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Exploring Home Environment and Self-Directed Learning Efficacy of Multilingual and Non-Multilingual Students

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ABSTRACT

The impact of school closures during the COVID-19 pandemic was disproportionate on multilingual learners (MLs) as compared to non-MLs. Utilizing the PISA 2022 dataset and focusing on differences between MLs and non-MLs, this study explores the relationships between family support for self-directed learning (SDL), feelings about learning at home, and SDL self-efficacy (SDL-SE) in the US. First, measurement invariance was examined to determine possible differences due to group membership. Next, we explored the mediating influence of feelings about learning at home on the relationship between family support for SDL and SDL-SE and examined differences in these relationships between groups. Findings revealed that MLs and non-MLs had similar levels of SDL-SE; however, ML students had a stronger direct relationship from family support for SDL to SDL-SE, whereas non-ML students had a stronger indirect effect through feelings about learning from home. Implications regarding research, practice, and policy for post-COVID era are discussed.

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INTRODUCTION

Understanding the factors that influence a student's ability to learn independently is crucial, especially when considering the role of the learning environment. Given how the coronavirus disease 2019 (COVID-19) pandemic has impacted the characteristics of learning all around the world (Bhamani et al., 2020; Chau et al., 2021), understanding what influences the development of self-directed learning (SDL) during secondary years is vital as students prepare to navigate the increase in virtual learning experiences in college (Hart et al., 2024). SDL is defined as a student taking initiative on their learning by examining their own learning needs, goals, resources, and evaluating the outcomes (Knowles, 1975). In recent years, the Programme for International Student Assessment (PISA) has included new scales to assess family support for SDL, feelings regarding learning from home, and student's self-efficacy (i.e., an individual's belief in their capabilities; Bandura, 1977) for SDL (SDL-SE) in 2022 (OECD, 2023a). Multiple researchers have

incorporated these constructs in an international context by utilizing PISA 2022 datasets. For example, as Ramazan et al. (2023) summarized, students' success is contingent on the individual's cultural and linguistic backgrounds, their level of English language proficiency and self-efficacy, as well as their learning environment (Han, 2019; Sandilos et al., 2020).

However, a gap in the literature still remains in examining specific relations between these constructs for multilingual learners (MLs). Therefore, grounded in Bandura's self-efficacy theory (1977, 1994) and Knowles' SDL framework (1975), this study aims to explore the mediating effects of family support for SDL on the relationship between feelings about learning at home and SDL-SE between MLs and non-MLs in the US.

The Study's Context

Given that this study uses a secondary dataset, as authors we find it essential to describe the context of which the data were collected. PISA studies have been conducted in various countries, including the United States (US), since the 2000s and are meant to assess the mathematics, science, and reading skills and knowledge of 15-year-old students (OECD, 2023b). The PISA dataset used in this study was initially designated for the assessment year of 2021; however, the COVID-19 pandemic caused a one-year delay due to lockdowns and school closures across the world which prompted the data to be collected in 2022 once school buildings had reopened (OECD, 2023b). Considering the significant impact of the COVID-19 pandemic on education and learning across the globe (Bhamani et al., 2020; Chau et al., 2021), the PISA survey included measures that reflected students' experiences (i.e., how students adapted to learning during the pandemic; e.g., family support for SDL, feelings about learning at home, and SDL-SE; OECD, 2023a).

School closures affected more than 60% of US students for over three months, which is higher than the average across the Organization for Economic Co-operation and Development (OECD) countries (e.g., Austria, Belgium, Canada, Türkiye), at a 51% school buildings closure rate (OECD, 2023c); thus, reshaping the learning environment and making the home learning experience critical. Home learning turned into a substitute for school learning, wherein providing necessary learning skills with limited resources at home became crucial (Bhamani et al., 2020). Subsequently, SDL emerged as a significant learning strategy because it "help[ed] a learner to learn according to his or her own pace, path and place" (Singh, 2020, p. 16), particularly in the virtual environment. COVID-19 shutdowns highlighted the importance of students' experiences with SDL, along with their self-efficacy – their beliefs in their ability to succeed – emphasizing that learners with a supportive learning environment paired with higher self-efficacy will better employ SDL (Mirzawati et al., 2020). However, to take further the insights of SDL and student learning post-COVID-19 shutdown, it is essential that we explore these student experiences across various groups, such as multilingual learners, to better prepare school entities to support all students in case of future closures, as well as the shift growing opportunities for online learning in higher education (Hart et al., 2024).

The population of interest is MLs, also referred to as English Language Learners or Bilingual Learners (WIDA, 2020). The PISA framework opts to capture the language status of students as it relates to the student's 'migration and language exposure', which is assessed with one item related to the primary language spoken at home (OECD, 2023a). In this study, we also operationalize MLs in alignment with WIDA's (2020) definition, identifying them as students whose home language differs from the instructional language used at school, which is English in US schools.

Multilingual Learners During COVID-19

According to the National Center for Education Statistics, more than 10% of the student population (about five million) in public schools in the US are MLs (2024). School closures during the COVID-19 pandemic had disproportionate impacts on MLs, affecting their economic stability, educational opportunities, and overall well-being compared to non-MLs (Napolitano, 2020; Office of English Language Acquisition [OELA], 2022; Sayer & Braun, 2020). Many US schools – especially those with higher socioeconomically marginalized populations– struggled to provide essential materials and resources for online learning

that were translated to multiple native languages; thus, limiting access to support for MLs (Napolitano, 2020; Sayer & Braun, 2020). Additionally, many families faced economic hardships that forced them to relocate, disrupting students' learning (Napolitano, 2020). With remote learning materials and online resources provided by the schools prioritizing content learning over language acquisition, opportunities for meaningful social interaction to maintain MLs' English language development were jeopardized (Sayer & Braun, 2020).

Sugarman and Lazarín (2020) also discussed how MLs were disproportionately impacted by the school closures in the U.S. during the COVID-19 pandemic because of the disadvantaged home learning environment. MLs did not participate in online classes as much as their non-ML classmates did mainly because of the limited access to online learning resources, language-related communication barriers between parents and schools, and limited capacity of parents' support for home learning of MLs (Sugarman & Lazarín, 2020). Similarly, OELA (2022) has also underlined the different aspects of how the family support for learning at home that MLs received and their experiences about learning at home were also severely impacted during the COVID-19 lockdowns. For instance, some MLs needed to allocate their time to working in order to financially help their families. Furthermore, some MLs took on responsibilities beyond their age, being the translator or the interpreter for their families who are not fluent in English while communicating with landlords or social service agencies (OELA, 2022). Thus, many MLs had to balance their education whilst navigating their world during COVID-19.

It is within this context that learner's SDL-SE can be a crucial component to academic success, especially given the trend towards higher education institutions increasing opportunities for online courses (Hart et al., 2024). The following section will provide a brief review of the literature to help build current and relevant understanding regarding the three main constructs used in this study, beginning with a theoretical overview of SDL and self-efficacy, followed by SDL-SE, feelings about learning at home, and family support for SDL.

THEORETICAL FRAMEWORKS AND CONSTRUCTS

Self-Efficacy

Self-efficacy was first conceptualized by Albert Bandura in 1977 as an individual's belief in their capability to produce desired effects (Bandura, 1977, 1994). According to Bandura (1977, 1994), self-efficacious beliefs are developed through four main sources (ordered least to most influential): (1) physiological responses (i.e., biological response or arousal to contextualized circumstance), (2) verbal persuasions from external sources, (3) vicarious experiences (i.e., observing the success of social models), and (4) mastery experiences (i.e., successful opportunities of achievement). When applied to a specific context (e.g., home learning environment), experiencing beliefs of self-efficacy can affect a learner's thinking and decision making, their level of effort and persistence, avoidance behavior, and even their emotional responses to stimuli (Lippke, 2017; Reeve, 2014). As such, learners who exhibit high self-efficacy beliefs (i.e., academic self-efficacy) are motivated to persist through challenges, willingly engage in challenging tasks, make an effort towards achievement, self-regulate their learning (e.g., goal-setting, progress monitoring, reflecting) through strategy use, and structure their environment to be conducive to their learning needs (Schunk & DiBenedetto, 2016). Therefore, it can be presumed that self-efficacy is vital for a learner to believe in their abilities to effectively manage their learning needs (Zimmerman & Cleary, 2006).

Self-Directed Learning

SDL has become more popular in recent years, with discussions about the concept tracing back to the 1970s (Asyhari et al., 2023; Ebrahimi, 2023; Nash, 2023; Pongsophon, 2024; Vaičiūnienė & Kazlauskienė, 2023). Knowles (1975) defines SDL as a self-initiated process where the learner determines their learning needs, designs their learning goals, detects resources for their learning, decides and applies learning strategies, and finally evaluates their learning outcomes. Knowles further explains the difference amongst SDL and other similar terms, such as self-planned learning, self-study, and

independent learning, in that these terms "imply learning in isolation, whereas SDL usually takes place in association with various kinds of helpers, such as teachers, tutors, mentors, resource people, and peers." (Knowles, 1975, p. 18). During the COVID-19 school shutdowns, these various kinds of helpers became particularly important for learners immersed in home learning environments where there was a need for family support for students' learning (Chifari et al., 2021; Sosa Díaz, 2021).

PISA Constructs in Context

The constructs of 'feelings about learning at home', 'family support for SDL', and 'SDL-SE' were first introduced in the PISA in 2022 which was disseminated post-COVID-19. Given that students were asked about their experiences with learning at home during the school building closures due to COVID-19, the 'feelings about learning at home' have been also called 'experience with learning at home' (OECD, 2023a) - for consistency, we will refer to the construct as 'feelings about learning at home'. However, considering that the dataset was made available recently, there is limited study on the relations of these constructs; yet alone as it relates to MLs.

Feelings/experience on home learning and familial support

In related research, Ye et al. (2023) found that when students experience positive feelings within their home learning environment (e.g., experiencing more joy and less anger or boredom), they have stronger academic self-concepts. Using the PISA 2022 dataset, Qiu et al. (2024) conducted a study on a total of 52,957 students' PISA 2022 scores from eight countries – Australia, Chinese Taipei, Hong Kong (China), Japan, Korea, Macao (China), Singapore, and the US. They found that higher levels of self-efficacy in SDL and better feelings about learning at home were significantly correlated with students' math performance.

Similar to the above studies, Pongsophon (2024) conducted an SEM analysis with PISA 2022 dataset to discover the role of enrichment activities, such as extracurricular activities and self-initiated learning endeavors, in enhancing SDL among students from Ireland, Saudi Arabia, and Portugal. Pongsophon

(2024) underlined the positive impact of the students' feelings about learning at home and SDL-SE on their SDL. As such, Pongsophon's (2024) analysis showed significant positive correlations among SDL-SE, feelings about learning at home, and family support for learning, which emphasizes the vital role of family support and home environment in fostering SDL across sampled countries with different cultural contexts. Although the aforementioned studies listed (e.g., Pongsophon, 2024; Qiu et al., 2024; Ye et al., 2023) have marginally explored the constructs of 'feelings about learning at home', 'family support for SDL' and 'SDL-SE', further evidence is needed to investigate the relationships amongst these constructs across different student groups, specifically MLs.

Self-directed learning self-efficacy (SDL-SE)

Although the concept of self-directed learning self-efficacy has not been extensively researched in the K-12 context, there are some studies that found a positive correlation between SDL and self-efficacy (e.g., Pan & Chen, 2021; Zhao et al., 2024). Moreover, Bandura (1995) alluded to the relationship stating that "efficacy beliefs play a vital role in the development of self-directed life-long learners" (p. 17). Additionally, Soland (2019) underlined that there was a gap between the self-efficacy scores of MLs vs. non-MLs favoring non-MLs because MLs might show less belief in their academic abilities compared to non-MLs. It can be presumed that MLs are inherently situated in a space where they may have to adopt effective levels of SDL to navigate their education setting, especially amidst a global pandemic. To our current knowledge, there has been little to no research that explores the concept of SDL, let alone SDL-SE, that ties amongst MLs. Therefore, to better situate the role of SDL-SE for MLs, SDL-SE will be discussed as it relates to family support for SDL and feelings about learning at home as it relates to the data collected by PISA.

Statement of Problem

The COVID-19 pandemic has reshaped learning, emphasizing the importance of SDL as students adapt to new learning environments. Understanding the factors influencing SDL, especially the student's

SDL-SE, family support for SDL and feelings about learning from home, is crucial for effective education. Considering the significant role that family support for SDL and feelings about learning at home play in nourishing SDL-SE (Pongsophon, 2024), along with the mentioned unique challenges of remote learning during the COVID-19 lockdowns for MLs (Napolitano, 2020; OELA, 2022; Sayer & Braun, 2020), it is essential to understand how these factors interact within diverse student groups. Particularly, taking into consideration the accessibility of supports for ML students' learning to further propagate the idea of success for all students is highly important when discussing the underlying advantages of the cultural and social factors (Ladson-Billings, 2014; Ramazan et al., 2023). Thus, utilizing assessment through large international databases, such as PISA datasets, could provide a broader perspective in terms of investigating the structural relationship between family support for SDL, feelings about learning at home, and SDL-SE. Using data from PISA 2022, this current study aims to address the following research questions:

Research Question 1: Are the measures of family support for SDL, feelings about learning at home, and SDL-SE invariant across ML and non-ML students?

Research Question 2: Do feelings about learning at home mediate the relationship between family support for SDL and SDL-SE?

Research Question 3: How does the mediation effect of feelings about learning at home on the relationship between family support for SDL and SDL-SE differ between ML and non-ML students?

Method

This study employs a quantitative methodology by consecutively testing measurement invariance, checking model fit through structural equation modeling (SEM), and conducting multigroup analysis utilizing PISA 2022 U.S. dataset.

Participants

In the US, a diverse group of students (*n* = 4552) from 154 schools participated in PISA 2022. After limiting the sample to those students who provided information on home language used, the study sample was reduced to 4344 students from 150 schools. The majority of the students were 10th graders (*n* = 3224), with the rest spanning from 8th to 12th grades (i.e., 749 students in 11th grade, 363 students in 9th grade, 7 students in 12th grade, and 1 student in 8th grade). Approximately half of the students (*n* = 2105) were 16 years old, with the remaining students being 15 years of age (*n* = 2239). Regarding sex, 2151 identified as female, 2188 as male, and 5 students who chose not to respond. Multilingual learner (ML) status of students was determined based on the question "What language do you speak at home most of the time?". According to students' answers, 850 students were determined as MLs, and 3494 students were non-MLs.

Measures
Three scales that were newly added under the PISA 2022 assessments were used in this study – 'family support for SDL', 'feelings about learning at home', and 'SDL-SE'.

Family support for self-directed learning
Students' perceptions of their families' support for SDL were measured by using this scale. There are eight items about how often their family members provided specific forms of support during SDL, with four response options: "Never," "A few times," "About once or twice a week," "Every day or almost every day". For example, one item asks: "*During COVID closures, how often did family member: Help you with your school work*" (OECD, 2023a). Reliability of this scale was assessed using McDonald's Omega (ω) yielded a value of 0.93.

Feelings about learning at home
Six items with four response options ("Strongly disagree," "Disagree," "Agree," "Strongly agree") were used to measure the students' feelings about learning at home during the COVID-19 closures. For instance, students were asked whether they agreed or disagreed with statements such as: "*I enjoyed learning by myself*" (OECD, 2023a). This scale demonstrated strong internal consistency (ω = 0.82).

Self-directed learning self-efficacy
There are eight items with four response options ("Not at all confident," "Not very confident," "Confident,"

"Very confident") to measure how confident students feel about doing the following things if their school building closes again in the future. An example task is: "*Finding learning resources online on my own*" (OECD, 2023a). The internal consistency of this scale was excellent (ω = 0.93).

Demographic variables

Considering the prior research regarding the impact of sex on self-efficacy (e.g., Vantieghem et al., 2014), the home possessions' effect on learning at home (e.g., Brachtl et al., 2023), and the relationship between SDL and parental education level (e.g., Ye et al., 2024), three demographic variables were selected as control variables: sex, home possessions, and parents' education level. Sex was measured as a binary variable (0 = female, 1 = male). Home possessions, a composite variable, was calculated by summing responses to items assessing access to resources at home, including having a room, a computer, internet access, cell phone, educational software, and access to the food. All the home possession variables except the food access were initially coded as binary variables (Yes = 1, No = 0). Access to the food was measured with the item, "In the past 30 days, how often did you not eat because there was not enough money to buy food?", were measured with five response options ("Never or almost never," "About once a week," "2 to 3 times a week," "4 to 5 times a week," "Every day or almost every day"). So, access to the food converted to the binary variable (Never experienced = 0, Experienced at least once = 1). Then, it was reverse coded and combined with other home possession variables so that higher scores indicated greater access to home resources. Finally, parents' education was calculated by using the index on the highest educational level of either parent (HISCED; OECD, 2022), which had 9 levels education for the US dataset with higher score meant higher level of education ("S/he did not complete grade 6," "S/he completed grade 6," "S/he completed grade 9," "S/he completed grade 12 (high school diploma or GED)," "S/he has a vocational or technical certificate/diploma after high school (such as cosmetology or medical assistant)," "S/he has an associate's degree," "S/he has a bachelor's degree or equivalent," "S/he has a master's degree or professional degree

(e.g., law, medicine) or equivalent," "S/he has a doctoral degree or equivalent".)

Data Collection and Analysis

Little's Test of Missing Completely at Random (MCAR) (1988) with the "mice" package in R (van Buuren & Groothuis-Oudshoorn, 2011) confirmed that the data were missing completely at random (MCAR). Pairwise deletion was then utilized to exclude cases only if they have missing values on the variables used in this study as suggested when data are MCAR (Shi et al., 2019). ChatGPT (OpenAI, 2024) was used for R coding assistance for this manuscript, and the codes provided by ChatGPT have been carefully checked by the authors. No intellectual output was provided by ChatGPT or any other AI tools in this study.

We examined the factor structures of family support for self-directed learning, feelings about learning at home, and self-directed learning self-efficacy constructs in the US context using the lavaan (Rosseel, 2023) and semTools (Jorgensen et al., 2022) packages. Considering that all items had 4-response options in given scales, we selected diagonally weighted least square (DWLS) estimation appropriate for both categorical and continuous variables (Baghdarnia et al., 2014). Then, we determined a model that best fits the US student population following suggested values by Hu and Bentler (1999): CFI ≥ 0.95, TLI ≥ 0.95, RMSEA ≤ 0.06, and SRMR ≤ 0.08. Measurement invariance across MLs and non-MLs was also evaluated. Measurement invariance does not mean that MLs and non-MLs have equal levels of SDL-SE, but rather that observed scores are not dependent on group membership. Measurement invariance is critical for any type of group comparison; if the measure does not function equivalently for both groups resulting differences cannot be valid. Next, a structural model using home possessions, sex, and the highest education level of either parent as control variables examined the mediator effect of feelings about learning at home on the relationship between family support for SDL and SDL-SE. Bootstrapping procedures were used to estimate indirect effects. Finally, multi-group analysis based on ML status was conducted to examine if the mediating effect of feelings about learning at home on the relationship between family support for SDL and SDL-SE differed between ML and non-ML students.

RESULTS

Descriptive Statistics

The descriptive statistics (means and standard deviations) as well as loadings (λ) for each of the items examined in this study can be seen in Table 1.

Research Question 1: Measurement Model and Invariance Testing

The initial measurement model showed acceptable fit to the data, $x^2(206) = 7969.872$, $p < .001$; CFI = 0.976; TLI = 0.973; RMSEA = 0.106 [90% CI: 0.104, 0.108]; SRMR = 0.055. The range of factor loadings was .50 to .87 for the initial measurement model. Some factor loadings were below the ideal cutoff point, λ = .70, (Hair et al., 2010), indicating lower convergent validity. After carefully examining the contextual necessity of the items with lower factor loadings, one item in family support for SDL (λ = .54), two items in feelings about learning at home (λ = .50 and λ = .58), and two items related to online platforms in the SDL-SE scale (λ = .65 and λ = .63) were removed.

The respecified measurement model showed good fit values ($x^2(116) = 2665.558$, $p < .001$; CFI = 0.989; TLI = 0.987; RMSEA = 0.081 [90% CI: 0.078, 0.084]; SRMR = 0.040). All factor loadings ranged between .65 and .87 in the respecified model, demonstrating moderate to high convergent validity. Two items in the feelings about learning at home scale had lower factor loadings (.65 and .69) than the cutoff point (λ = .70), as shown in Table 1. However, these items were retained due to their contextual relevance and to preserve the scale's four-item structure. Correlations between factors ranged from .28 to .61 indicating discriminant validity. Moreover, the result of the chi-square difference test between the initial and respecified measurement models indicated improved fit (Δx^2 (90) = 5304.3, $p < .001$; ΔCFI = .013), suggesting that the respecified measurement model fits the data significantly better than the initial measurement model.

Before conducting the measurement invariance analysis, the US dataset was divided into two

Table 1: Descriptive Statistics for the Respecified Measurement Model

Factors	Items	λ	M(SD) for MLs	M(SD) for non-MLs
Family Support for Self-Directed Learning	1) Help you with your school work	.77	1.99 (0.89)	2.29 (0.95)
	2) Ask you what you were learning	.73	2.30 (0.98)	2.54 (1.03)
	3) Help you create a learning schedule	.80	1.71 (0.92)	1.87 (1.04)
	4) Help you access learning materials online	.86	1.99 (0.97)	2.10 (1.05)
	5) Explain new content to you	.85	1.83 (0.95)	1.97 (1.01)
	6) Help you find additional learning resources	.86	1.88 (0.93)	1.92 (1.02)
	7) Teach you additional topics not part of your school assignments	.74	1.87 (1.00)	1.88 (1.03)
Feelings (Experiences) about Learning at Home	1) I enjoyed learning by myself.	.69	2.54 (0.91)	2.46 (0.95)
	2) I was motivated to learn.	.80	2.15 (0.80)	2.01 (0.87)
	3) I improved my skills in using digital devices for learning purposes.	.65	2.71 (0.84)	2.58 (0.86)
	4) I was well prepared to learn on my own.	.79	2.46 (0.80)	2.37 (0.89)
Self-Directed Learning Self-Efficacy	1) Finding learning resources online on my own	.71	2.87 (0.84)	2.86 (0.85)
	2) Planning when to do school work on my own	.86	2.81 (0.81)	2.82 (0.86)
	3) Motivating myself to do school work	.83	2.61 (0.87)	2.52 (0.92)
	4) Focusing on school work without reminders	.84	2.60 (0.91)	2.60 (0.89)
	5) Completing school work independently	.81	2.83 (0.82)	2.88 (0.84)
	6) Assessing my progress with learning	.87	2.80 (0.80)	2.78 (0.86)

Table 2: Measurement Invariance Across ML Status

Model	$x2$	df	$\Delta x2$	*p*-value	CFI	ΔCFI	RMSEA	ΔRMSEA
Configural	1489.644	1396.901	-	-	0.975	-	0.124	-
Weak	1683.475	1551.759	193.831	.018	0.970	0.005	0.133	0.009
Strong	1737.064	1589.853	53.589	.049	0.969	0.001	0.131	0.002
Strict	1766.904	1617.933	29.84	.375	0.969	0.000	0.127	0.003

Note. Fit indices were calculated using with random 100 subsamples to account for differences in sample sizes between MLs and non-MLs groups.

categories: MLs and non-MLs. Because severely unbalanced sample size can mask violations of invariance, we use random subsamples from the larger group according to the procedure outlined by Yoon and Lai (2018). Using our split sample (n_{MLs} = 850, $n_{non-MLs}$ = 3494), 100 subsamples of the non-MLs were randomly generated and compared to the ML sample and results averaged across the individual model fittings. Furthermore, making decisions on the invariance testing based on x^2 differences is not recommended with large samples; thus, as suggested by Cheung and Rensvold (2002), we used a cut point of ΔCFI ≤ .010 for retaining the null hypothesis of invariance. Configural invariance, metric invariance, scalar invariance, and strict invariance were tested, respectively, as represented in Table 2.

The configural model, also known as the baseline model, showed that the same items measured the same constructs for MLs and non-MLs in the US context. Metric invariance indicated that the factor loadings are equivalent across the ML and non-ML groups. The scalar model in which both factor loading and intercepts were constrained to be equal, also supports invariance. Finally, the strict model has been tested to confirm residual variances were also equal between MLs and non-MLs. Overall, measurement invariance analysis indicated that the constructs of family support for SDL, feelings about learning at home, and SDL-SE were all measured equivalently across MLs and non-MLs.

Research Question 2: Structural Model
The structural mediation model showed acceptable goodness of fit values ($x^2(164)$ = 5127.073, *p* < .001; CFI = 0.984; TLI = 0.982; RMSEA = 0.083 [90% CI: 0.082, 0.085]; SRMR = 0.044). However, this model explained only 9.4% of the variance in feelings about learning at home, while it accounted for 40.7% of the variance in SDL-SE, representing a moderate effect size (Flora et al., 2025). There is a significant direct path from family support for SDL to SDL-SE (ß = .103, *p* < .001). The significant indirect effect (ß = .178, *p* < .001) indicates that feelings about learning at home partially mediates the relationship between family support for SDL and SDL-SE.

Additionally, sex, home possessions, and parent education significantly influenced SDL-SE, emphasizing the role of socioeconomic and demographic factors in shaping educational outcomes. Males have lower levels of SDL-SE (ß = −.043, *p* < .001). Larger amounts of home possessions (i.e., greater SES) indicate higher levels of SDL-SE (ß = .114, *p* < .001). Higher parents' education levels result in higher levels of SDL-SE (ß = .073, *p* < .001).

Research Question 3: Multi-group Analysis
In order to address the final research question pertaining to whether relationships between these variables differ between ML and non-ML students, multi-group moderation of path differences were tested. Starting with a fully constrained model where all structural paths were set to be equal across two groups, paths were freed iteratively to identify significant differences and improve model fit. We used the lavTestScore function in lavaan package (Rosseel, 2023) to examine whether freeing constrained paths would improve the model's fit. The chi-square difference test comparing the fully constrained model and the final partially constrained model revealed a significant improvement in fit ($\Delta x^2(3)$ = 316.99, *p* < .001). This indicates that structural paths – the path from family support for SDL to feelings about

learning at home, the path from feelings about learning at home to SDL-SE, and the path from family support for SDL to SDL-SE differ significantly between ML and non-ML students, as represented in Figure 1. The indirect effect for ML (β = .113, p < .001) was weaker than the indirect effect for non-ML students (β = .196, p < .001); whereas the direct effect for MLs (β = .162, p < .001) was stronger than the direct effect for non-MLs (β = .086, p < .001).

Fig.1: Structural Model with Standardized Estimates

Note. All paths marked with (*) are statistically significant at p < .001. Specific items are not included in the figure for simplicity. Standardized estimates are presented, with those for multilingual learners highlighted in **bold** and those for non-multilingual learners shown in *italics*.

Discussion

Grounded in self-efficacy (Bandura, 1977, 1994) and Knowles's approach to SDL (1975), this quantitative study investigated the relationships among the constructs of family support for SDL, students' feelings about learning at home, and SDL-SE among MLs and non-MLs by utilizing the PISA 2022 dataset. We discuss the findings within the broader impacts of the COVID-19 pandemic, which significantly changed the educational experiences and augmented the importance of SDL, specifically related to the need in preemptively preparing learners as education trends towards the increase in online learning opportunities (Hart et al., 2024).

The findings of this study align with and expand upon existing literature. Using measures that are invariant across the sub populations, analysis revealed that students' feelings about learning at home partially mediated the significant relationship between family support for SDL and SDL-SE. That is, the identified relationship between family support for

SDL and SDL-SE is explained by the student's feelings regarding learning from the home environment. Although our study does not bring insight to the specific traits that elicit these feelings, it is a stepping stone towards understanding the role of the environment (e.g., in-person versus virtual) towards student's SDL and academic success (Ye et al., 2023) in a post-COVID era (Hart et al., 2024). Additionally, our findings build upon Pongsophon's (2024) work which not only described the correlations between SDL-SE, feelings about learning at home, and family support for learning, but further highlighted the value of supportive home environments in fostering SDL across different cultural contexts.

The multi-group analysis findings demonstrate that the mediating role of feelings about learning from home is weaker for MLs, consistent with studies emphasizing the challenges ML families face in providing effective home learning environments during remote schooling (Napolitano, 2020; Sayer & Braun, 2020). Interestingly though, MLs demonstrated a stronger direct relationship from family support for SDL to SDL-SE. Further research is needed to understand the dynamics of the relationships between these variables.

In tandem to our findings, Sayer and Braun (2020), for instance, underlines that MLs' families in the US, particularly during the pandemic, lacked access to necessary educational resources in their languages and faced challenges in creating an efficient learning environment at home that met the educational needs of MLs. For example, the typical support strategies, such as providing devices and software (Napolitano, 2020) that may foster SDL-SE in non-MLs, could be less effective for MLs because those strategies may not be aligned with the needs of MLs who are often exposed to different linguistic and cultural experiences in their home environments than in the school environments therefore influencing their feelings about learning from home. This perspective aligns with culturally responsive pedagogy, which emphasizes the importance of validating and leveraging students' cultural and linguistic backgrounds to enhance learning outcomes (Gay, 2018, 2021). Our study adds to this body of work by revealing that MLs' SDL-SE is shaped by unique barriers related to their home

and educational environments, particularly during periods of disruption like the COVID-19 pandemic.

CONCLUSIONS AND SUGGESTIONS

There are many factors that influence a student's ability to engage in SDL, let alone their SDL-SE. These factors have been of importance since COVID-19 when students were expected to continue their learning in their home environment which could be influenced by their feelings about learning from home and the support provided by their family members. The post-COVID era has not diminished the importance of SDL and learning at home; on the contrary, the advancement in technology emphasizes the learning out of school contexts more than ever. Our study aimed to explore whether feelings about learning at home mediated the relationship between family support for SDL and SDL-SE between MLs and non-MLs. We found that even though both MLs and non-MLs have similar levels of SDL-SE, ML students had a stronger direct relationship from family support for SDL to SDL-SE; whereas non-ML students had a stronger indirect effect via feelings about learning from home. By encouraging educators and policymakers to take further consideration to the diverse needs of their learners, we can better understand how to best support learners as they independently navigate the demands of an increasingly complex and interconnected world, equipping them with the skills to achieve academically in the post-COVID world.

Incorporating qualitative approaches led by researchers with diverse cultural, ethnic, and linguistic backgrounds the study may provide richer insights into the specific support structures available to ML students. Such approaches would also allow for a deeper understanding of the nuances in SDL across different cultural contexts. Moreover, research indicates that MLs have a higher rate of absenteeism, particularly in remote-only learning environments, compared to non-MLs (Korman et al., 2020), which can hinder the development of self-efficacy (OELA, 2020; Santibañez & Guarino, 2021). Finally, as educational technologies that support students' home learning continue to evolve, researchers should consider exploring the role of these technological advances on SDL-SE amongst MLs and non-MLs. Exploring these

additional parameters may provide a more nuanced understanding of the factors that influence SDL-SE across diverse populations.

Overall, it can be stated that:

- There is a relationship between family support for SDL and SDL-SE; however, that relationship is influenced by the student's feelings regarding learning from home.
- Particularly, this interaction (mediating role of feelings about learning from home) towards SDL-SE is stronger for non-MLs and weaker for MLs, indicating that for MLs SDL-SE is shaped by the context of their home environment (i.e., resources, barriers); however, compared to non-MLs, MLs favored a stronger direct relationship from family support for SDL and their SDL-SE.
- Future SDL-SE interventions should incorporate both individual- and/or family-centered supports to bolster engagement with learning at home.
- There is very limited to no research exploring the SDL-SE of MLs, thus, more research is needed to inform the school administrations at the school-level, district-level, and state-level to develop and uphold policies that support MLs SDL in the home environment.

LIMITATIONS

In this quantitative study, several limitations must be acknowledged, as they provide directions for future research in this area. First, the participants of this study may not represent the students in the U.S. because most of the students in this study were 10th graders, and students had generally more home possessions and higher parent education levels than the general U.S. population. Second, and perhaps most significantly, is the way MLs and non-MLs were defined and the potential for overgeneralization of findings based on this definition. We aligned with WIDA's definition of MLs as "all children and youth who are, or have been, consistently exposed to multiple languages" (WIDA, 2020, p. 11) by using the PISA item that captures students' primary home language. Students whose primary home language differed

from the language of instruction at school were classified as MLs. This resulted in the identification of 850 MLs and 3494 non-MLs. When examining the languages spoken by MLs, we found that 650 students primarily spoke Spanish at home, while 200 reported speaking "another language." However, this approach has several limitations. For example, families may choose to speak English at home despite cultural and linguistic diversity, potentially underestimating the number of 'true' MLs. Furthermore, PISA lacks a formal definition of MLs, which raises questions about whether students receiving additional English learning services were consistently included. This ambiguity complicates the interpretation of the ML sample and limits the reliability of the data in representing the broader ML population. Moreover, the dataset does not specify 'another language' chosen by 200 students as the home language, which limits our ability to fully understand the diversity within the ML group. This may give the impression that MLs are a homogeneous group, which is far from accurate.

We may also see differences in experiences across cultures and languages. Some MLs, particularly those of Asian descent, may have faced discrimination due to their ethnicity during the pandemic (OELA, 2022; Tamanaha, 2020). Therefore, an Asian student's experiences during the pandemic and their responses to the items might substantially differ from a Turkish student. Thus, the generalization of findings may fail to accurately capture the diverse realities of not only MLs, but also non-MLs.

Another limitation is the reliance on self-reported data. Understanding of SDL can vary significantly based on cultural attitudes toward education (Wang et al., 2021), thus a students' understanding of items (see Table 1) can vary based on their cultural background. Additionally, the PISA dataset, while comprehensive, may not fully capture the complexity of family support or home learning environments, particularly in diverse cultural and linguistic contexts. Moreover, students' self-reported responses may be influenced by fear of stigma or legal concerns. For instance, some students might misreport their ML status due to fears related to free/reduced lunch eligibility or legal issues, which extends beyond the scope of this study but remain important for future research. In order to handle all these aforementioned concerns, a qualitative or mixed method approach may be utilized in future studies to provide a more nuanced understanding of the individual needs of culturally and linguistically diverse learners.

IMPLICATIONS

There are several implications as the result of this study for educational practice and research. First, the findings imply that efforts to improve SDL-SE should include both individual-focused interventions and family-centered supports that help parents and guardians meaningfully engage in students' learning at home. Second, the results of the study emphasize that teachers, school administrators, and policymakers should recognize the distinct needs of MLs' families to support MLs' SDL at home. Existing literature underscores that MLs often face disparities in accessing educational resources and familial support (Niehaus & Adelson, 2014; OELA, 2022), potentially impacting their SDL-SE during remote learning.

For instance, parents/caregivers of MLs may have limited time and trouble accessing educational resources in their native language, disallowing them to provide familial support during learning, hindering the effectiveness of the learning environment (Niehaus & Adelson, 2014; OELA, 2022). Therefore, school administrations should reconsider the existing resources for all students and prioritize creating culturally and linguistically responsive resources to promote SDL among MLs, highlighting the home culture as an asset rather than a deficit, especially for at-home learning contexts where family support is crucial (Napolitano, 2020; Sayer & Braun, 2020).

REFERENCES

1. Asyhari, A., Sunyono, S., Haenilah, E. Y., & Hariri, H. (2023). A systematic review of self-directed learning: Empirical evidence from STEM teaching and learning. *Review of Science, Mathematics and ICT Education, 17*(2). https://pasithee.library.upatras.gr/review/article/view/4501

2. Baghdarnia M., Firozy Soreh R., & Gorji R. (2014). The Comparison of Two Methods of Maximum Likelihood (ML) and Diagonally Weighted Least Squares (DWLS) in Testing Construct Validity of Achievement Goals. *Journal of Educational and Management Studies*, *4*(1):22-28.

3. Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psycholo gical Review, 84*(2), 191-215. https://doi.org/10.1037/0033-295x.84.2.191

4. Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). Academic Press. (Reprinted in H. Friedman [Ed.], Encyclopedia of mental health. Academic Press, 1998).

5. Bandura, A. (1995). Exercise of personal and collective efficacy in changing societies. In A. Bandura. (Ed.). *Self-efficacy in changing societies*. Cambridge University Press.

6. Bhamani, S., Makhdoom, A. Z., Bharuchi, V., Ali, N., Kaleem, S., & Ahmed, D. (2020). Home learning in times of COVID: Experiences of parents. *Journal of education and educational development, 7*(1), 9-26. http://dx.doi.org/10.22555/joeed.v7i1.3260

7. Brachtl, S., Ipser, C., Keser Aschenberger, F., Oppl, S., Oppl, S., Pakoy, E. K., & Radinger, G. (2023). Physical home-learning environments of traditional and non-traditional students during the COVID pandemic: exploring the impact of learning space on students' motivation, stress and well-being. *Smart Learning Environments, 10*(1), 7. https://doi.org/10.1186/s40561-023-00222-4

8. Chau, K. Y., Law, K. M., & Tang, Y. M. (2021). Impact of Self-Directed Learning and Educational Technology Readiness on Synchronous E-Learning. *Journal of Organizational and End User Computing (JOEUC), 33*(6), 1-20. https://doi.org/10.4018/JOEUC.20211101.oa26

9. Cheung, G. W., & Rensvold, R. B. (2002). Evaluating goodness-of-fit indexes for testing measurement invariance. *Structural Equation Modeling: A Multidisciplinary Journal, 9*(2), 233–255. https://doi.org/10.1207/S15328007SEM0902_5

10. Chifari, A., Allegra, M., Benigno, V., Caruso, G., Fulantelli, G., & Gentile, M. (2021). Distance learning during the first lockdown: Impact on the family and its effect on students' engagement. *Frontiers in Psychology, 12*, 762213. https://doi.org/10.3389/fpsyg.2021.762213

11. Ebrahimi, A. (2023). Self-directed and self-designed learning: Integrating imperative topics in the case of COVID-19. *Technologies, 11*(4), 85. https://doi.org/10.3390/technologies11040085

12. Flora, D. B., Crone, G., & Bell, S. M. (2025). Effect Size Interpretation in Structural Equation Models. *Structural Equation Modeling: A Multidisciplinary Journal,* 1–8. https://doi.org/10.1080/10705511.2025.2459768

13. Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). *Multivariate Data Analysis* (7th ed.). Pearson Education International.

14. Han, F. (2019). Self–concept and achievement in math among Australian primary students: Gender and culture issues. *Frontiers in Psychology, 10*, 1–9. https://doi.org/10.3389/fpsyg.2019.00603

15. Hart, C. M. D., Hill, M., Alonso, E., & Xu, D. (2024). "I don't think the system will ever be the same": Distance education leaders' predictions and recommendations for the use of online learning in community colleges post-COVID. *Journal of Higher Education:* 1–25. https://doi. org/10.1080/00221546.2024.2347810.

16. Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. *Structural Equation Modeling, 6*(1), 1–55.

17. Jorgensen, T. D., Pornprasertmanit, S., Schoemann, A. M., & Rosseel, Y. (2022). semTools: Useful tools for structural equation modeling (R package 0.5-6). https://CRAN.R- project.org/package=semTools.

18. Khan, F. N., Begum, M., & Imad, M. (2019). Relationship between students' home environment and their academic achievement at secondary school level. *Pakistan Journal of Distance & Online Learning, 5*(2), 223–234. https://files.eric.ed.gov/fulltext/EJ1266643.pdf

19. Knowles, J. L. (1975). Self-directed learning. Association Press.

20. Korman, H., O'Keefe, B., & Repka, M. (2020, Oct. 21). Missing in the margins: Estimating the. scale of the COVID-19 attendance crisis. Bellwether Education Partners. https://bellwether.org/publications/missing-in-the-margins-2021-revisiting-the-covid-19-attendance-crisis/

21. Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: aka the remix. *Harvard educational review, 84*(1), 74-84. https://doi.org/10.17763/haer.84.1.p2rj131485484751

22. Lippke, S. (2017). Self-efficacy theory. In V. Zeigler-Hill, & T. K. Shackelford (Eds.), *Encyclopedia of personality and individual differences* (pp. 1-6). https://doi.org/10.1007/978-3-319-28099-8_1167-1

23. Little, R. J. A. (1988) A Test of Missing Completely at Random for Multivariate Data with Missing Values. *Journal of the American Statistical Association, 83,* 1198-1202. http://dx.doi.org/10.1080/01621459.1988.10478722

24. Mao, W. (2022). Family socioeconomic status and young children's learning behaviors: The mediational role of parental expectation, home environment, and parental involvement. *International Journal of Chinese Education, 11*(3). https://doi.org/10.1177/2212585X221124155

25. Mirzawati, N., Neviyarni, N., Rusdinal, R. (2020). The Relationship between Self- efficacy and Learning Environment with Students' Self-directed Learning. *Jurnal Aplikasi IPTEK Indonesia, 4*(1), 37-42. https://doi.org/10.24036/4.14343

26. Napolitano, J. (2020, April 29). *How teachers are trying to reach English language learners during pandemic.* PBS NewsHour. https://www.pbs.org/newshour/education/how-teachers-are-trying-to-reach-english-language-learners-during-pandemic

27. Nash, C. (2023). Scoping review of self-directed online learning, public school students' mental health, and COVID-19 in noting positive psychosocial outcomes with self-initiated learning. *COVID, 3*(8), 1187–1208. https://doi.org/10.3390/covid3080084

28. National Center for Education Statistics. (2024). English learners in public schools: *Condition of Education.* U.S. Department of Education, Institute of Education Sciences. https://nces.ed.gov/programs/coe/indicator/cgf/english-learners

29. Niehaus, K., & Adelson, J. L. (2014). School support, parental involvement, and academic and social-emotional outcomes for English language learners. *American Educational Research Journal, 51*(4), 810-844. https://doi.org/10.3102/00028312145313

30. Office of English Language Acquisition. (2022, April). *Addressing the impact of COVID-19 on multilingual learners and their social and emotional well-being* [Infographic]. U.S. Department of Education. https://files.eric.ed.gov/fulltext/ED625582.pdf

31. OpenAI. (2024). *ChatGPT (ChatGPT4o, May 13 version)* [Large language model]. https://chat.openai.com/chat

32. Organisation for Economic Co-operation and Development (OECD). (2022). *PISA-based test for schools: Technical report 2022.* OECD Publishing. https://www.oecd.org/content/dam/oecd/en/about/projects/edu/pisa-based-test-for-schools/PISA-S_TechnicalReport2022.pdf

33. Organisation for Economic Co-operation and Development (OECD). (2023a). *PISA 2022 results (Volume II): Learning during – and from – disruption.* OECD Publishing. https://doi.org/10.1787/a97db61c-en

34. Organisation for Economic Co-operation and Development (OECD). (2023b, December 5). *PISA 2022 results: Factsheets – United States.* OECD. https://www.oecd.org/publication/pisa-2022-results/country-notes/united-states-a78ba65a/

35. Organisation for Economic Co-operation and Development (OECD). (2023c). United States. Student Performance. Education GPS. https://gpseducation.oecd.org/CountryProfile?primaryCountry=USA&treshold=10&topic=PI

36. Pan, X., & Chen, W. (2021). Modeling Teacher Supports Toward Self-Directed Language Learning Beyond the Classroom: Technology Acceptance and Technological Self-Efficacy as Mediators. *Frontiers in Psychology, 12*, 751017. https://doi.org/10.3389/fpsyg.2021.751017

37. Pongsophon, P. (2024). Cross-cultural dynamics of self-directed learning: an SEM analysis of enrichment activities and psychological constructs. *Behaviormetrika,* 1-20. https://doi.org/10.1007/s41237-024-00240-7.

38. Qiu, X., Yuan, J., Wu, J., Li, W., & Guo, J. (2024). Comparing the impact of COVID-19 on student mathematics achievement: A multilevel machine learning analysis of PISA 2022. *Research Square.* https://doi.org/10.21203/rs.3.rs-5068619/v1

39. Ramazan, O., Danielson, R. W., Rougee, A., Ardasheva, Y., & Austin, B. W. (2023). Effects of classroom and school climate on language minority students' PISA mathematics self-concept and achievement scores. *Large-scale Assessments in Education, 11*(11). https://doi.org/10.1186/s40536-023-00156-w

40. Reeve, J. (2014). Understanding motivation and emotion. John Wiley & Sons, Inc.

41. Rosseel, Y., Jorgensen, T. D., & Rockwood, N. (2023). lavaan: Latent variable analysis (R package 0.6-13). https://CRAN.R-project.org/package=lavaan.

42. Sandilos, L. E., Baroody, A. E., Rimm– Kaufman, S. E., & Merritt, E. G. (2020). English learners' achievement in mathematics and science: Examining the role of self–efficacy. *Journal of School Psychology, 79*, 1–15. https://doi.org/10.1016/j.jsp.2020.02.002

43. Santibañez, L., & Guarino, C. M. (2021). *The effects of absenteeism on academic and social-emotional outcomes: Lessons for COVID-19.* Educational Researcher, 50(6), 392–400. https://doi.org/10.3102/0013189X21994488

44. Sayer, P., & Braun, D. (2020). The disparate impact of COVID-19 remote learning on English learners in the United States. *TESOL Journal, 11*(3), e546. https://doi.org/10.1002/tesj.546

45. Schunk, D. H., & DiBenedetto, M. K. (2016). Self-efficacy theory in education. In K. R. Wentzel & D. B. Miele (Eds.), *Handbook of motivation at school* (2nd ed., pp. 34-52). Routledge.

46. Shi, D., Lee, T., Fairchild, A. J., & Maydeu-Olivares, A. (2019). Fitting Ordinal Factor Analysis Models with Missing Data: A Comparison Between Pairwise Deletion and Multiple Imputation. *Educational and Psychological Measurement, 80*(1), 41-66. https://doi.org/10.1177/0013164419845039

47. Singh, D. K. (2020). Self-directed learning strategy as the need of the hour during COVID-19 pandemic. In R. Sarkar (Ed.), *Education in the 21st century: Emerging issues and the way forward*. Namya.

48. Soland, J. (2019). English Language Learners, Self-efficacy, and the Achievement Gap (The Collaborative for Student Growth at NWEA Research Brief). https://www.nwea.org/uploads/2020/03/researchbrief-collaborative-for-student-growth-english-language-learners-self-efficacy-and-the-achievement-gap-2019.pdf

49. Sosa Díaz, M. J. (2021). Emergency remote education, family support, and the digital divide in the context of the COVID-19 lockdown. *International Journal of Environmental Research and Public Health, 18*(15), 7956. https://doi.org/10.3390/ijerph18157956

50. Sugarman, J., & Lazarín, M. (2020). Educating English learners during the COVID-19 pandemic. *Migration Policy Institute, 1*, 1-30. https://www.migrationpolicy.org/sites/default/files/publications/mpi-english-learners-covid-19-final.pdf

51. Tamanaha, A. (2020, April 1). *Rep. Judy Chu says attacks on Asian Americans at about 100 per day due to Coronavirus fear*. AsAm News. https://asamnews.com/2020/04/01/california-representative-judy-chu-says-attacks-on-asian-americans-are-at-100-per-day-due-to-racism-surrounding-coronavirus-fears/

52. Vaičiūnienė, A., & Kazlauskienė, A. (2023). Liberating and oppressive factors for self-directed learning: A systematic literature review. *Education Sciences, 13*(10), 1020. https://doi.org/10.3390/educsci13101020

53. van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate Imputation by Chained Equations in R. *Journal of Statistical Software, 45*(3), 1-67. doi:10.18637/jss.v045.i03.

54. Vantieghem, W., Vermeersch, H., & Van Houtte, M. (2014). Transcending the gender dichotomy in educational gender gap research: The association between gender identity and academic self-efficacy. *Contemporary Educational Psychology, 39*(4), 369-378. https://doi.org/10.1016/j.cedpsych.2014.10.001

55. WIDA. (2020). WIDA English language development standards framework, 2020 edition: Kindergarten–grade 12. Board of Regents of the University of Wisconsin System. https://wida.wisc.edu/sites/default/files/resource/WIDA-ELD-Standards-Framework-2020.pdf

56. Ye, F. T. F., Gao, X., Sin, K. F., & Yang, L. (2023). Remote learning and mental health during the societal lockdown: a study of primary school students and parents in times of COVID-19. *BMC Public Health, 23*(1), 1106. https://doi.org/10.1186/s12889-023-16040-9

57. Ye, S., Yue, W., Chen, Y., Gui, K., Li, Y., He, R., & Liu, X. (2024). The relationship between psychological capital and self-directed learning ability among undergraduate nursing students—a cross-sectional study. *Frontiers in Psychology, 15*, 1413151. https://doi.org/10.3389/fpsyg.2024.1413151

58. Yoon, M., & Lai, M. H. C. (2018). Testing factorial invariance with unbalanced samples. *Structural Equation Modeling: A Multidisciplinary Journal, 25*(2), 201–213. https://doi.org/10.1080/10705511.2017.1387859

59. Zhao, R., Zhuang, Y., Xie, Z. W., & Yu, P. L. H. (2024). Facilitating self-directed language learning in real-life scene description tasks with automated evaluation. *Computers & Education, 219*, 105106. https://doi.org/10.1016/j.compedu.2024.105106

60. Zimmerman, B. J., & Cleary, T. J. (2006). Adolescents' development of personal agency. In F. Pajares & T. Urdan (Eds.), *Adolescence and education* (pp. 45-69). Information Age Publishing.