The Development of the Flipped Learning Student Engagement Scale

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Abstract. The goal of this study was to develop a flipped learning student engagement scale for college students. There were 450 college students who took part. A comprehensive review of the literature and interviews were done in order to design the scale's items. With a total of 21 items, four components were determined: cognitive engagement, peer relationships (emotional engagement-I), teacher relationships (emotional engagement-II), and behavioral engagement. The cumulative contribution variance in the exploratory factor analysis was 77.970%, and the confirmatory factor analysis showed that the theoretical model of classroom engagement among students suited the data well. The total Cronbach's alpha coefficient for this scale was 0.959. The findings demonstrate that the scale has good validity and reliability and may be used to measure students' engagement in the flipped classroom.

Keywords: Student Engagement · Flipped Classroom · Evaluation Scales

1 Introduction

The "flipped classroom" teaching approach, which debuted in the first year of the twenty-first century, has grown swiftly and had a significant impact on education and teaching practice [1]. However, from a bibliometric perspective, the assessment of the quality of teaching and learning in the flipped classroom model has not received attention from researchers. With the continuous development of information technology and artificial intelligence, the lack of a teaching quality assessment system is bound to hamper effective teaching in the flipped classroom. Student engagement is both an important indicator of the student learning process and an important predictor of student academic achievement, playing a key role in learning and learning outputs. Numerous studies have demonstrated that student engagement is an essential element of effective teaching and learning [2]. In addition, effective student engagement promotes deep learning [3], and it has a significant impact on academic achievement and teaching reform [4–6]. Therefore, evaluating and improving flipped classroom engagement in learning is an urgent issue for higher education. Currently, in the research on student engagement in higher education, the main research scenarios are the traditional classroom [7] and the online classroom [8], while there is a lack of research, especially empirical research,

on students' learning engagement in the 'flipped classroom' model. This study aims to analyze the classical student engagement scale and student engagement theory and to develop a student engagement scale in the blended learning environment of "Massive Open Online Courses (MOOCs) + flipped classrooms" in universities by combining the characteristics of flipped learning. The aim is to evaluate and improve the quality of student engagement and educational services in Chinese higher education.

1.1 Analysis of the Classical Student Engagement Scale

School and classroom engagement scales for primary and secondary school students make up a large proportion of the various types of student engagement scales used nationally and internationally. For example, the Attitudes Toward Mathematics Survey (ATM), developed by Raymond B. Miller et al. [9], has a pool of items largely derived from items that Raymond B. Miller et al. [10] have been used successfully. The Student Engagement Instrument (SEI), developed by Appleton et al. [11], is divided into two dimensions, affective engagement, and cognitive engagement, as well as the School Engagement Measure (SEM) developed by J. A. Fredricks et al. [4]. Of these, the SEM is the classical scale that has been cited more often. J. A. Fredricks et al. identify student engagement as a meaningful combination of behavioral, emotional, and cognitive dimensions, and the measurement of student engagement should examine all three dimensions simultaneously. Cognitive engagement is defined as the application of deep cognitive strategies and effective self-monitoring and regulation of learning. Behavioral engagement is defined as students' focused effort and persistence in learning, and emotional engagement focuses on students' emotional experience of learning in the course [12]. Some of the more classic scales for measuring student engagement among university students are the Student Engagement Scale (SES) [7] developed by Selim and Abdullah, which includes two components: campus engagement and classroom engagement. Campus engagement is mainly used to measure students' school learning engagement, while classroom engagement includes three dimensions cognitive, emotional, and behavioral engagement, which is an important reference for this study. The National Survey of Student Engagement (NSSE) [13] includes five dimensions, which is an important reference for evaluating college student engagement around the world.

1.2 Analysis of the Classical Online Student Engagement Scale

The Online Student Engagement Survey (OSES) [14], developed by Dixson, has been validated for rigorous reliability and validity on distance or online student engagement scales. It consults two student engagement instruments: the Classroom Survey of Student Engagement (CLASSE) [15] and the Student Course Engagement Questionnaire (SCEQ) [16], and an online course interaction instrument: Rubric for Assessing Interactive Qualities in Distance Courses (RAIQDC) [17]. The scale is divided into four dimensions: skills, emotions, participation, and performance. Sun and Rueda developed the Distance Student Engagement Scale (DSES-USA) [8] based on the SEM developed by Fredricks, and the Distance Student Engagement Scale (DSES-China) [18] developed by Wang Shuang at Beijing Normal University, China.

An analysis of existing classical student engagement scales shows that the scales differ in their measurement dimensions and indicators, depending on their measurement intentions and target populations (see Table 1). The majority of the scale's statements, like "I try to do my best during classes," focus on the attitudes and behaviors of students. Students scored each item a mark based on how much they agreed with it. Most of the scales use a five-point Likert format, with the total score of the questionnaire representing the level of student engagement. The scales have been administered to primary, secondary, and university students to assess the effectiveness of teaching interventions, to assess teachers' teaching, to assess the quality of schooling, and to investigate learning. The scales focus on a range of educational activities including schools, curricula, classrooms, and learning tasks. Although definitions of student engagement are mixed, the vast majority of instruments view student engagement as a multidimensional concept [4, 19], with behavioral, emotional, and cognitive being the more commonly accepted dimensions of student engagement measurement [20]. The other scale dimensions can likewise be translated into behavioral, emotional, and cognitive dimensions [21]. These classic scales serve as valuable for scale structure and item development in this study, but they cannot be used directly because the objects, intentions, and learning experiences described in the items do not correspond to actual student engagement in the flipped classroom. On the whole, there is a lack of mature scales of student engagement in the flipped classroom. This is partly due to the lack of wider trial and validation of the scales, and partly since the existing scales are mainly based on primary and secondary student engagement scales, such as those developed by Miller, Fredricks, and Appleton, which lack a comprehensive integration of the flipped classroom learning experience and ignore some of the more important indicators of engagement in flipped learning, such as self-monitoring of learning. To summarize, the flipped classroom learning engagement scale needs to be developed for China's teaching realities.

Table 1. A comparison of seven classic student engagement scales

NO.	Instrument Name	Samples	Dimension	Scale Intention
1	Attitudes Toward Mathematics Survey (ATM) [9]	High school students in grades 10 through 12, college-level samples	Self-regulation (9 items), Deep cognitive strategy use (7 items), Shallow cognitive strategy use (4 items), Persistence (8 items)	Measure the level of student engagement in academic activities.

(*continued*)

Table 1. (*continued*)

NO.	Instrument Name	Samples	Dimension	Scale Intention
2	School Engagement Measure (SEM) [4]	Upper elementary school students	Behavioral engagement (5 items), Emotional engagement (6 items), Cognitive engagement (8 items)	Evaluating primary school students' classroom performance.
3	Student Engagement Instrument (SEI) [11]	Students in grades 6 through 12	Affective engagement: Teacher-student relationships (9 items), Peer support for learning (6 items), Family support for learning (4 items), Cognitive engagement: Control and relevance of schoolwork (9 items), Future aspirations goals (5 items)	Assess two types of student engagement with school.
4	Online Student Engagement Survey (OSES) [14]	College students	Skills (6 items), Emotional (5 items), Participation (6 items), Performance (2 items)	Evaluating student performance in online courses in higher education.
5	Student Engagement Scale (SES) [7]	College students	Valuing (3 items), Sense of belonging (8 items), Cognitive engagement (10 items), Peer relationships (emotional engagement-I) (6 items), Relationships with faculty members (emotional engagement-II) (10 items), Behavioural engagement (4 items)	Measure student engagement for higher education.

Table 1. (*continued*)

NO.	Instrument Name	Samples	Dimension	Scale Intention
6	Distance Student Engagement Scale (DSES)-China [18]	College students	Behavioral engagement (18 items), Emotional engagement (19 items), Cognitive engagement (26 items)	Analyzing differences in distance student learning engagement in terms of learner-related characteristics.
7	Distance Student Engagement Scale (DSES)-USA [8]	College students	Behavioral engagement (5 items), Emotional engagement (6 items), Cognitive engagement (8 items)	Assessing college students' levels of engagement in distance education.

2   Method

2.1   Sample

A total of 450 valid research samples were collected at Longdong University through the online research platform "Questionnaire Star", excluding incomplete and unqualified questionnaires. The samples were grouped according to their odd or even number, with one group undergoing Exploratory Factor Analysis (EFA) for determining the factor structure and one group undergoing Confirmatory Factor Analysis (CFA) for verifying the factor structure. As can be seen from Table 2, the data for EFA and CFA were obtained from 225 students each.

2.2   Data Collection Tools

Initial Scale Structure and Item Development
In this study, it was chosen to use the behavioral, emotional, and cognitive dimensions to create an evaluation scale for measuring student engagement in flipped classrooms. Behavioral engagement focuses on students' active participation, persistence, and inter-action in course learning, similar to the research of Fredricks, Miserandino and Marianne et al. [4, 22]. Emotional engagement focuses on the student's emotional experience of learning in the course, both between teachers and students, and among peers, similar to the research of Selim and Abdullah [7]. Cognitive engagement focuses on students' use of learning strategies and self-monitoring and regulation of learning in the curriculum, similar to the research of Raymond B. Miller et al. [9]. Based on the above-mentioned, 34 items were prepared for this study in combination with student interviews, including 8 items for behavioral engagement, 14 items for emotional engagement, and 12 items

Table 2. Samples for EFA and CFA

Variable	EFA		CFA	
	f	**%**	**f**	**%**
Gender				
Female	130	57.8	127	56.4
Male	95	42.2	98	43.6
Total	225	100	225	100
Department				
Mathematics and Statistics	65	28.9	65	28.9
Information engineering	22	9.8	18	8
Chemical engineering	67	29.8	72	32
Civil engineering	71	31.5	70	31.1
Total	225	100	225	100

Table 3. Student Engagement Dimensions, Items Number, and References

Subscale	No.	Documentary sources
Cognitive Engagement (12 items)	Q1–Q12	[4, 7–9, 14, 18], Interviews
Emotional Engagement (14 items)	Q13–Q26	
Behavioural Engagement (8 items)	Q27–Q34	

for cognitive engagement (see Table 3). Participants rate the scale on a five-point Likert scale from 1 (totally disagree) to 5 (totally agree) depending on how closely the scale descriptors reflect their own. The overall scale score represents the level of student engagement.

Scale Applicability Analysis, Item Analysis

Three experts who have been teaching for many years and have experience implementing flipped classrooms were invited to participate in this study, and the content and wording of the descriptors were revised based on the experts' comments, and the formulation of the items was adjusted based on the feedback. Later, analyses and applications regarding EFA and CFA were conducted.

3 Findings

3.1 Preparing the Data and Examining the Assumptions

Four students with outliers were excluded from the EFA, leaving 221 students. This is consistent with the international scale design principle: the sample size should be at least 5 to 10 times the number of items [23]. Nine outliers were removed from the CFA,

leaving 216. A sample size of 150 for an SEM model is "usually sufficient to obtain convergence and an appropriate solution [24]".

3.2 Item Analysis

Table 4 shows the descriptive statistics for the FLSES (Flipped Learning Student Engagement Scale, abbreviations FLSES) total scores. It can be seen that the values of skewness (0.18; $\pm$ 1) and the values of kurtosis (0.006; $\pm$ 1) for the total score are within an acceptable range. Each item's descriptive statistics were also examined. The normal distribution's skewness and kurtosis values for each item can be observed to be within acceptable ranges. In addition, the histogram shows that the total score of student engagement is normally distributed (see Fig. 1).

Subjects were divided into high ($\geq$137 points) and low ($\leq$119 points) subgroups according to the FLSES total score ranking, and differences between high and low subgroups on each item were tested by independent samples t-test. The data were analyzed and items that did not reach significance were removed. The results of the independent samples t-test showed that all t-values had a P-value of $<$ 0.05 (95% confidence interval), indicating that all 34 items in the initial formulation of the scale were statistically different and that the energy efficiency performance of the items met the requirements. The reasonableness of the scale items was verified [23]. Correlation analysis of the 34 items and the total score of the scale, as well as between the items, revealed that the product difference between the two variables was significantly correlated (p $<$ 0.05). The correlation coefficient between the items and the total score were all higher than 0.4 and lower than 0.9, and the Pearson correlation values between the items were all less than 0.90 [25]. This suggests that the scales are homogeneous, with all items aiming to

Table 4. Descriptive Statistics Regarding the FLSES Total Scores

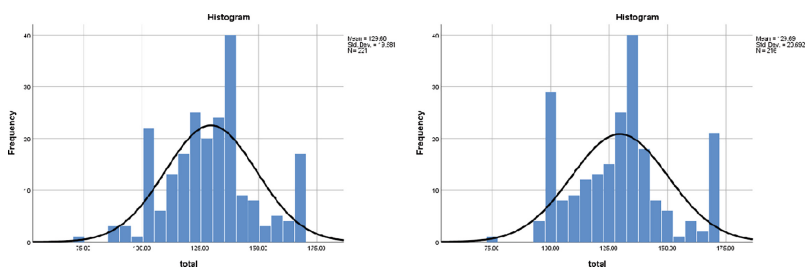|	n	$\overline{X}$	Var.	Sd	Min.	Max.	Skewness	Kurtosis
Statistic for EFA	221	129.60	383.42	19.58	73.00	170.00	0.18	0.006
Statistic for CFA	216	129.69	428.16	20.69	75.00	170.00	0.25	-0.375

Fig. 1. Distribution of Total Score of FLSES for EFA and CFA

measure the same underlying variable (student engagement), but as different indicators. Cronbach's Alpha for the total scale was 0.972, which is higher than 0.9. The value is regarded as highly reliable [23]. This would imply that the items on the scale have a high degree of internal consistency and stability. In the Cronbach's alpha (α) internal consistency reliability analysis, in the "Corrected item-total correlations" column, the Pearson correlation coefficients for each item aggregated with the other items ranged from 0.771 to 0.878 for cognitive engagement, 0.622 to 0.796 for emotional engagement, and 0.728 to 0.837 for behavioral engagement, all of which were greater than 0.6, indicating that the item was at least moderately high degree of correlation. The Cronbach's Alpha coefficients for the cognitive, emotional, and behavioral dimensions of the scale were 0.964, 0.941, and 0.945, respectively (as shown in Table 5).

3.3 Exploratory Factor Analysis

To determine the factor structure of the initial scale, the researcher conducted an EFA of the scale. The factor analysis can continue if the Kaiser-Meyer-Olkin (KMO) value is higher than 0.50 [26]. According to Table 6, the KMO value was significant (P < 0.05), and the KMO values for the three subscales of cognitive engagement, emotional engagement, and behavioral engagement were 0.951, 0.912, and 0.921, respectively. These results show that the subscales are suitable for factor analysis. Data were EFA using SPSS 26.0, common factors were extracted using principal component analysis with eigenvalues > 1, and the factors were orthogonally rotated using the maximum variance method. A scale with a cumulative variance of the common factor explaining more than 50%, a common factor variance of > 0.4, and a factor loading of > 0.4 for each item is generally regarded as having good construct validity [27]. The results showed that the scale ended up with four common factors, with a cumulative variance explained of 73.051% and a factor loading of > 0.5 for each item. Taking the theoretical framework, item-item and item-total scale correlations, and the item cross-loading problem into account, a total of 13 items were deleted from the initial scale during these analyses. The variance explained by the remaining four-factor 21 items was found to be 77.970%. After EFA, the revised scale Item factor loading see Table 7. Through EFA, the dimensions related to classroom student engagement can be seen to parallel the literature in that they refer to the three dimensions of cognitive, emotional, and behavioral engagement. The factors of relationships with the faculty member and peer relationships constituted emotional engagement, this parallels the literature of Selim and Abdullah [7] on emotional engagement. Of these three dimensions, Factor 1 is cognitive engagement and includes ten items that examine the use of learning strategies and self-monitoring related to students [4, 28]. Factor 2 is peer relationships (Emotional engagement-I), which consists of three items and focuses on peer relationships, and factor 3 is relationships with the faculty member (Emotional engagement-II), which consists of four items and focuses on student-teacher relationships [29]. Factor 4 is behavioral engagement and includes four items that focus on students' behavior in three areas: participation, interaction, and concentration [30].

Table 5. Cronbach's Alpha Coefficient Analysis Results

Dimension	Cronbach's Alpha	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Cognitive Engagement	0.964	Q1	0.792	0.961
		Q2	0.771	0.962
		Q3	0.84	0.96
		Q4	0.795	0.961
		Q5	0.778	0.962
		Q6	0.817	0.961
		Q7	0.866	0.959
		Q8	0.796	0.961
		Q9	0.878	0.959
		Q10	0.878	0.959
		Q11	0.783	0.961
		Q12	0.791	0.961
Emotional Engagement	0.941	Q13	0.622	0.94
		Q14	0.64	0.939
		Q15	0.68	0.938
		Q16	0.684	0.938
		Q17	0.703	0.937
		Q18	0.739	0.936
		Q19	0.787	0.935
		Q20	0.766	0.935
		Q21	0.796	0.935
		Q22	0.767	0.935
		Q23	0.677	0.938
		Q24	0.744	0.936
		Q25	0.657	0.938
		Q26	0.669	0.938
Behavioural Engagement	0.945	Q27	0.728	0.942
		Q28	0.779	0.939

Table 5. (*continued*)

Dimension	Cronbach's Alpha	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
		Q29	0.796	0.938
		Q30	0.816	0.936
		Q31	0.837	0.935
		Q32	0.816	0.936
		Q33	0.809	0.937
		Q34	0.816	0.936

Table 6. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.951
Bartlett's Test of Sphericity	Approx. Chi-Square	7736.148
	df	561
	Sig.	0.000

Table 7. Scale Item Factor Loading

Cognitive Engagement		Emotional Engagement-I		Emotional Engagement-II		Behavioural Engagement	
Item	Factor Loading	Item	Factor Loading	Item	Factor Loading	Item	Factor Loading
Q1	0.755	Q17	0.689	Q20	0.669	Q30	0.696
Q3	0.762	Q18	0.802	Q21	0.817	Q31	0.729
Q4	0.722	Q19	0.754	Q22	0.845	Q32	0.772
Q5	0.783			Q24	0.72	Q34	0.677
Q6	0.803						
Q7	0.86						
Q9	0.798						
Q10	0.838						
Q11	0.803						
Q12	0.753						

Table 8. Evaluation of Fit Indices Regarding CFA

Indices	Sample statistic	Perfect fit	Good fit	Decision	Rationale
χ^2/df	2.376	χ^2/df ≤ 2	χ^2/df ≤ 3	Good fit	[25, 32]
RMSEA	0.080	RMSEA $\leq$ .05	RMSEA $\leq$ .08	Good fit	[33]
SRMR	0.044	SRMR $\leq$ .05	SRMR $\leq$ .08	Perfect fit	[34, 35]
NFI	0.912	NFI $\geq$ .95	NFI $\geq$ .90	Good fit	[32]
NNFI	0.939	NNFI $\geq$ .95	NNFI $\geq$ .90	Good fit	[36]
CFI	0.947	CFI $\geq$ .95	CFI $\geq$ .90	Good fit	[32, 35]
GFI	0.833	GFI $\geq$ .95	GFI $\geq$ .90	Poor fit	[33, 35]

The reliability coefficients for the revised scale was calculated to be 0.959, for cognitive engagement, peer relationship (emotional engagement-I), teacher-student relationship (emotional engagement-II), and behavioral engagement were 0.959, 0.872, 0.906, 0.926 respectively (see Table 9).

3.4 Confirmatory Factor Analysis

To further test the relationship model between the potential variables and the question items corresponding to the potential variables in the theoretical framework, and the degree of correlation between one of the measured variables and the others, CFA was used on the sample data. AMOS 24.0 software is used for data analysis. The results of the CFA analysis are used to assess how well the designed theoretical model fits the measured data, thus testing the correctness of the theoretical structure. Because the data set had a normal distribution (see Fig. 1, Table 4), the parameter estimation method was the Maximum Likelihood Method, and the data matrix was the Covariance Matrix.

Table 9 shows the outputs examined, the unstandardized coefficient (Unstd.), the error variances (S.E.), the Z-values, the P-values, the standardized coefficient (Std.), the Cronbach's Alpha value, the Construct reliability value (CR), the Average Variance Extracted value (AVE). As can be seen in Table 10, the Z-value for each item was higher than $\pm$ 1.96 (p < .05) [25], and the error variance was lower than .90. The path diagram for the model is shown in Fig. 2.

The resulting metrics show that the measurement model fits the data well (X2/df = 2.376, GFI = 0.833, CFI = 0.947, NFI = 0.912, NNFI/TLI = 0.939, RMSEA = 0.080, SRMR = 0.044). Except for GFI which is very close to the ideal fit criterion of 0.90, all the indicators met the ideal fit criteria (see Table 8). It can be seen that the three-dimensional models fit well and the revised FLSES has good construct validity. Next, the CR value of each dimension of the scale was tested. CR value reflects whether all indicators in each latent variable consistently explain that latent variable. In general, if the CR value is > 0.7 [31], it means that the intrinsic quality of the potential variables is satisfactory. In addition, the AVE value was calculated for each dimension. The results show (see Table 10) that the dimensions' CR value ranged from 0.921 to 0.963, which was higher than 0.7, and the dimensions' AVE value ranged from 0.722 to 0.848, which was higher than 0.5 [31]. According to the findings of the preceding statistical study, the FLSES shows good convergent validity.

Table 9. Item Statistics Regarding the CFA Findings

Dimension	Item	Unstd.	S.E.	Z	P	Std.	Cronbach's Alpha	CR	AVE
Cognitive Engagement	Q1	1				0.817	0.959	0.963	0.722
	Q3	0.946	0.063	15.041	***	0.841			
	Q4	0.954	0.064	14.884	***	0.835			
	Q5	0.887	0.062	14.402	***	0.817			
	Q6	0.982	0.057	17.286	***	0.917			
	Q7	0.876	0.059	14.799	***	0.832			
	Q8	0.965	0.059	16.417	***	0.889			
	Q9	0.927	0.059	15.732	***	0.865			
	Q10	0.851	0.056	15.101	***	0.843			
Emotional Engagement-I	Q11	1				0.797	0.872	0.941	0.848
	Q12	1.311	0.077	16.944	***	0.958			
	Q13	1.327	0.079	16.738	***	0.94			
Emotional Engagement-II	Q14	1				0.838	0.906	0.937	0.788
	Q15	1.137	0.062	18.291	***	0.932			
	Q16	1.078	0.062	17.53	***	0.908			
	Q17	1.074	0.066	16.331	***	0.871			
Behavioural Engagement	Q18	1				0.848	0.926	0.921	0.745
	Q19	1.033	0.06	17.089	***	0.901			
	Q20	0.94	0.061	15.342	***	0.842			
	Q21	0.933	0.059	15.89	***	0.86			

Note: * indicates p < 0.05; ** indicates p < 0.01; *** indicates p < 0.001
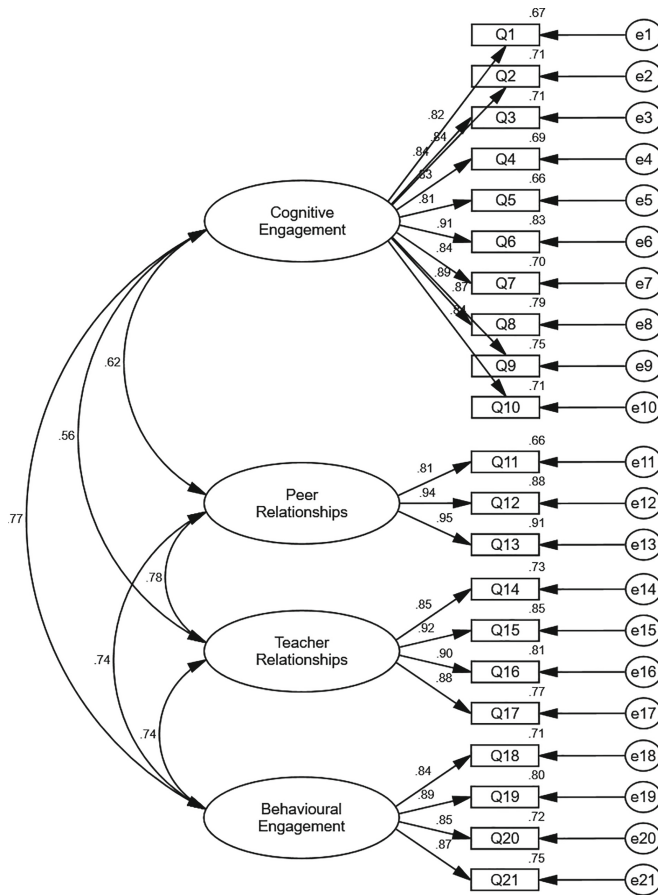
Fig. 2. Standardized Path Diagram

4 Conclusions and Discussion

The scale was assessed using EFA and CFA, which were carried out individually with distinct sample groups, yielding a 21-item, five-point Likert format student engagement scale with three dimensions. The total variance explained regarding the four factors of the scale was calculated as 77.970%. Cronbach's Alpha was 0.959 for the whole scale, 0.959 for cognitive engagement, 0.872 for peer interactions (emotional engagement-I), 0.906 for the relationship with the instructor (emotional engagement-II), and 0.926 for behavioral engagement. The scale has good internal consistency and stability. A CFA of the scale structure using AMOS 24.0 software revealed that the resulting indicators: the z-values for each item ranged from 14.402 to 18.291, all higher than $\pm$ 1.96, the standardized coefficients for each item ranged from 0.797 to 0.958, all higher than 0.70, and the error variances for each item ranged from 0.056 to 0.079, all lower than 0.90, following the literature. The $\chi 2/df$ was 2.376, within 3; CFI was 0.947, NFI was 0.912 and NNFI was 0.939, all above 0.9, RMSEA was 0.080 and SRMR was .044, all lower

than 0.08. It can be seen that the three-dimensional models fit well and the revised FLSES has good construct validity. The CR value of dimensions ranged from 0.921 to 0.963, all of which were higher than 0.7, and the intrinsic quality of the potential variables was more satisfactory. In addition, the AVE value of all dimensions ranged from 0.722 to 0.848, all of which were higher than 0.5, indicating good convergent validity of the student engagement scale in the 'flipped classroom' teaching model.

In summary, the dimensions of FLESE are cognitive engagement, emotional engagement, and behavioral engagement respectively. The scale developed on this basis has been tested and found to have good reliability and validity and can reflect the degree of students' engagement in classroom learning in a scientific way, which is a reliable tool for measuring teaching quality.

In the current study, participants were from a provincial university in China, and the scale could be validated and revised in the future by applying it to a larger and more diverse group of university students, including those from different universities, and taking into account their characteristics including major, grade, and school level. Furthermore, the relationship between the dimensions of student engagement could be analyzed in more detail in future studies (e.g. path analysis).

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