.398–0.665; $\alpha = 0.835$). Modern teaching (MOD) reflected instructional planning aligned with learners' needs, creativity, participation, technology integration, knowledge promotion, and diverse assessment methods, including planning, learning environment, real-experience activities, media and technology use, and evaluation (item-total correlation = 0.438–0.688; $\alpha = 0.897$).

The learning ecosystem (ECO) captured supportive relationships and environments that facilitate learning, incorporating learning methods, equipment and technology, goal setting, skill integration, and transparent information (item-total correlation = 0.444–0.660; $\alpha = 0.904$). Mindset was measured as fixed mindset (belief in innate abilities) and growth mindset (belief in developable abilities), both demonstrating acceptable discriminant validity and reliability (fixed: $r = 0.533$ –0.731, $\alpha = 0.712$; growth: $r = 0.702$ –0.747, $\alpha = 0.795$).

Data Collection

The researchers contacted and made appointments with schools to collect data. They began by introducing themselves, explaining the objectives, clarifying the instruments and data collection methods to the students, as well as informing them about their rights to provide information, the duration, and the confidentiality of the data. Each student received a questionnaire without time constraints. The researchers prepared 1,100 questionnaire sets for random data collection in classrooms with a large number of students. The data collection results showed that 991 questionnaires were returned. Of these, 7 questionnaires were incomplete, with more than 30 percent of the responses missing, which were therefore excluded from the analysis. This resulted in 984 valid questionnaires for analyzing the relationships between variables, which exceeded the minimum estimated requirement. Overall, the students did not have any questions during the response process, and the response time ranged between 14–22 minutes. All research procedures were approved by the Human Research Ethics Committees of Chiang Mai University, under the project numbers COA No.165/66 and CMUREC No. 66/294.

Data Analysis

This study employed partial least squares structural equation modeling (PLS-SEM) to analyze causal relationships among multidimensional variables. Parameter estimation was conducted using the PLS algorithm with 5,000 bootstrap resamples to assess the significance of the path coefficients (Hair et al., 2017).

Given the higher-order reflective–reflective model structure, the analysis was performed using ADANCO 2.4 with the Disjoint Two-Stage Approach to ensure adequate validity and reliability (Sarstedt et al., 2019).

Model evaluation followed established PLS-SEM guidelines and included assessments of overall model fit, the measurement model, and the structural model. Overall model fit was evaluated using the standardized root mean square residual (SRMR < 0.080). The measurement model was assessed based on factor loadings, composite reliability, average variance extracted, cross-loadings, the heterotrait–monotrait ratio, and the Fornell–Larcker criterion. The structural model was evaluated using path coefficients, significance levels, coefficients of determination (R^2), and effect sizes (f^2). Mediation effects, including single and serial mediation, were examined through direct, indirect, and total effects, with the variance accounted for (VAF) used to determine the magnitude of mediation effects (Hair et al., 2017; Nitzl et al., 2016).

Results

Overall and Outer Model Fit Assessment

The goodness-of-fit indices for the structural equation model in this research are: the SRMR (Standardized Root Mean Square Residual) value is 0.0386, the dULS (Unweighted Least Squares Discrepancy) value is 0.5628, and the dG (Geodesic Discrepancy) value is 0.3075. These index values are lower than the critical values at

the 99 percent significance level (HI99), indicating that the model fits the empirical data at an acceptable level. Therefore, the results can be reliably used to describe and explain the causal relationships among the variables. See [Table 1](#) for details.

The measurement models for all six latent variables—self-directed learning, fixed mindset, growth mindset, achievement motivation, modern teaching, and learning ecosystem—demonstrated strong construct validity. Self-directed learning, measured by eight indicators, showed high internal consistency (factor loadings = 0.784–0.854; CR = 0.944; ρA = 0.945; AVE = 0.680). Fixed and growth mindsets, each measured by three indicators, exhibited unidimensionality with satisfactory reliability and convergent validity (factor loadings > 0.80; CR and ρA > 0.80; AVE > 0.70). Achievement motivation (three indicators), modern teaching (five indicators), and learning ecosystem (five indicators) also demonstrated good construct validity, with factor loadings exceeding 0.80, composite reliability above 0.86, and AVE values greater than 0.66. Overall, all measurement models met the recommended criteria for reliability, convergent validity, and discriminant validity, indicating that the observed indicators reliably represented their respective latent constructs and supported subsequent causal analysis. Detailed results are reported in [Table 2](#).

Table 1 Goodness of model fit (saturated model)

	Value	HI95	HI99
SRMR	0.0386	0.0289	0.0298
dULS	0.5628	0.3152	0.3352
dG	0.3075	0.2281	0.2000

Table 2 Confirmatory Factor Analysis result

Construct	Mean	SD	Sk	Kur	Loading	CA	ρA	CR	AVE
Self-directed Learning ^a (SDL)						0.9443	0.9447	0.9443	0.6796
OLO	0.000	1.000	-0.650	0.132	0.7840				
SEC	0.000	1.000	-0.608	0.222	0.7852				
INL	0.000	1.000	-0.602	0.234	0.8209				
ROL	0.000	1.000	-0.618	-0.059	0.8404				
LOL	0.000	1.000	-0.738	0.297	0.8382				
CRE	0.000	1.000	-0.455	-0.127	0.8404				
PDF	0.000	1.000	-0.693	0.078	0.8293				
APS	0.000	1.000	-0.501	-0.099	0.8539				
Fix Mindset (FIX)						0.8161	0.8170	0.8907	0.7310
FIX1	3.816	0.946	-0.601	0.142	0.8520				
FIX2	3.704	0.966	-0.392	-0.246	0.8733				
FIX3	3.757	0.956	-0.45	-0.282	0.8394				
Growth Mindset (GRO)						0.8554	0.856	0.912	0.7756
GRO1	4.161	0.855	-0.685	-0.316	0.8794				
GRO2	4.142	0.891	-0.819	0.261	0.8783				
GRO3	4.209	0.863	-0.911	0.363	0.8843				

Table 2 Continued

Construct	Mean	SD	Sk	Kur	Loading	CA	ρA	CR	AVE
Achievement Motivation (ACM)						0.7466	0.7467	0.8555	0.6637
GOA	3.997	0.833	-0.465	-0.317	0.8187				
NAL	3.941	0.837	-0.442	-0.310	0.8146				
ENJ	3.992	0.855	-0.501	-0.272	0.8171				
Modern Teaching (MOD)						0.8821	0.8826	0.9138	0.6795
PLP	3.979	0.84	-0.394	-0.604	0.8178				
ERE	3.928	0.849	-0.516	0.031	0.8295				
TSI	3.941	0.847	-0.549	-0.001	0.8383				
MIT	3.917	0.871	-0.435	-0.318	0.8148				
MEU	3.864	0.865	-0.387	-0.252	0.8202				
Learning Ecosystem (ECO)						0.8807	0.8807	0.9129	0.6770
LEN	3.882	0.887	-0.442	-0.293	0.8178				
STS	3.876	0.889	-0.468	-0.261	0.8330				
TAR	3.833	0.906	-0.461	-0.141	0.8197				
INT	3.880	0.857	-0.421	-0.236	0.8362				
TRA	3.968	0.872	-0.525	-0.213	0.8070				

Note: ^a: Used standardized z-scores in the first step of the analysis; CA: Cronbach's Alpha; CR: composite reliability; ρA : construct reliability measure; AVE: average variance extracted.

Discriminant validity was assessed using the heterotrait–monotrait ratio of correlations (HTMT) and the Fornell–Larcker criterion. The results confirmed that the six latent variables—self-directed learning, fixed mindset, growth mindset, achievement motivation, modern teaching, and learning ecosystem—were empirically distinct. All HTMT values were below the recommended threshold of 0.85, and for each construct, the average variance extracted (AVE) exceeded the squared correlations with other constructs. These findings indicate that each latent variable shared more variance with its own indicators than with other constructs, demonstrating adequate discriminant validity. Accordingly, the measurement model supported the independent examination and interpretation of the relationships among the study variables within the proposed conceptual framework. Detailed results are reported in [Tables 3](#) and [4](#).

Table 3 Discriminant Validity: Heterotrait-Monotrait Ratio of Correlations (HTMT)

Latent	SDL	FIX	GRO	ACM	MOD
FIX	0.5090				
GRO	0.756	0.4672			
ACM	0.7419	0.5374	0.6850		
MOD	0.7050	0.4515	0.6985	0.6524	
ECO	0.6860	0.6942	0.7010	0.6707	0.7628

Structural Model Assessment

The structural equation model revealed that multiple factors exerted meaningful influences on students' self-directed learning (SDL), supporting the proposed conceptual hypotheses. The learning ecosystem demonstrated the strongest overall influence on SDL ($TE = 0.6443$, $p < .001$), with its effects transmitted through motivational and instructional mechanisms, including modern teaching, growth mindset, and achievement motivation. Modern teaching also showed a substantial total effect on SDL ($TE = 0.4201$, $p < .001$), operating through both direct and indirect pathways. Achievement motivation and growth mindset exhibited significant contributions to SDL, indicating their important motivational and cognitive roles within the model.

Table 4 Discriminant validity: Fornell-Larcker Criterion

Latent	SDL	FIX	GRO	ACM	MOD	ECO
SDL	(0.6796)					
FIX	0.2122	(0.731)				
GRO	0.4896	0.1526	(0.7756)			
ACM	0.4111	0.1761	0.3006	(0.6637)		
MOD	0.4401	0.1483	0.3687	0.2814	(0.6795)	
ECO	0.4151	0.3483	0.3711	0.2961	0.4522	(0.677)

Note: Values in parentheses represent the AVE of the latent variable; SDL: self-directed learning; FIX: fix mindset; GRO: growth mindset; ACM: achievement motivation; MOD: modern teaching; ECO: learning ecosystem

Overall, the findings provide overall support for the proposed mediating mechanisms (H2–H5), highlighting the interconnected roles of contextual, instructional, and motivational factors in fostering self-directed learning (SDL). In contrast, fixed mindset exhibited a small but statistically significant positive direct effect on SDL ($DE = 0.0745$, $p < .05$), which was not consistent with the expected negative

direction proposed in H1. This unexpected finding suggests that the role of fixed mindset in SDL may be more nuanced than initially conceptualized and warrants further investigation.

The model explained 64.6% of the variance in SDL, underscoring the importance of a multifaceted approach to promoting self-directed learning. Detailed results are presented in Table 5 and Figure 1.

Table 5 Structural model result

Path	DE	IE	TE	f^2	Conclusion
FIX → SDL	0.0745*		0.0745*	0.0100	Not Support H1
GRO → SDL	0.3273***		0.3273***	0.1574	Support H1
ACM → SDL	0.248***	0.0903***	0.3384***	0.1039	Support H1
ACM → FIX → SDL		0.0117			
ACM → GRO → SDL		0.0788			
MOD → SDL	0.2292***	0.1909***	0.4201***	0.0697	Support H1
MOD → FIX → SDL		-0.0051			
MOD → GRO → SDL		0.0942			
MOD → ACM → SDL		0.0744			
MOD → ACM → FIX → SDL		0.0035			
MOD → ACM → GRO → SDL		0.0236			
ECO → SDL	0.1118*	0.5325***	0.6443***	0.0134	Support H1
ECO → FIX → SDL		0.0413			
ECO → GRO → SDL		0.0929			
ECO → ACM → SDL		0.0848			
ECO → MOD → SDL		0.1539			
ECO → ACM → FIX → SDL		0.0040			
ECO → ACM → GRO → SDL		0.0270			
ECO → MOD → ACM → FIX → SDL		0.0024			
ECO → MOD → ACM → GRO → SDL		0.0159			

Note: * $p < .05$, ** $p < .01$, *** $p < .001$, SDL: self-directed learning; FIX: fix mindset; GRO: growth mindset; ACM: achievement motivation; MOD: modern teaching; ECO: learning ecosystem

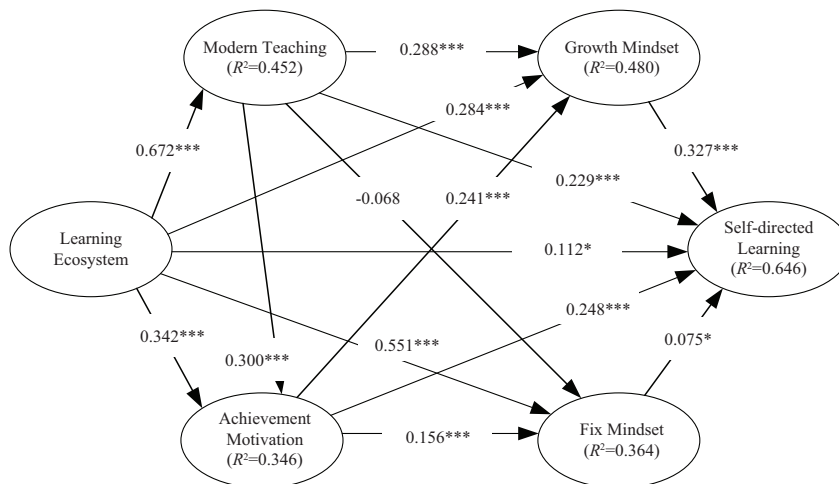


Figure 1 Factors influencing self-directed learning

Note: * $p < .05$, ** $p < .01$, *** $p < .001$, R^2 : coefficient of determination

Mediation Analysis

Mediation analysis demonstrated that the effects of achievement motivation, modern teaching, and the learning ecosystem on students' self-directed learning were transmitted through learners' motivational and cognitive mechanisms. In particular, growth mindset emerged as a central pathway through which these factors exerted their influence on self-directed learning, indicating partial mediation within the proposed conceptual framework. In contrast, fixed mindset did not exhibit a meaningful mediating role in the relationships examined. Achievement motivation also functioned as an important motivational pathway linking instructional practices to self-directed learning, reinforcing the overall mediating mechanisms proposed in this study.

Further analysis highlighted the pivotal role of the learning ecosystem as an overarching contextual factor influencing self-directed learning through interconnected instructional and motivational processes. The ecosystem's effects were partially transmitted through modern teaching, achievement motivation, and learners' mindsets, reflecting a coordinated mediation structure. When these mechanisms operated sequentially, particularly with growth mindset functioning as a key intermediary, the influence of the learning ecosystem on self-directed learning was maximized. These findings underscore the complex and interrelated pathways through which contextual, instructional, and motivational factors jointly contribute to the development of self-directed learning (Table 6).

Table 6 Result of mediation and series mediation analysis

Path	Effect	Coefficients	t-value	VAF	Conclusion
ACM → FIX → SDL	TE	0.2782***	7.4193	0.1118	No Mediation (Not Support H2)
	DE (C)	0.2475***	6.8784		
	DE (C')	0.2472***	6.8086		
	IE	0.0311*	2.4736		
ACM → GRO → SDL	TE	0.4274***	11.9278	0.4214	Partial Mediation (Support H3)
	DE (C)	0.2475***	6.8784		
	DE (C')	0.2473***	6.8334		
	IE	0.1801***	8.3476		
MOD → FIX → SDL	TE	0.2580***	6.6793	0.1112	No Mediation (Not Support H2)
	DE (C)	0.2292***	6.2534		
	DE (C')	0.2293***	6.0397		
	IE	0.0287*	2.3957		
MOD → GRO → SDL	TE	0.4274***	11.0356	0.4647	Partial Mediation (Support H3)
	DE (C)	0.2292***	6.2534		
	DE (C')	0.2289**	6.3123		
	IE	0.1986***	8.9013		
MOD → ACM → SDL	TE	0.3606***	9.4384	0.3644	Partial Mediation (Support H4)
	DE (C)	0.2292***	6.2534		
	DE (C')	0.2293***	6.0897		
	IE	0.1314***	6.2773		
MOD → ACM → FIX → SDL	TE	0.3771***	9.9093	0.3917	Partial Mediation (Support H5)
	DE (C)	0.2292***	6.2534		
	DE (C')	0.2294***	6.0906		
	IE	0.1477***	6.7017		
MOD → ACM → GRO → SDL	TE	0.4562***	12.0200	0.4974	Partial Mediation (Support H5)
	DE (C)	0.2292***	6.2534		
	DE (C')	0.2293***	6.0706		
	IE	0.2269***	9.3963		
ECO → FIX → SDL	TE	0.1560***	3.9732	0.2814	Partial Mediation (Support H2)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1120*	2.5151		
	IE	0.0439*	2.4525		
ECO → GRO → SDL	TE	0.3112***	7.3325	0.6420	Partial Mediation (Support H3)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1114*	2.5173		
	IE	0.1998***	9.0203		

Table 6 Continued

Path	Effect	Coefficients	t-value	VAF	Conclusion
ECO → ACM → SDL	TE	0.2464***	5.4963	0.5463	Partial Mediation (Support H4)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1118*	2.5204		
	IE	0.1346***	6.4490		
ECO → MOD → SDL	TE	0.2655***	6.2439	0.5797	Partial Mediation (Support H4)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1117*	2.4831		
	IE	0.1539***	6.2168		
ECO → ACM → FIX → SDL	TE	0.2635***	6.2212	0.5746	Partial Mediation (Support H5)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1121*	2.4912		
	IE	0.1514***	6.8078		
ECO → ACM → GRO → SDL	TE	0.3445***	8.1077	0.6752	Partial Mediation (Support H5)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1119*	2.5325		
	IE	0.2326***	9.466		
ECO → MOD → ACM → FIX → SDL	TE	0.3654***	9.6749	0.6935	Partial Mediation (Support H5)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1120*	2.5655		
	IE	0.2534***	9.3114		
ECO → MOD → ACM → GRO → SDL	TE	0.4184***	10.8082	0.733	Partial Mediation (Support H5)
	DE (C)	0.1121*	2.5068		
	DE (C')	0.1118*	2.5032		
	IE	0.3066***	10.9862		

Note: * $p < .05$, ** $p < .01$, *** $p < .001$; SDL: self-directed learning; FIX: fix mindset; GRO: growth mindset; ACM: achievement motivation; MOD: modern teaching; ECO: learning ecosystem

Discussion

This study provides important insights into the complex dynamics of self-directed learning (SDL) among students by illustrating how multiple contextual, instructional, and motivational factors jointly shape SDL development. The findings indicate that growth mindset, achievement motivation, modern teaching practices, and a supportive learning ecosystem are closely associated with higher levels of SDL, which is consistent with previous research (Afshar et al., 2016; Dweck, 2006; Lee & Hannafin, 2016; Sáiz-Manzanares et al., 2017). Rather than operating independently, these factors appear to influence SDL through interconnected processes that highlight the multifaceted nature of SDL development. Although fixed mindset demonstrated a small relationship with SDL, its contribution was relatively limited, suggesting that other contextual and instructional factors may play a more prominent role in fostering SDL. This finding points to a more nuanced role of mindset in SDL development and warrants further investigation.

The mediation results highlight the important roles of growth mindset and achievement motivation in transmitting the effects of environmental and instructional factors on self-directed learning (SDL). Growth mindset emerged as a key mediator linking supportive learning environments to enhanced SDL, consistent with Dweck's (2006) theoretical perspective. Achievement motivation also functioned as an important motivational pathway through which modern teaching practices and the learning ecosystem influenced SDL.

Notably, the serial mediation findings suggest a cascading process in which supportive environments and innovative teaching practices foster a growth mindset, strengthen achievement motivation, and ultimately promote SDL. This integrated pathway extends existing literature by illustrating how contextual, instructional, and motivational factors operate together rather than in isolation.

These findings underscore the importance of adopting an integrated approach to promoting self-directed learning (SDL) in educational practice. Rather than focusing on isolated interventions, efforts to enhance SDL should simultaneously address instructional practices, learning environments, and learners' motivational and

cognitive characteristics. Consistent with Fischer and Scharff (1998), supportive learning technologies and instructional designs can function as enabling conditions that foster learner autonomy, reflection, and self-regulation. Moreover, in line with Bandura's (1986) social cognitive theory, the results suggest that improvements in teaching practices or learning environments are unlikely to produce sustained gains in SDL unless they also foster positive changes in learners' mindsets and motivation. Together, these findings provide a coherent framework for understanding SDL development in contemporary educational contexts, including technology-enhanced learning environments such as MOOCs, and offer practical guidance for educators and policymakers seeking to cultivate SDL as a critical 21st-century skill (Alismail & McGuire, 2015).

Limitations

While this study provides valuable insights into self-directed learning (SDL), several limitations should be acknowledged. First, the findings are derived from data collected within the Thai educational context, which may limit their generalizability to other cultural or institutional settings. Differences in educational systems, instructional practices, and sociocultural values may influence how learning environments, motivation, and mindsets interact to support SDL. Future research should adapt and validate the proposed framework in diverse national and educational contexts to examine its broader applicability.

Second, the reliance on self-reported data may introduce response bias or recall errors. To strengthen the robustness of future research, multiple data collection methods—such as classroom observations, performance-based assessments, interviews, or learning journals—should be employed to triangulate learners' SDL behaviors. Third, the cross-sectional design restricts the ability to draw definitive causal conclusions. Longitudinal studies or experimental designs are recommended to better capture the developmental dynamics and causal pathways of SDL over time. Finally, this study did not explicitly examine potential moderating variables. Future studies should consider factors such as socioeconomic status, cultural background, and school characteristics to better understand how SDL-related mechanisms operate across different learner groups and educational contexts. Addressing these limitations will enhance the applicability and explanatory power of research on SDL in diverse educational settings.

Conclusion and Recommendation

This study on self-directed learning (SDL) among Thai high school students offers insights that may inform educational management in broader contexts, while recognizing the need for cultural adaptation. Effective implementation of SDL requires a coordinated effort among key stakeholders. Teachers can support SDL by adopting facilitative roles, designing learner-centered and technology-enhanced activities that promote higher-order thinking, goal setting, and reflective feedback. School administrators play a critical role in establishing SDL-supportive ecosystems by providing appropriate learning resources, integrating digital tools, and strengthening teachers' capacities through professional learning communities. At the learner level, students should be encouraged to set challenging goals, monitor their progress, and engage in reflective practices, such as maintaining learning journals or using digital platforms for independent inquiry.

The application of these recommendations should be adapted to local cultural and educational contexts. For example, in collectivist learning cultures such as Japan, SDL initiatives may emphasize collaborative problem-solving and group-based reflection, whereas in the United States, SDL-oriented instruction may incorporate culturally diverse case studies and inquiry-based projects. In resource-constrained contexts, such as rural areas in developing countries, SDL may be supported through low-cost or offline mobile learning applications. Future research should further examine the transferability of SDL frameworks across cultural settings, including comparative studies within Southeast Asia and longitudinal investigations of SDL development in international or cross-cultural educational environments. Such efforts will support the development of adaptable learners while respecting contextual differences in educational practice.

Conflict of Interest

The author declares that there is no conflict of interest.

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