The interdependency between engagement, basic psychological needs, and L2 proficiency among EFL learners in Japan: A psychological network approach

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Abstract

Student engagement is steadily gaining interest among SLA researchers; however, few studies have examined the intricate associations between student engagement and its antecedents and outcomes. This study explores the complex interdependencies between basic psychological needs, engagement, and L2 proficiency of English language learners. The participants were 203 high school students in Japan, and data were collected using a questionnaire. Prior to analyses for addressing the research questions, we confirmed the factor structures of a systematically translated second-language (L2) student engagement scale. The results of reliability analysis and confirmatory factor analysis showed that the Japanese version of L2 student engagement scale was highly reliable and had valid factor structures. Subsequently, psychological network analysis was performed to identify the relative associations and central variables among psychological needs, engagement, and L2 proficiency. The results revealed that the three engagement dimensions exhibited small-to-moderate intercorrelations, and cognitive engagement was identified as the central variable within the system. We discuss the theoretical and pedagogical implications of the interconnectedness of psychological variables in relation to student engagement and the pivotal role of cognitive engagement.

Introduction

Researchers of second language acquisition (SLA) have devoted significant attention to various individual differences (IDs) among learners, and motivation has been actively explored in both international and Japanese domestic contexts (Hiromori et al., 2024; Mahmoodi & Yousefi, 2022). Previous studies on motivation in L2 learning have indicated that students with higher motivation generally attain higher L2 proficiency. However, highly motivated L2 learners do not always achieve high proficiency. One potential explanation for this phenomenon is a lack of corresponding actions regarding motivation (Mercer & Dörnyei, 2020).

In response to these observations, another distinct yet related construct—student engagement—has recently garnered attention as a means of capturing motivation more holistically, including student actions. While theoretical studies have demonstrated the complex nature of student engagement, there has been a paucity of empirical research exploring the interrelations between its behavioral, cognitive, and emotional dimensions (Hiver, 2022), partly due to the dearth of pertinent methodologies (Freeborn et al., 2023). Furthermore, conventional analytical methods are limited in their ability to examine complex relationships, such as non-linear interactions and the centrality of variables, between antecedents, engagement, and outcomes within a single study. Psychological network analysis (PNA) is an innovative approach to overcome these difficulties. In the current study, we applied PNA to examine how basic psychological needs (BPNs), engagement dimensions, and L2 proficiency interact among high school students in Japan. The current study represents a pioneering effort to explore the multifaceted nature of student engagement by employing PNA in SLA research, providing a novel methodological perspective and advancing our deeper understanding of the complexity of engagement.

Literature Review

Student Engagement in Education and SLA Research

Student engagement refers to a learner's "energized, defined, and sustained actions" (Skinner et al., 2009, p. 225) towards learning. It can be considered a meta-construct, and it is essential to gain a comprehensive understanding of student engagement through multiple dimensions (Fredricks et al., 2004). There is a general consensus that the core components encompass behavioral, cognitive, and emotional dimensions (e.g., Fredricks et al., 2004). Behavioral engagement pertains to learners' efforts to learn tasks and the quality of their active participation in learning. Cognitive engagement refers to their focused attention and mental effort during the learning process. Emotional engagement is their manifestation of positive feelings, such as enjoyment or enthusiasm, in the learning process (Hiver et al., 2024). In alignment with educational research, SLA researchers have acknowledged the importance of engagement in language learning, as highlighted by the phrase, "Engagement defines all learning" (Hiver et al., 2024, p. 202).

We believe that the increasing interest in student engagement among educational and SLA researchers can be attributed to two plausible reasons: the malleability of the construct and its association with positive outcomes (Fredricks et al., 2004; Hiver et al., 2024; Mercer, 2019). Regarding malleability, previous SLA research has discovered that many individual (e.g., belief: Hoi, 2022; positive emotions: Liu, 2022) and contextual factors (e.g., task characteristics: Xu & Qiu, 2024; the teacher–student relationship: Huang, 2023) contribute to enhancing student engagement. As one of the individual factors, Mercer's (2019) theoretical research argues that self-determination theory (SDT) is "a key framework" (p. 648) in engagement research and demonstrates that enhancing L2 learners' BPNs can lead to further engagement. BPNs theory is considered the central foundation of SDT (Ryan & Deci, 2017). BPNs consist of the psychological needs for autonomy, competence, and relatedness. Autonomy refers to the notion that an individual's actions are derived from their intrinsic values or beliefs. Competence refers to the sense of an individual's capability for actions or learning. Relatedness refers to the feeling of having close relationships with others. Mercer (2019) contended that satisfaction with these needs can enhance engagement.

In turn, the associations between engagement and positive outcomes (e.g., academic achievement) are evident, as educational and SLA researchers have conducted meta-analyses on this link (Chang et al., 2016; Lei et al., 2018; Okunuki & Kashimura, 2024; Wong et al., 2024). In educational research, three meta-analyses have reported similar findings. Briefly, summarizing the results of Chang et al. (2016), Lei et al. (2018), and Wong et al. (2024), behavioral engagement was most strongly associated with academic achievement ($r = .30$, $.35$, and $.39$, respectively). This was followed by the cognitive ($r = .24$, $.25$, and $.31$, respectively) and emotional dimensions ($r = .23$, $.22$, and $.26$, respectively). Turning to SLA research, Okunuki and Kashimura (2024) recently conducted a meta-analysis of L2 engagement and its association with academic achievement. Cognitive engagement was most strongly correlated with achievement ($r = .26$), followed by behavioral ($r = .24$) and emotional engagement ($r = .16$). In sum, despite some minor variations between educational and SLA research, all three dimensions of student engagement were positively associated with achievement.

Although empirical studies remain limited, some SLA researchers have examined the comprehensive associations between student engagement, its antecedents, and outcomes, highlighting their connections with malleability and academic outcomes (e.g., Dincer et al., 2019; Jiang & Peng, 2025). Dincer et al. (2019) investigated the relationships among four dimensions of student engagement (behavioral, cognitive, emotional, and agentic), two antecedents (teacher autonomy support and students' BPNs), and two outcomes (academic achievement and absenteeism). They used SEM to analyze data collected from 412 Turkish university students learning English as a foreign language (EFL). The results revealed that teacher autonomy support predicted students' BPNs, which in turn predicted the four dimensions of student engagement. Furthermore, emotional engagement positively predicted academic achievement,

whereas cognitive engagement was a negative predictor of absenteeism. Jiang and Peng (2025) examined the mediating effects of three aspects of engagement (behavioral, cognitive, and emotional) on the relationship between autonomy and academic performance in the context of online language learning. Based on data collected from 115 EFL university students in China, the results showed that only cognitive engagement had a significant and positive mediating effect on the relationship between autonomy and academic performance (β = .17). The aforementioned previous studies suggest that all dimensions of engagement are related to academic achievement. In the field of SLA research, BPNs seem to be associated with each dimension of engagement. Cognitive engagement, in particular, may play a crucial role in positive academic outcomes.

Complexity of L2 Student Engagement

As previously mentioned, prior studies have explored the relationship between engagement, malleability, and academic outcomes. However, relatively few empirical examinations of the intricate interrelations among engagement dimensions have been conducted. It has been argued that the dimensions of student engagement are interwoven in complex ways, resulting in emergent student engagement patterns that vary depending on the individual and the context (Zhou et al., 2023). In fact, Hiver (2022) emphasizes that, as one of the research agendas in L2 engagement research, researchers should investigate "how the various dimensions of engagement interact with one another" (p. 57). These studies indicate that understanding the relationships among the dimensions of student engagement requires a framework that captures their complexity. Addressing such complexity, complex dynamic systems theory (CDST; Larsen-Freeman, 1997), a meta-theory employed in SLA research, helps comprehend the complex and dynamic features of language, its use, and its development (Hulstijn, 2020). This framework enables engagement researchers to explore interactions between individual and contextual variables, providing insights into complex systems (see Hiver et al., 2022 for further details). With respect to a complex system, Hilpert and Marchand (2018) described it as a collection of interacting components, including students, teachers, motivation, cognitive variables, and discourses, that give rise to complex behavior. They propose three approaches to conceptualizing complex systems: time intensive (i.e., analyzing system behavior through closely spaced observations over time), relation intensive (i.e., examining dependent relationships between variables to infer system behavior), and time-relation-intensive (i.e., investigating both within-element changes and between-element relationships using closely spaced, simultaneous observations, Hilpert & Marchand, 2018), which contribute to understanding complex systems.

While not all explicitly employ CDST, there have been a few L2 studies investigating the complex nature of student engagement (e.g., Hiromori, 2021; Peng et al., 2023; Zhou et al., 2023). Zhou et al. (2023) conducted a 17-week longitudinal study to examine both inter- and intra-individual variations in student engagement, with the interactions of psychological needs as antecedents among 686 EFL university students

in China. They included four dimensions of student engagement and disengagement (behavioral, cognitive, emotional, and agentic). They revealed different changes in student engagement at both the group and individual levels. Furthermore, they confirmed that BPNs are powerful positive predictors of student engagement. Hiromori (2021) examined the combinations of four dimensions of student engagement (behavioral, cognitive, emotional, and social) among a sample of Japanese EFL university students. Using cluster analysis, the students were grouped into three groups in which all dimensions of student engagement were positively associated with each other. However, correlation analysis showed that the behavioral and emotional dimensions were sometimes negatively correlated. Hiromori explained that one plausible reason for this was that if they focused on one dimension, they might have failed to pay attention to others. Peng et al. (2023) adopted a mixed-methods approach to explore the interactions among the four dimensions of student engagement, temporal changes, and their effects on writing development. The participants were two EFL university students in China who engaged in digital storytelling tasks for 10 months. The results showed that while one student was consistently engaged, the other gradually became reluctant to engage in the task because of individual and contextual factors.

The aforementioned studies, although not employing the previously mentioned complex systems framework, provided empirical evidence of the nature of L2 engagement through time intensive, relation intensive, and time-relation intensive approaches. On the other hand, they were not designed to examine the interrelations among dimensions within the holistic structure of engagement, nor to identify which dimensions are more significant and play central roles. That said, clarifying the interrelations and identifying key variables among dimensions of student engagement are crucial, equally important to exploring the complex relationships between engagement, its antecedents, and its outcomes, as Hiver (2022) emphasized the need to investigate how engagement dimensions interact.

Psychological Network Analysis
As demonstrated above, while previous studies on SLA provide theoretical discussions for understanding the complex nature of student engagement, few empirical studies explicitly labeled as adopting the CDST or complex systems perspective have been conducted. One possible reason for the lack of empirical studies in this area is the methodological challenges, such as the fact that "our methodological toolbox for relation-intensive methods is lacking" (Freeborn et al., 2023, p. 527). Researchers in fields other than SLA (i.e., network psychometrics) have developed a novel statistical method called PNA that detects the interrelatedness of psychological variables and displays them as a network in an exploratory manner (Isvoranu et al., 2022). PNA holds potential for application in SLA research. It is rooted in the principle that diverse psychological variables are not situated in isolation but are interconnected with each other and that these interactions cause psychological phenomena that can vary depending on the individual. The network consists of nodes (i.e., psychological

variables) and edges linking nodes (i.e., statistical estimates representing partial correlation coefficients, which are values calculated after conditioning the effects from the other variables).

The unique strengths of this method lie in visualizing the associations between variables as an easily understandable network and identifying central variables in the network. Specifically, PNA can calculate three centrality indices (strength, closeness, and betweenness), which enable researchers to identify the variables that play a crucial role in the network. The strength index indicates the abundance and robustness of node-to-node connections, helping us understand "how strongly a node is directly related to other nodes in the network" (Epskamp, 2017, p. 6). Second, the closeness index refers to the accessibility of other nodes to a specific node, which indicates "how strongly a node is indirectly connected to other nodes in the network" (Epskamp, 2017, p. 6). Finally, the betweenness index represents the frequency of a node being part of the shortest paths between a pair of nodes, thus identifying a significant node in connecting other nodes. Given that this method has exponentially advanced in psychology in recent years, Burger et al. (2022) developed reporting standards for PNA to analyze cross-sectional data. The current study primarily followed these standards in the Methods and Results sections.

In the SLA field, since Freeborn et al. (2023) introduced the potential utility of PNA, only a handful of studies have utilized it to explore complex networks of variables of interest (e.g., Freeborn et al., 2023; Paradowski et al., 2023; Zalbidea et al., 2023). The adoption of PNA in L2 engagement research has been rationalized from both theoretical and pedagogical viewpoints. From a theoretical perspective, student engagement can be considered a meta-construct. In other words, "it is more than the sum of its dynamically interacting parts" (Mercer & Dörnyei, 2020, p. 7), and researchers are encouraged to examine the interconnectedness between the dimensions of student engagement. From a pedagogical standpoint, PNA can identify pivotal variables within a system. This identification of central variables can lead to suggestions that teachers should focus on and prioritize enhancing this factor to effectively bring about positive changes in students' psychological networks, including engagement, its antecedents, and outcomes.

The Current Study

There are a few limitations to the existing L2 engagement research. First, few studies have examined the complex interrelations between the three engagement components and the relationships between student engagement and other related variables (Hiver, 2022). Second, despite its malleability, no study has identified a central variable within a complex system that includes student engagement. This limitation may hinder researchers and practitioners from implementing intervention studies to effectively enhance learners' psychological complex systems (Hiver et al., 2022). To address these gaps, the aims of the current study are twofold. First, we investigate the linear relationships among BPNs, student engagement, and L2 proficiency. Second,

we explore the complex interplay between the three variables using a novel approach through PNA, which enables a relation-intensive approach, and identify a central variable within the network. More specifically, the current study addressed the following two research questions (RQs):

RQ$_1$: To what extent are variables among BPNs, L2 student engagement, and L2 proficiency relatively intercorrelated with each other?

RQ$_2$: Which variable has a pivotal role within the complex network?

Method

Participants

We collected data from 203 EFL learners in three high schools in Japan. Of these, 14 dishonest responses were removed, resulting in 189 valid responses for analysis. There were 30 first-year, 157 second-year, and two third-year students. The sample consisted of 98 males and 85 females, and six students preferred not to report their gender. The majority of the respondents' first language (L1) was Japanese (n = 187), while the remaining students' L1s were Pakistani (n = 1) and Tagalog (n = 1).

Instruments

L2 Engagement Scale

We adapted the L2 Engagement Scale (Hiver et al., 2020) to examine students' engagement in English language learning. This scale is composed of three dimensions of engagement: behavioral, cognitive, and emotional. There were 24 items in total, with eight items for each component (e.g., *In my English language class, I participated in all the activities* for behavioral engagement; *In my English language class, I went through my work carefully to make sure it was done right* for cognitive engagement, and *In my English language class, I enjoyed learning new things* for emotional engagement). The scale was evaluated using a six-point Likert scale ranging from 1 = *Not at all true of me* to 6 = *Very true of me*.

Basic Psychological Needs Scale

The BPNs scale developed by Hiromori (2003) was employed to assess students' three psychological needs: autonomy, competence, and relatedness. The scale consisted of 11 items in total: four about autonomy (e.g., *In my English language class, I could decide how I studied*), three about competence (e.g., *In my English language class, I believed I could obtain high grades*), and four about relatedness (e.g., *In my English language class, I got along well with my friends*). This scale was also assessed using a six-point Likert scale ranging from 1 = *Not at all true of me* to 6 = *Very true of me*.

L2 Proficiency

We adopted one item to assess the participants' L2 proficiency levels based on their EIKEN grades (EIKEN Foundation of Japan, n.d.). EIKEN is a widely recognized English proficiency test in Japan, with seven grades ranging from Grade 5 (lowest) to Grade 1 (highest), which correspond to levels from A1 to C1 in the Common European Framework of Reference for Languages (CEFR). Although not all students had taken

EIKEN, they assessed their English proficiency using the EIKEN grades as a reference on a seven-point rating scale: 1 = *Grade 5 or below*, 2 = *Grade 4*, 3 = *Grade 3*, 4 = *Grade Pre-2*, 5 = *Grade 2*, 6 = *Grade Pre-1*, and 7 = *Grade 1 or above*.

Procedure

The L2 Engagement Scale (Hiver et al., 2020) was originally in English; thus, we systematically translated it into Japanese using a back-translation method. As Dörnyei and Dewaele (2023) pointed out, scale translation "has typically been marginalized and treated as an addendum in questionnaire design" (p. 52), and the poor quality of translated questionnaires could lead to researchers unintentionally collecting data that they did not intend to collect. Therefore, we recognized the need for the systematic development of a translated version of the questionnaire. We followed Wild et al.'s (2005) 10-step guidelines for scale translation, which have recently been applied to SLA research (Kashimura & Hashimoto, 2023). The steps taken in this study are detailed as follows: Before commencing the translation process, we sought permission from Dr. Phil Hiver, the first author of Hiver et al. (2020), to translate the questionnaire (*preparation*). Once consent was obtained, both authors independently translated the questionnaire into Japanese (*forward translation*). We subsequently compared our translations and conducted a thorough reconciliation process to address disparities (*reconciliation*). In cases where differences were found, we engaged in discussions until a consensus was reached. Following this reconciliation phase, we enlisted the services of a private company to perform a back-translation and created another English version based on our Japanese-translated version (*back translation*). Upon receiving the back-translated questionnaire in English, we reviewed it to identify any inconsistencies compared with Hiver et al.'s (2020) original version (*back translation review*), and made necessary revisions to a few phrases (*harmonization*). To ensure the overall comprehensibility of the Japanese-translated items, we sought feedback from one professor and two graduate students, all of whom were Japanese and specialized in the psychology of language learning (*cognitive debriefing*). We examined their comments and incorporated the suggested revisions (*review of cognitive debriefing results and finalization*). Finally, we thoroughly proofread the questionnaire (*proofreading*), resulting in the final Japanese version of the L2 engagement scale (*final report*: see https://doi.org/10.17605/OSF.IO/6PE43).

Data were collected using Google Forms. We first reached out to three high school teachers and sought their cooperation in sending the Google Forms links to their students and collecting the data. Students were initially briefed on the study objectives and the confidentiality of the data. They were also assured that their participation in the survey was entirely voluntary and would have no impact on their grades. Consent was obtained from those who chose to participate. All questionnaire items were administered in Japanese to ensure complete understanding.

Data Analysis

All statistical analyses were conducted using R version 4.3.0 (R Core Team, 2023). Prior to the analyses of the RQs, preliminary analyses were performed to check for missing values, reverse-code negatively keyed items, and calculate composite mean scores for the L2 engagement scale and BPNs scale. We then checked the skewness and kurtosis of the L2 Engagement scale, BPNs scale, and L2 proficiency to detect outliers. If the values of either skewness or kurtosis were observed beyond ±2, we interpreted them as outliers (Roever & Phakiti, 2018). These analyses were performed using the *psych* package version 2.3.6 (Revelle, 2023).

Furthermore, we first used the *psych* package version 2.3.6 (Revelle, 2023) and conducted an assessment of the factor structures of the L2 engagement scale and BPNs scale using Cronbach's α. We then performed confirmatory factor analysis (CFA) of the L2 engagement scale with maximum likelihood estimation using the *lavaan* package version 0.6.16 (Rosseel, 2012) to examine the factor structure of the scale. We assessed the measurement model based on factor loadings and goodness-of-fit indices. Following Hair et al. (2019), factor loadings should not be below .30. Concerning goodness-of-fit indices, the following measures were adopted: χ^2 value, comparative fit index (CFI), standardized root mean square residual (SRMR), root-mean-square error of approximation (RMSEA), and its 95% confidence interval (CI).

To address RQ1, we conducted a correlation analysis using the *psych* package version 2.3.6 (Revelle, 2023) and interpreted correlation coefficients of .25, .40, and .60 as small, medium, and large, respectively, following a field-specific benchmark (Plonsky & Oswald, 2014). To address RQ2, we employed PNA to visualize the network and summarized three centrality indices (strength, closeness, and betweenness) using the *qgraph* package version 1.9.5 (Epskamp et al., 2012). To estimate the network, we used graphical least absolute shrinkage and selection operator (GLASSO) regularization and the Extended Bayesian Information Criterion (EBIC). These two methods automatically shrink small edges to zero and exclude them from the network. Finally, we assessed the estimated network's edge-weight accuracy and the stability of centrality indices with a nonparametric bootstrapped 95% CI (*n*boots = 2,500) using the *bootnet* package version 1.5.13 (Epskamp et al., 2018). When judging edge weight accuracy, we considered smaller CIs of the parameters as more accurately estimated. In addition, centrality stability was estimated using the correlation stability (CS) coefficient. Epskamp et al. (2018) recommended that .25 and .50 of CS coefficients can be interpreted as good and preferable.

Results and Discussion

Preliminary Analyses

Before answering the RQs, we conducted preliminary analyses to examine the descriptive statistics and normality of the scales (Table 1). We confirmed that the data were normally distributed in terms of skewness and kurtosis, both within the range of ±2.

Table 1

*Descriptive Statistics for All Variables*

Variables	k	M	SD	Skewness	Kurtosis	α	95% CI
Aut	4	3.53	0.84	.31	.25	.63	[.55, .72]
Com	3	3.67	1.14	.11	−.14	.79	[.74, .84]
Rel	4	4.51	0.86	−.62	.58	.75	[.70, .81]
Beh	8	4.58	0.84	−.74	1.10	.87	[.84, .90]
Cog	8	4.01	0.84	−.14	.52	.84	[.80, .87]
Emo	8	4.41	0.97	−.71	.49	.91	[.89, .93]
Pro	1	2.53	1.24	.67	.57	-	-

Note. Aut = autonomy; Com = competence; Rel = relatedness; Beh = behavioral engagement; Cog = cognitive engagement; Emo = emotional engagement; Pro = proficiency; CI = confidence interval.

Subsequently, the descriptive statistics of all the variables revealed that the sample exhibited a relatively high level of engagement. Specifically, the behavioral dimension scored the highest, followed by the emotional and cognitive dimensions. Furthermore, the sample perceived relatedness the most strongly among the three BPNs. Finally, participants assessed their L2 proficiency as relatively low.

Additionally, we assessed the psychometric properties of the Japanese-translated L2 Engagement Scale. Regarding the reliability of the L2 engagement scale, internal consistency revealed that Cronbach's α ranged from .84 to .91, indicating high reliability. In addition, we assessed the reliability of the BPNs scale (α = .63 to.79). However, one variable (autonomy) exhibited low reliability. To ensure the factor structure of the newly translated Japanese version of the L2 Engagement Scale, we employed CFA for the measurement model. The results, as shown in Figure 1, showed that all factor loadings were above .30. Furthermore, the values of the goodness-of-fit indices demonstrated an adequate fit: $\chi^2(237) = 492.635$ ($p < .001$), CFI = .902, SRMR = .063, RMSEA = .076, and its 90% CI [.066, .085]. Although one item (EE3) exhibited a slightly low factor loading (.35), we considered the results to be acceptable as per the criteria set by Gana and Broc (2019). Overall, these findings suggest that the Japanese-translated L2 Engagement Scale is psychometrically sound for assessing student engagement in English learning. Nonetheless, future studies should replicate these findings and validate the factor structure of the scale using different samples, such as university students in Japan.

Figure 1
CFA Model of L2 Engagement Scale
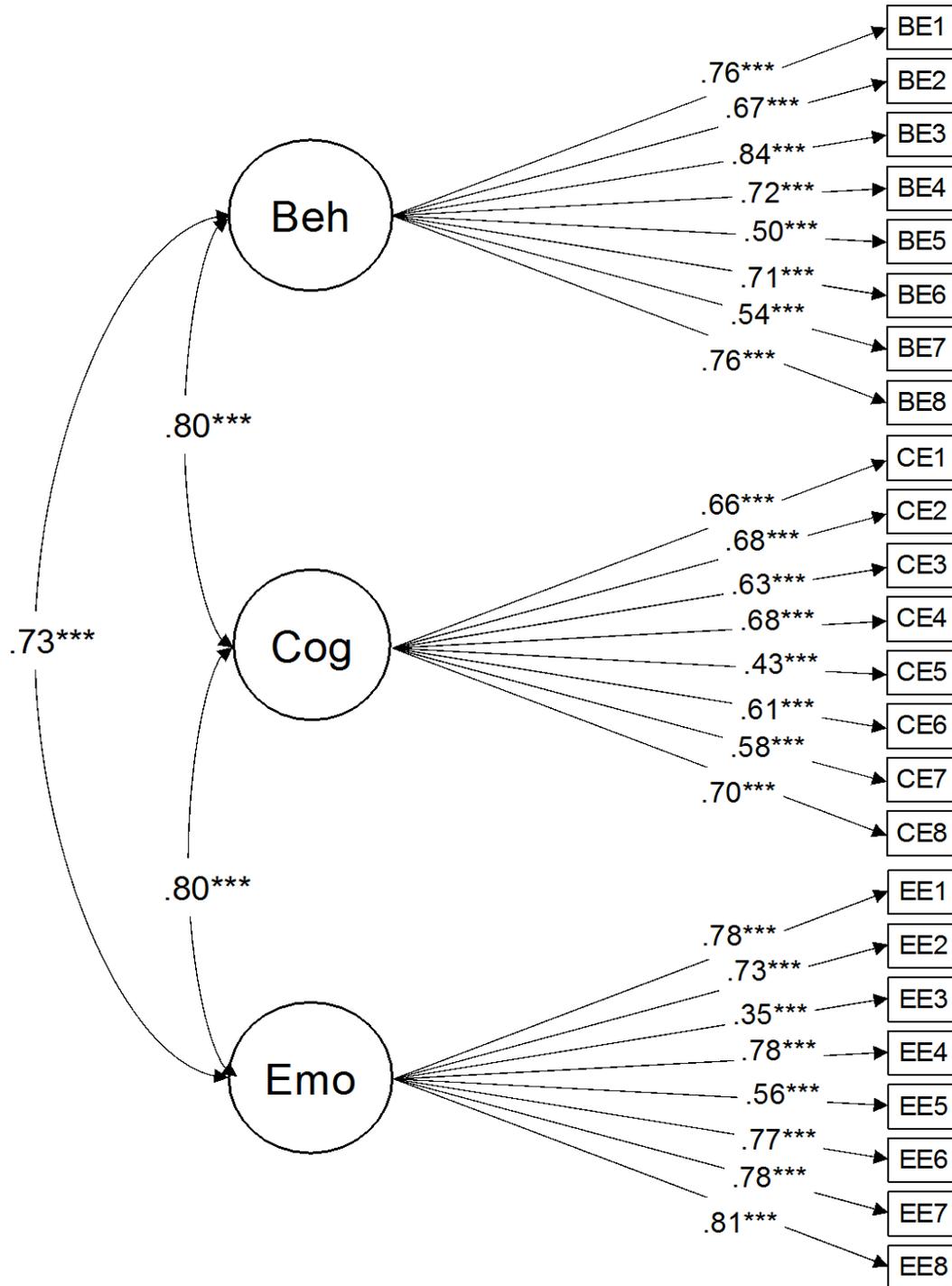
Note. Beh = behavioral engagement; Cog = cognitive engagement; Emo = emotional engagement; BE = behavioral engagement; EE = emotional engagement; CE = cognitive engagement. All modeled correlations and path coefficients are standardized.

Linear Relationship between BPNs, Engagement, and L2 Proficiency

RQ1 concerned the linear relationship between BPNs, engagement, and L2 proficiency. We initially performed a correlation analysis of these three variables (see

Table 2). The results revealed that the three dimensions of student engagement had statistically significant and large intercorrelations (r = .70 to .77). Furthermore, the three dimensions of student engagement were more strongly correlated with the need for competence (r = .56 to .68) than with autonomy and relatedness. Finally, only cognitive engagement exhibited a significant small correlation with L2 proficiency (r = .26).

In summary, among the BPNs, the need for competence showed the strongest correlation with all three dimensions of student engagement. These results align with those of previous studies in the EFL context (e.g., Dincer et al., 2019). In other words, student satisfaction with the need for competence plays a significant role in making language learners more behaviorally, cognitively, and emotionally engaged. This finding also resonates with the fundamental principles of SDT (Bureau et al., 2022; Ryan & Deci, 2017). While all three psychological needs are essential for well-being and success in many domains (e.g., academic or professional), the need for competence has been posited as central in SLA (Al-Hoorie et al., 2022).

Table 2
Correlations for BPNs, Engagement, and L2 Proficiency

	1	2	3	4	5	6	7
1. Aut	-						
2. Com	.49***	-					
3. Rel	.35***	.22***	-				
4. Beh	.36***	.56***	.35***	-			
5. Cog	.54***	.68***	.28***	.77***	-		
6. Emo	.48***	.58***	.32***	.70***	.73***	-	
7. Pro	.25***	.36***	.02	.08	.26***	.12	-

Note. Aut = autonomy; Com = competence; Rel = relatedness; Beh = behavioral engagement; Cog = cognitive engagement; Emo = emotional engagement; Pro = proficiency.
***p < .001.

Therefore, while the fundamental role of the need for competence has been emphasized in previous studies, it becomes crucial for educators to implement practical strategies that align with these findings. Specifically, to enhance students' sense of competence, we reassert that educators should be encouraged to provide EFL learners with adequately challenging tasks or learning materials and to scaffold their learning. Consequently, learners can become confident about mastering English lessons and assignments. This support enhances their sense of competence, consequently leading to an overall improvement in their engagement.

Furthermore, of the three dimensions of student engagement, cognitive engagement had the strongest association with L2 proficiency. This result corroborates the findings of previous studies, including the aforementioned meta-analysis, and underscores the crucial role of cognitive engagement in L2 proficiency development (e.g., Dincer et al., 2019; Jiang & Peng, 2023; Okunuki & Kashimura, 2024). EFL learners in Japan, especially high school students, tend to study English at school to

prepare for high-stakes university entrance examinations. This situation demands significant mental effort and deliberate and sustained attention. Consequently, those who are highly cognitively engaged are likely to perceive their L2 proficiency as high. However, it is worth noting that both behavioral and emotional engagement demonstrated large correlations with cognitive engagement in the CFA results (both r = .80, see Figure 1). This implies that the behavioral and emotional dimensions also hold significant value for enhancing L2 proficiency through the mediating role of cognitive engagement. Nevertheless, given the limited number of previous studies addressing the engagement–achievement link, further research is warranted to investigate this link and replicate the findings of the current study.

Complex Relationship between BPNs, Engagement, and L2 Proficiency
RQ2 concerned the complex relationships between BPNs, engagement, and L2 proficiency. The network resulting from the PNA provides a visual representation of the associations between the three variables (see Figure 2), and the partial correlations between each pair of variables (see Table 3). The network illustrates that all three dimensions of engagement are closely linked and positioned near each other compared with the other variables, exhibiting small-to-moderate partial correlations ranging from .28 to .42.

Figure 2
Network for BPNs, Engagement, and L2 Proficiency
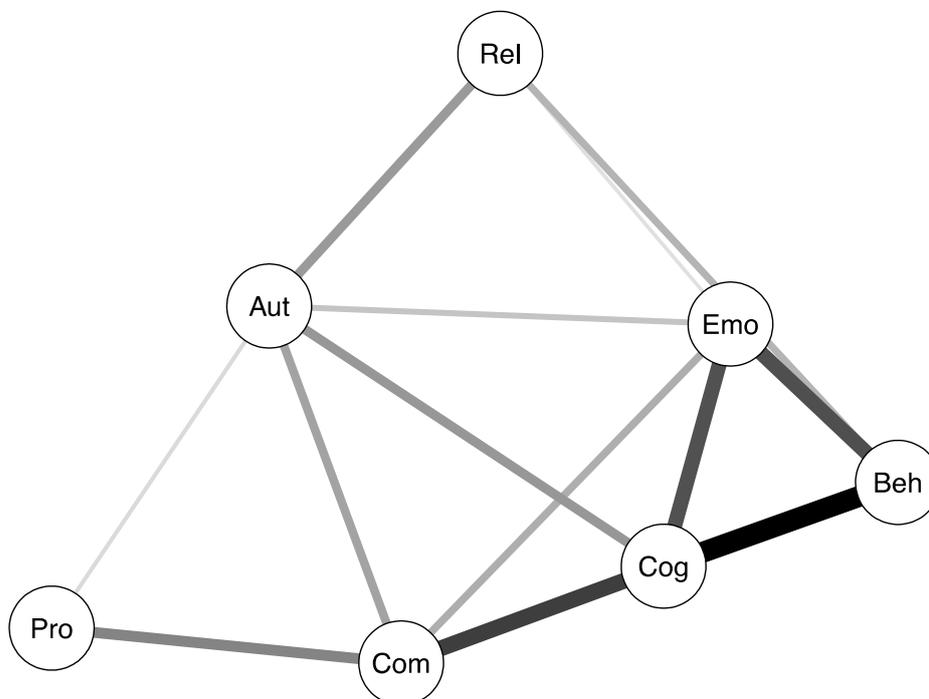
Note. Aut = autonomy; Com = competence; Rel = relatedness; Beh = behavioral engagement; Cog = cognitive engagement; Emo = emotional engagement; Pro = proficiency.

Regarding BPNs, the results indicated that only competence was associated with the three dimensions of student engagement, with partial correlation coefficients of .31, .13, and .05 for cognitive, emotional, and behavioral engagement, respectively. Autonomy serves as a bridge between relatedness and competence, while L2 proficiency was linked to two BPN variables: competence and autonomy.

Within the network, the cognitive dimension appears to be more strongly associated with other variables. While the network resulting from the PNA provides a visual representation of the associations between the variables and identifies a superficially central variable, "nodes placed in the center of the visualization are not necessarily important to the network architecture or well connected" (Isvoranu et al., 2022, p. 52). Therefore, we calculated centrality indices to statistically specify the central variables in the network. The results presented in Figure 3 and Table 4 indicate that cognitive engagement had the highest values across all three indices and served as a "hub" in the network. Based on the strength index, cognitive engagement had the highest value and was most strongly connected to other variables. Enhancing cognitive engagement is the most effective way to foster positive development across an entire network. According to the closeness index, cognitive engagement also had the densest connections with other variables, which means that the network structure is vulnerable to change if cognitive engagement changes, because this dimension is positioned close to the related variables. Additionally, the betweenness index yielded the highest value for cognitive engagement, suggesting that it plays a significant role in connecting other nodes in the network, thus functioning as a frequent mediator between other nodes.

Table 3

Weight Matrix

|	1	2	3	4	5	6	7
1. Aut	-						
2. Com	.15	-					
3. Rel	.17	.00	-				
4. Beh	.00	.05	.12	-			
5. Cog	.17	.31	.00	.42	-		
6. Emo	.10	.13	.05	.29	.28	-	
7. Pro	.06	.20	.00	.00	.00	.00	-

Note. To enhance interpretability, the values of zero were displayed with gray.

Table 4

Centrality Measures per Variable

|	Strength	Closeness	Betweenness
Cog	1.44	1.43	1.56
Beh	0.50	0.75	−0.06
Com	0.42	0.57	1.15
Emo	0.41	−0.09	−0.86
Aut	−0.22	−0.19	−0.06
Rel	−1.16	−1.27	−0.86
Pro	−1.39	−1.19	−0.86

Figure 3

Centrality Indices of Network for BPNs, Engagement, and L2 Proficiency
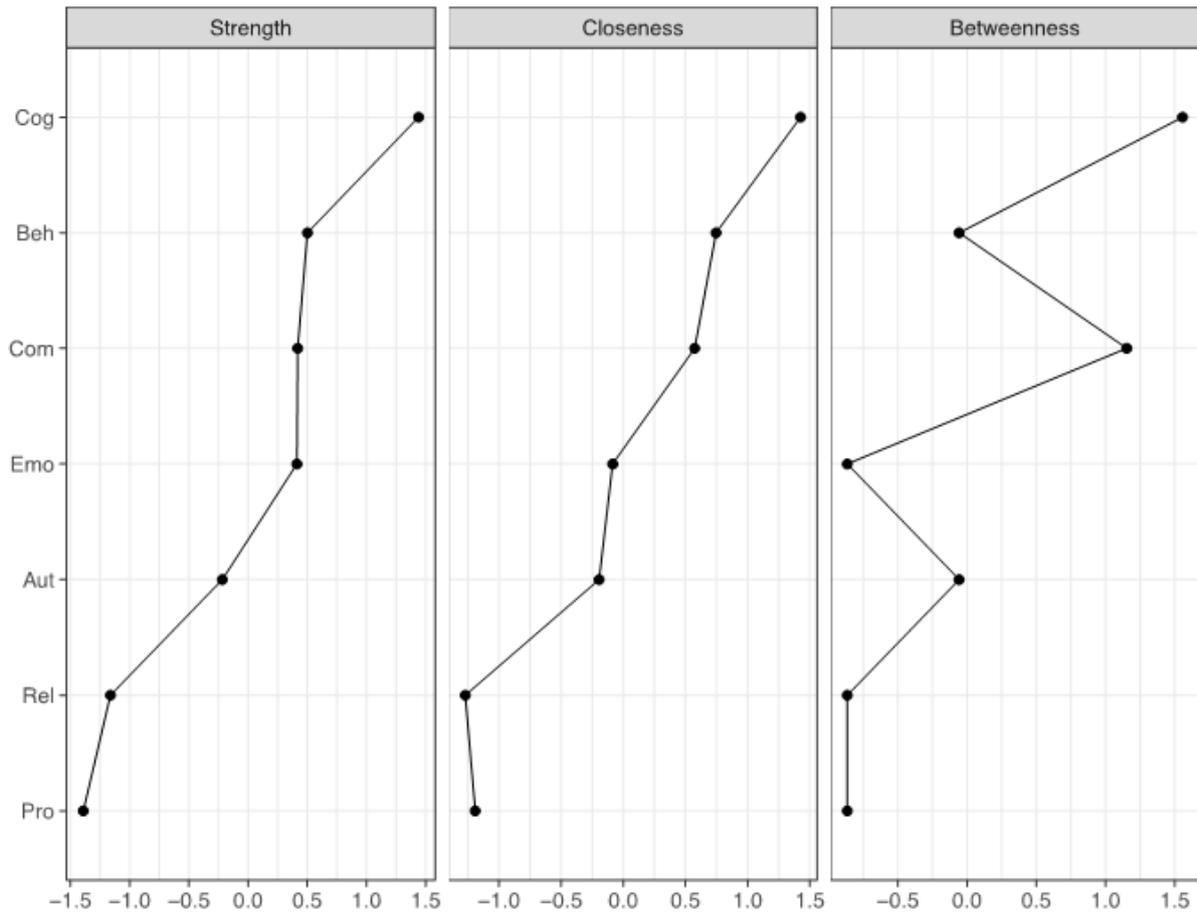
Note. The horizontal axis represents z-scores, and the vertical axis means each variable. Variables with greater centrality are positioned to the right. Aut = autonomy; Com = competence; Rel = relatedness; Beh = behavioral engagement; Cog = cognitive engagement; Emo = emotional engagement; Pro = proficiency.

Furthermore, we conducted two additional analyses to confirm the stability of the results. First, we calculated the edge weight accuracy of the network (see Figure 4). The results showed that the estimated and bootstrapped means moderately overlapped, indicating that the network shown in Figure 2 is relatively stable. We then assessed the stability of the centrality indices using CS coefficients. The results showed that the CS coefficients were .67 for the strength, .52 for the closeness, and .13 for the betweenness indices. These results indicate that, while we could interpret the values of the strength and closeness indices, caution must be exercised when interpreting the betweenness index.

Figure 4
Edge-Weight Accuracy
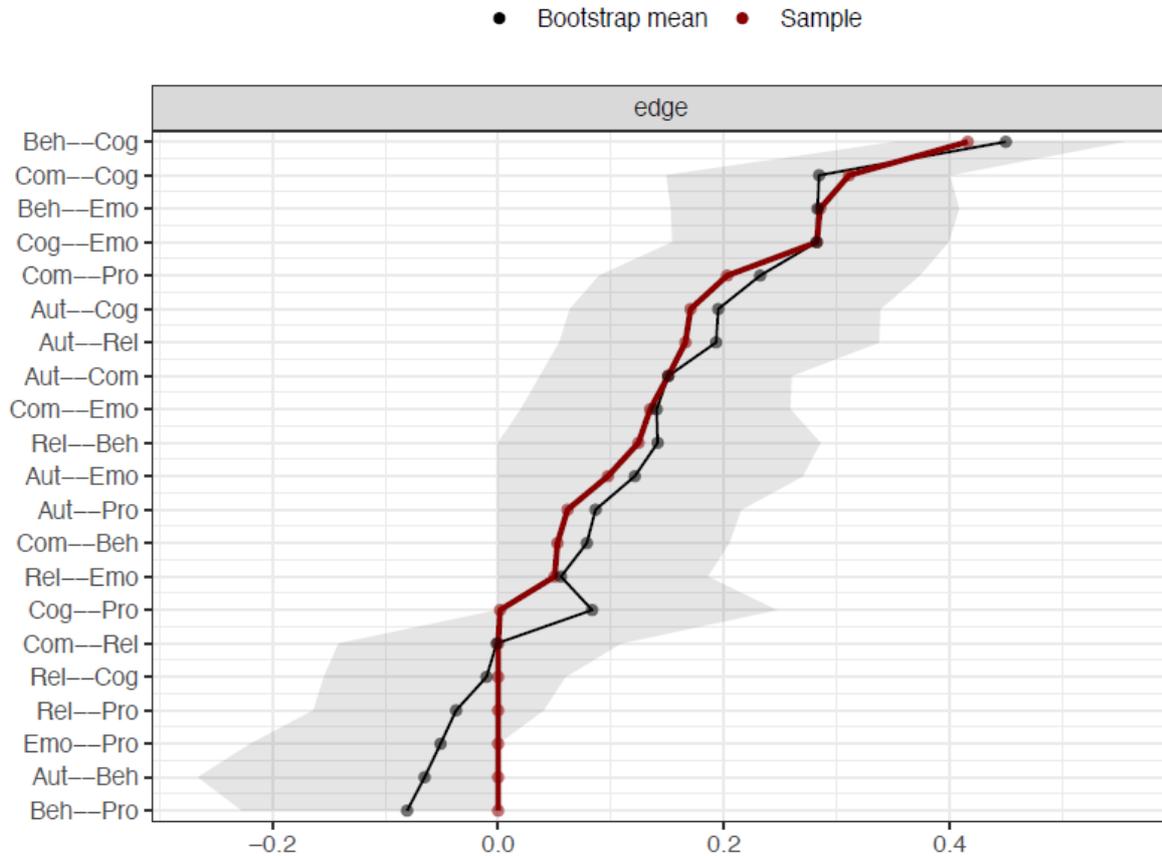
Note. The red line represents the sampled values, and the gray area depicts the bootstrapped CIs. Each horizontal line corresponds to an individual edge of the network.

Overall, the findings suggest that the behavioral, cognitive, and emotional dimensions of student engagement exhibit small-to-moderate intercorrelations and are closely positioned relative to other variables within the network. Meanwhile, the BPN constructs (i.e., autonomy, competence, and relatedness) did not exhibit such interrelations. These results align with the theoretical foundation of student engagement being a multidimensional construct (Hiver et al., 2024), with each dimension closely interacting with the others. Notably, cognitive engagement demonstrated the strongest correlation with L2 proficiency in the correlation analysis and served as the central hub in the network analysis. However, while the correlation analysis identified a significant link between the cognitive dimension and proficiency, the network did not confirm this connection. This discrepancy might be attributed to the low mean values of the need for autonomy and competence compared to the three engagement dimensions, as well as the relatively low average L2 proficiency of the participants. As indicated in Table 1, descriptive statistics showed that the participants' perceived autonomy and competence were relatively lower ($M = 3.53$ and 3.67, respectively) than their behavioral, cognitive, and emotional engagement ($M = 4.58$, 4.01, and 4.41, respectively). Mercer (2019) argues that BPNs are key factors in enhancing student engagement. Therefore, BPNs should be considered concurrently

in student engagement research to comprehensively understand the relationship between student engagement and L2 proficiency.

Theoretical and Pedagogical Implications

The findings of this study have both theoretical and pedagogical implications. The theoretical implications relate to the intimate interconnections between the three dimensions of student engagement and between student engagement and psychological needs. The results obtained from the PNA revealed that the three dimensions of student engagement exhibited small-to-moderate correlations. This suggests that researching student engagement as a multi-dimensional construct should become the "default instead of focusing on one or two dimensions separately" (Zhou et al., 2021, p. 90). Second, this study indicated that the three BPNs, particularly the need for competence, were significantly associated with student engagement. The PNA results suggest that enhancing the need for competence may lead to positive changes in overall student engagement, with cognitive engagement mediating this effect. Given the key characteristics of malleability in student engagement, we recommend that researchers investigate both BPNs and student engagement to identify the most effective ways to promote positive development in students' psychological networks.

The pedagogical implications emphasize the vital role of cognitive engagement in L2 learning, echoing the findings of Okunuki and Kashimura's (2024) meta-analysis. These findings highlight the importance of understanding how cognitive engagement operates in specific educational contexts, particularly among EFL learners such as the Japanese high school students who participated in this study. In typical classroom settings, where the number of students is often large, lessons are often centered around activities such as listening to teachers' explanations and solving problems in L2 learning. These activities demand significant attention and mental effort from students, requiring a certain level of cognitive engagement. In this case, where lecture-style teaching predominates, teachers should monitor whether their instruction, which should be neither too challenging nor too easy, satisfies students' need for competence, as this is a key factor in fostering cognitive engagement. In other words, by closely monitoring students' cognitive engagement levels in the classroom, teachers can determine whether the tasks they are working on align with individual students' satisfaction of competence. It is important to note that, while emphasizing students' BPNs, they should also pay attention to other dimensions of student engagement (e.g., behavioral and emotional) along with cognitive engagement, as the three dimensions of student engagement are closely interrelated.

Conclusion

Triggered by the call for research proposed by Hiver (2022), which emphasizes the needs to examine the interrelations of the dimensions of student engagement and focusing on its complex nature, this study aimed to investigate the complex relationships between student engagement, its antecedents, and outcomes in L2

learning, utilizing the novel approaches of PNA. Before presenting our conclusions, we acknowledge the following limitations. First, the sample sizes in the present study were relatively small ($N = 203$), given that PNA was used. Future research could address this limitation by collecting data from a larger sample to assess the replicability of the network structure depicted in our study. Second, the stability of the PNA results in this study should be considered. In our study, cognitive engagement played a central role within the network, although the sample demonstrated L2 proficiency to be relatively low. As argued by Vu et al. (2022), the centrality of variables within a network may differ when considering participants with different characteristics (e.g., higher L2 proficiency). Therefore, it may be difficult to generalize the findings of this study to other populations. Finally, the cross-sectional approach employed had methodological limitations. Associations between engagement and other psychological and contextual factors exhibited are malleable and reciprocal relationships. Therefore, future research should employ a longitudinal design to examine the dynamics and mutual connections among these dimensions and variables.

Despite these limitations, this study represents an initial attempt to explore the complex relationship between student engagement and its associated variables using PNA. Considering the current absence of a systematically developed L2 engagement scale in Japanese, we initially addressed the psychometric properties of the scale. Furthermore, we found a significant role for the need for competence in enhancing student engagement and highlighted the crucial role of cognitive engagement in L2 learning. We hope that SLA researchers will focus on the intricate nature of student engagement and investigate the interdependence between the dimensions of student engagement and other individual and contextual factors. Such efforts will contribute to the accumulation of concrete evidence on the central variables in this network. This will enable researchers and practitioners to conduct intervention studies aimed at enhancing student engagement and fostering positive outcomes.

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