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ORIGINAL PAPER

Engagement of Higher Education Students in Live Online Classes: Scale Development and Validation

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Abstract
This study aimed to develop and validate the Live Online Classes Engagement Scale (LOCES) to measure higher education (HE) students' live online classes (LOCs) engagement levels. The scale items were created after reviewing the studies focusing on engagement and those developing engagement scales. For validity and reliability, data were collected from 1039 students (Female = 749, Male = 290) who were receiving distance education via LOCs in 34 different departments of 21 universities in Turkey. As a result of exploratory and confirmatory factor analyses, a structure with six factors (social, instructional, technological, emotional, behavioral, and withdrawal) and 46 items was obtained. The total variance explained was 63.45%. As a result, the LOCES met the criteria necessary for validity and reliability. In conclusion, the LOCES can be used to measure the engagement levels of HE students in LOCs.

Keywords Engagement · Live online classes · Scale development · Higher education

Introduction

With the outbreak of the Covid-19 pandemic, restrictions, and quarantine implementations were initiated in many countries. As a result, face-to-face education was suspended. Almost all universities carried on their educational activities with synchronous or asynchronous methods by orienting themselves towards distance education (Lowenthal et al., 2020; Murphy, 2020). However, distance education brought about difficulties as well. For example, well-planned online learning experiences differed from courses offered online in times of disaster (Hodges et al., 2020). Also, many teachers and learners did not, and still do not know about the online education method. Many teachers have had to adapt to distance education without sufficient planning (Donitsa-Schmidt & Ramot, 2020). Since they were not experienced in distance education technological and pedagogical, they faced problems in turning the conventional education setting into an online platform (Dinh & Nguyen, 2020). Many lecturers and students have had to use platforms and digital tools, such as *Learning Management System (LMS)*, *Moodle*, *Blackboard*, *Zoom*, *Hangouts*, *Skype*, *Microsoft Teams,* and *BigBlueButton* they have never used before (Christian et al., 2020). As a result, most teachers and learners have started to teach and learn on a platform they have not experienced before: in front of a screen (Bao, 2020).

Synchronous and Asynchronous Distance Education

Distance education is mainly implemented with two different methods, synchronous and asynchronous methods. The asynchronous method is usually implemented with activities performed by teachers, such as presenting educational materials, homework, quizzes, and forums in LMS platforms. In this method, giving the students a flexible study opportunity by extending the activities within a period (Hrastinski, 2008a; Lall & Singh, 2020) is considered a significant advantage. On the other hand, its inadequacy in terms of interaction and feedback constitutes a disadvantage. The asynchronous method was the most preferred method until

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recently, but synchronous education has been more popular along with the development of web technologies and internet infrastructure in particular (Al-Samarraie, 2019; Keyyan, 2019; Kinshuk & Chen, 2006; Rehn et al., 2016). Synchronous education has become so popular during the pandemic that it has threatened the internet infrastructure due to high data size and insufficient bandwidth (Christian et al., 2020). Synchronous education is frequently preferred because it is an ideal alternative method to face-to-face education (Al-Samarraie, 2019). It aims to create a real classroom environment (Hrastinski, 2008b).

The Role of Live Online Classes (LOCs)

Synchronous education is a teaching method where teachers and students can meet in live online classes for a certain period and make audio and video calls. Synchronous education is more eligible for instant communication, instant feedback, interaction, discussion, and expression of an opinion, showing that it is socially more effective (Francescucci & Rohani, 2019; Gillies, 2008; Hrastinski, 2008b; Motteram, 2001). No matter how many technical problems are encountered while having audio and video calls in synchronous education, LOCs can be held without problems over various video conference systems if the sufficient technical infrastructure is available. In this study, the concept of "live online classes" means a live lesson using the video conference system (synchronously both video and audio sharing). The scale developed aims to determine engagement only in such classes.

LOCs are important in continuing educational activities with minor problems during extraordinary conditions such as pandemics (Correia et al., 2020; Lowenthal et al., 2020). Even though there is a general belief that digital learning platforms cannot be as effective as face-to-face education, it is claimed that they have significant potential in terms of focusing on the teaching process and providing efficiency (Kotryakhov et al., 2019). It can even be said that well-designed online classes may have no significant difference from face-to-face classes in terms of efficiency (Correia et al., 2020).

Lecturers' abilities to use technology effectively and their pedagogical approaches are also important elements in achieving efficiency in LOCs (Assunção Flores & Gago, 2020; Christian et al., 2020; Rovai & Downey, 2010). Student engagement is significantly influenced by the teachers' abilities, communication environment, or interaction (Umphrey et al., 2008). All such elements can affect the engagement levels and learning performance of students. Indeed, Karal et al. (2011) state that engagement levels are critically important for effective distance education. Thus, measuring engagement levels in LOCs will substantially contribute to the efficiency and productivity of education.

The Background of Student Engagement in LOCs

What is Student Engagement?

Student engagement is defined as participating and spending time in educational activities (Kuh, 2003). Moreover, students' willingness for and frequency of participating in learning activities can also be defined as engagement (Astin, 1999; Reeve et al., 2004; Smith et al., 2005). Although different categories (e.g., academic, psychological, narrative) are put forward for the definition of students' engagement in classes (Appleton et al., 2006; Visser et al., 2016), the concept is generally explained by cognitive, affective, and behavioral dimensions (Gunuc & Kuzu, 2015).

Cognitive engagement includes students' cognitive efforts regarding classes, while affective engagement is related to their attitudes, motivation, and students' relations with their environment (peer, content, or teacher). Behavioral engagement is the fulfillment of class-related tasks by the students (Fatawi et al., 2020; Francescucci & Rohani, 2019; Gunuc & Kuzu, 2015; Liu et al., 2019). Hrastinski (2008c) stated that engagement consists of elements such as doing, communication, thinking, belonging, and feeling by including all these dimensions.

The engagement has often attracted the attention of researchers in education because is an important factor in the learning and satisfaction of students in face-to-face learning environments and online platforms (Fatawi et al., 2020). The engagement has the potential to motivate them for learning, and to increase their learning performance (Gunuc & Kuzu, 2015; Martin & Bolliger, 2018; Zhoc et al., 2019). It is a significant element for learners' achievement because it decreases drop-out rates and enhances graduation rates (Appleton et al., 2006). The most important reason for this is that engaged students are interested in the class, focus on it, and are determined and target-oriented. In contrast, disengaged students are distracted and passive (Reeve et al., 2004).

The Theoretical Structure of Student Engagement

Presence, interaction, and motivation are crucial to achieving the expected engagement level. Presence can be a prerequisite for engagement, but it may not be enough because studies show no significant increase in engagement despite the increased presence level (Dow et al., 2007). Presence is explained by three factors; i.e., social, cognitive, and instructional presence (Garrison, 2007), and generally with the feeling of attachment to a medium psychologically (Dow et al., 2007). Presence is also a prerequisite

for engagement, just like motivation, and defines a psychological process. Presence is important for learning, but may not be enough to enable learning alone (Appleton et al., 2006; Reeve et al., 2004). However, the most critical point that distinguishes engagement from motivation is transforming the individual's ideas into behaviors. As is understood, reflection on behaviors and observability are required for the formation of engagement because student engagement is directly correlated with the constructivist approach and indicates the learner-centered implementation of the teaching process (Coates, 2005).

Learner-centered teaching obligates interaction between learner-learner, learner-teacher, and learner-content. Thus, students are at the center of the constructivist approach, and learning achievement aims at interaction with environmental elements. Students' interactions with teachers, peers, content, and interface are the four modes of interaction affecting the student engagement level in LOCs (Chakraborty & Muyia Nafukho, 2014). Various studies have proven that all these interaction modes affect engagement (Bryan et al., 2018; Dixson, 2010; Rabe-Hemp et al., 2009).

Another factor that has an important role in engagement is transactional distance. Transactional distance is defined as the perception of psychological distance between the student and their peers, instructor, and content (Weidlich & Bastiaens, 2018). Doo et al. (2021) have recently confirmed that transactional distance is important in learning engagement. Transactional distance relies on technologically-mediated communication or interaction (Weidlich & Bastiaens, 2018).

In LOCs, lecturers are expected to make more efforts to ensure engagement. The lecturer's teaching style also influences the learners' engagement levels (Liu et al., 2019), and lecturers should increase students' engagement levels (Fatawi et al., 2020). Gillies (2008) reports that students emphasize communication with the lecturer rather than pedagogy in LOCs. The expectation of students for communication reveals the significance of social presence and interaction. In live online courses, student engagement can be enhanced with the constitution of the interaction element because the live and online aspects of the classes may not be enough to create an environment suitable for increasing the engagement level (Anastasiades et al., 2010). In live online courses in which the lecturer holds in a monologue form or does not prioritize interaction, student engagement may not reach an adequate level. Additionally, the usability of video conference platforms used for LOCs and lecturers' command of the technical features of these platforms contribute to student engagement (Chen et al., 2020; Farhan et al., 2019).

LOCs may increase the distance learning motivation of students and decrease their feelings of loneliness (Hrastinski, 2008b). However, although there is a view that LOCs increase students' motivation, presence, engagement levels, and student–student, teacher-learner, and learner-content interaction, this is not always valid (Candarli & Yuksel, 2012). This is because technical and software problems likely to be faced in LOCs have been minimized today. Still, the lecturer's adoption of a method similar to face-to-face education in LOCs may not be appropriate.

Regardless of being experienced in distance education, LOCs cause the teacher to face specific difficulties. Elimination of loneliness resulting from a distance can be possible with technological and pedagogical skills and implement appropriate teaching strategies (Rehn et al., 2016). These skills and techniques should keep the cognitive loads of the students at the optimum level and encourage their presence (Cornelius & Gordon, 2013). It can be difficult, especially to attract students' attention in LOCs, to maintain and ensure their class engagement (Candarli & Yuksel, 2012).

Pedagogy helps learner improve their learning performance in a constructivist framework (Brown, 2019). Accordingly, not practicing pedagogy in LOCs can be the most common problem (Cornelius & Gordon, 2013; Gillies, 2008). Teaching should include new approaches and pedagogical elements (Correia et al., 2020). Although LOCs provide significant advantages for interaction and communication, they do not eliminate the importance of pedagogical features (Keyyan, 2019). At this point, it is important to employ pedagogical elements to ensure the effective participation of students while designing the learning environment (Basaran & Yalman, 2020). Enhancing student engagement in LOCs, developing an environment supporting their 'presence' levels, and including interaction elements in the teaching process can directly affect students' performance and achievement (Al-Samarraie, 2019; Gillies, 2008; Jackson, 2017; Xiao, 2017). Therefore, engagement plays a crucial role in LOCs to achieve targeted learning performance (Gillies, 2008). As a result, the flexibility and richness provided by LOCs offer significant opportunities to increase students' engagement (Keyyan, 2019). Also, teachers' pedagogical and technological competency plays a crucial role in engagement. In line with the literature (summarized in Table 1), the theoretical structure of engagement regarding LOCs is presented in Fig. 1.

Purpose of the Study

The fact that institutions and lecturers were not ready for distance education during the Covid-19 pandemic has caused difficulties in maintaining teaching effectively (Trust, 2020). Students have found the distance education skills of the lecturers unsuccessful (Karadağ & Yücel, 2020), which can be considered an outcome of these difficulties. This may be because most lecturers did not have any experience in distance education before the pandemic. However, teaching experience is highly important for learning and developing in such a process (Kolb, 1984) because based on experience,

Table 1 Theoretical structure of student engagement in LOCs

Teacher	
• Lecturers' abilities to use technology effectively and their pedagogical approaches (Assunção Flores & Gago, 2020; Christian et al., 2020; Rovai & Downey, 2010; Umphrey et al., 2008)	• The teacher's digital communication skills (Chiu, 2022)
• Instructional presence (Garrison, 2007)	• Having some technological and pedagogical skills and implementing appropriate teaching strategies (Rehn et al., 2016)
• Constructivist approach and learner-centered teaching process (Coates, 2005)	• Being able to practice pedagogy in LOCs (Cornelius & Gordon, 2013; Gillies, 2008)
• The interactions of the student with the teacher (Bryan et al., 2018; Chakraborty & Muyia Nafukho, 2014; Dixson, 2010; Rabe-Hemp et al., 2009)	• Distance education skills of the lecturers (Karadağ & Yücel, 2020)
• The teaching style of the lecturer (Fatawi et al., 2020; Liu et al., 2019)	• Teacher-student relationship (Appleton et al., 2006; Gunuc & Kuzu, 2015; Zhoc et al., 2019)
	• Scales which include the "teacher" factor (Gunuc & Kuzu, 2015; Matthews et al., 2017)
Peer	
• Communication environment and interaction (Anastasiades et al., 2010; Hrastinski, 2008c; Umphrey et al., 2008)	• Student–student interaction and communication (Candarli & Yuksel, 2012; Gillies, 2008)
• Presence is explained with social, etc. (Garrison, 2007)	• Developing an environment supporting students' presence levels and including interaction elements in the teaching process (Al-Samarraie, 2019; Gillies, 2008; Jackson, 2017; Xiao, 2017)
• The interactions of the student with the peer, etc. (Bryan et al., 2018; Chakraborty & Muyia Nafukho, 2014; Dixson, 2010; Rabe-Hemp et al., 2009)	• Scales include "peer" related factors (Appleton et al., 2006; Gunuc & Kuzu, 2015; Zhoc et al., 2019)
Technological	
• Usability of video conference platforms and lecturers' command of technical features of these platforms (Chen et al., 2020; Farhan et al., 2019)	• The features of the platforms and technological opportunities (phone, computer, internet speed, etc.; Chakraborty & Muyia Nafukho, 2014; Chen et al., 2010; Chen et al., 2020)
• Lecturers' technological skills abilities to use technology effectively (Assunção Flores & Gago, 2020; Christian et al., 2020; Rehn et al., 2016; Rovai & Downey, 2010)	• Developing an environment supporting students' presence and including interaction elements in the teaching process (Al-Samarraie, 2019; Gillies, 2008; Jackson, 2017; Xiao, 2017)
• Flexibility and richness of LOCs (Keyyan, 2019)	• Well-designed online classes (Correia et al., 2020)
Emotional	
• Students' willingness for and frequency of participating in learning activities (Astin, 1999; Reeve et al., 2004; Smith et al., 2005)	• The feeling of attachment to a medium psychologically (Dow et al., 2007)
• Engagement consisted of thinking, belonging, feeling, etc. (Hrastinski, 2008c)	• Distance learning motivation and feeling of loneliness (Hrastinski, 2008b)
• Decreasing drop-out and withdrawal rates (Appleton et al., 2006; Hospel et al., 2016)	• Emotional engagement is defined as motivation and determination (Fatawi et al., 2020; Liu et al., 2019; Northey et al., 2015), enjoying the lessons more (Skinner et al., 2008)
• Disengaged students are distracted and passive (Reeve et al., 2004)	• Attracting students' attention in LOCs (Candarli & Yuksel, 2012)
• Presence can be a prerequisite for engagement (Appleton et al., 2006; Dow et al., 2007; Reeve et al., 2004)	• Emotional engagement in online courses (Baloran et al., 2021; Chiu, 2022)
Cognitive	
• Psychological, narrative, cognitive, etc. dimension for the definition of students' engagement in classes (Appleton et al., 2006; Gunuc & Kuzu, 2015; Visser et al., 2016)	• Presence is explained with cognitive, etc. factors (Garrison, 2007), and feeling of attachment to a medium psychologically (Dow et al., 2007)
• Engagement consisted of elements such as thinking, belonging, etc. (Hrastinski, 2008c)	• Presence, motivation, psychological process (Appleton et al., 2006; Reeve et al., 2004)
• Drop-out rates, graduating in time (Appleton et al., 2006)	• Cognitive loads and presence of the students (Cornelius & Gordon, 2013)
	• Cognitive engagement (Chiu, 2022)
Content	
• The interactions of the student with the content and interface (Bryan et al., 2018; Chakraborty & Muyia Nafukho, 2014; Dixson, 2010; Rabe-Hemp et al., 2009)	• The quality of the teaching process (Gašpar & Mabić, 2015; Goldspink et al., 2008)
• Having pedagogical skills and implementing appropriate teaching strategies (Rehn et al., 2016)	• New approaches and pedagogical elements (Correia et al., 2020; Keyyan, 2019)
• Practicing pedagogy in LOCs (Cornelius & Gordon, 2013; Gillies, 2008)	• Effective participation of the students (Basaran & Yalman, 2020)
• Instructional presence (Garrison, 2007)	• The scale includes the "content" factor in the engagement scale (Matthews et al., 2017)
• Constructivist approach and learner-centered teaching process (Brown, 2019; Coates, 2005)	

Table 1 (continued)

Behavioral	
• Students' participation and spending time in educational activities (Kuh, 2003) • Doing (Hrastinski, 2008c). Class-related tasks (Fatawi et al., 2020; Francescucci & Rohani, 2019; Gunuc & Kuzu, 2015; Liu et al., 2019), task-related behaviors of the students (Fatawi et al., 2020; Liu et al., 2019; Northey et al., 2015) • Withdrawal, non-completion, and unsatisfactory learning process (Appleton et al., 2006; Farrell & Brunton, 2020; Kahu et al., 2020)	• Withdrawal is a sub-factor in the behavioral engagement scale (Hospel et al., 2016) • Reflection on behaviors and observability (Coates, 2005) • Participation (Baloran et al., 2021) and behavioral engagement (Chiu, 2022) • The scale includes "behavioral" factor in engagement scale (Gunuc & Kuzu, 2015)

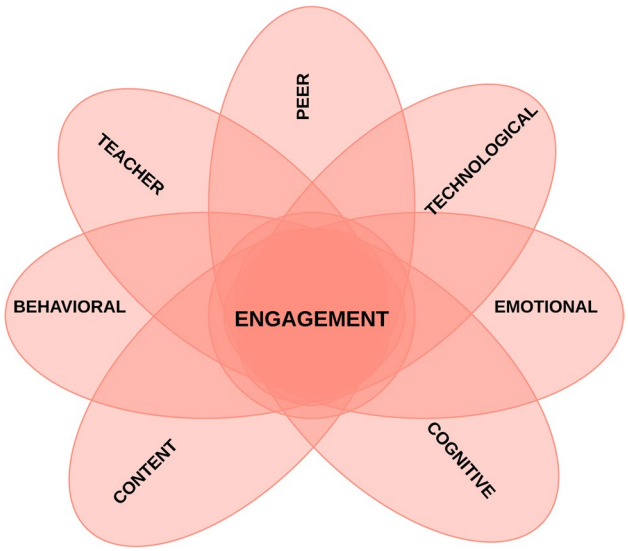

Fig. 1 The theoretical structure of engagement

teachers can handle distance education policies, LOC systems, and curricula. Measurement of students' engagement levels for LOCs and the management of the teaching processes in line with the results can facilitate achievement because engagement is an important indicator in determining the quality of the teaching process (Gašpar & Mabić, 2015; Goldspink et al., 2008). It is assumed that the Live Online Classes Engagement Scale (LOCES) developed in this study will meet this need. When the literature was reviewed, no descriptive and experimental studies were located regarding learners' and teachers' perspectives (Karal et al., 2011; Kear et al., 2012), attitudes (Basaran & Yalman, 2020), presence levels (Giesbers et al., 2009), drop-out and academic achievement (Gegenfurtner & Ebner, 2019) in LOCs.

There are some engagement scales on distance education or online learning environments (Francescucci & Foster, 2013; Matthews et al., 2017), video (Visser et al., 2016), and higher education (HE; Gunuc & Kuzu, 2015; Zhoc et al., 2019) in the literature. However, these studies focused on engagement in online learning environments and did not consider LOCs and asynchronous learning environments separately. Also, no scales have been developed to measure students' engagement levels in "live online classes" in HE. Therefore, it is clear that such a scale is needed. This study embarks on such a need and develops the first engagement scale towards LOCs in Turkey and the world. In this sense, the LOCES is expected to contribute to practitioners and researchers and fill the gap in the literature. To put it more clearly, the need for distance education, and especially LOCs, has emerged in recent years due to compulsory reasons (e.g., the pandemic) or the development of video conferencing technologies. In addition, the fact that practitioners gained distance education experience during the pandemic strengthens the possibility that the use of this method in the learning process will become widespread in the following periods. Therefore, this scale is expected to serve as a tool that practitioners and researchers can use to evaluate engagement, a critical factor in LOCs.

Method

Sample

The data were collected from 1039 students, 290 males and 749 females, who were studying in 34 different departments of 21 universities in Turkey. The purposive sampling method was used in selecting the samples, and maximum diversity was ensured. All students confirmed that they had participated in LOCs within the last week and evaluated the previous live online course they attended. The data collection process was completed in two stages in December 2020. Data were collected for the Exploratory Factor Analysis (EFA) (N = 536) in the first stage and for the Confirmatory Factor Analysis (CFA) (N = 503) in the second stage. In both phases, data were collected from a different sampling group. Students' gender, class, education level, and the video conference system they used for attending live classes are presented in Table 2.

Research Process

This study followed standardized steps used in scale development research (Carpenter, 2018; Kyriazos & Stalikas,

Table 2 Samples characteristics for EFA and CFA

	EFA		CFA	
	f	%	*f*	%
Gender				
Male	141	26.3	149	29.6
Female	395	73.7	354	70.4
Grade				
First	311	58.0	225	44.7
Second	113	21.1	191	38.0
Third	43	8.0	39	7.8
Fourth	69	12.9	48	9.5
Education level				
College*	213	39.7	103	20.5
Undergraduate	290	54.1	361	71.76
Graduate	33	6.2	39	7.74
Platform**				
ALMS (Perculus-Advancity***)	216	40.3	236	46.9
BigBluebutton (Moodle based)	192	35.8	207	41.2
Zoom	64	11.9	39	7.8
Google meet	35	6.5	6	1.2
Adobe connect	29	5.4	11	2.2
Microsoft teams	-	-	4	0.7
Total	536	100	503	100

College usually involves vocational training, ** All the platforms enable students to chat and communicate on audio and video calls. * This platform has both LMS and video conference components*

2018; Worthington & Whittaker, 2006). These steps include (1) literature review and obtaining experts' opinions, (2) creating an item pool, (3) evaluation of the item pool by experts, (4) pilot implementation, (5) revision of the scale and development of the draft scale, (6) implementation and analysis of the draft scale and (7) finalizing the scale.

In the first step of the scale development process, two researchers searched the literature independently. They examined the studies focusing on LOCs in the literature review stage and obtaining experts' opinions. Again, in this step, the items proposed to be included in a scale that aims to measure the engagement level in LOCs were received in writing from two experts working in distance learning. In the second step, the items created based on the literature review and experts' opinions were gathered in "the item pool", and recurrent items were removed. In the third step, the item pool ($N_{item} = 65$) was revised by two distance education experts, an educational psychology expert, and a scale development expert. In line with the experts' recommendations, two items were removed from the scale, the factor including three items was amended, four new items were added, and 27 items were revised. A Turkish linguist revised the resulting draft scale ($N_{item} = 67$), correcting unclear or misunderstood items via a pilot implementation (fourth step). The draft of the LOCES scale was constructed covering seven factors and 67 items (fifth step). These factors included six items about "peer", 12 items for "teacher", 11 items for "content", nine items for "technological", 11 items for "emotional", nine items for "cognitive" and nine items for "behavioral". This draft scale, which was developed in a five-point Likert-type scale, was scored as strongly disagree (1), slightly disagree (2), neutral (3), slightly agree (4), and strongly agree (5).

The draft scale was implemented via the online survey method (step six) after the ethics committee's approval (ID: 88,656,144–000-E.2000326592). The authors ensured the participation of voluntary students from the universities they were working at by contacting 19 different universities through their colleagues. Two control items as "If you have read this item, mark the option (3) Neutral", were added to the online form to determine the participants who marked the items randomly (seventh step).

Data Analysis

We used the statistical methods of EFA, CFA, and reliability analysis (Cronbach's alpha and Guttman split-half) in the scale development process. EFA and reliability analysis were carried out via IBM SPSS 32, and CFA analysis via IBM SPSS AMOS 23. Firstly, the control items in the online form were examined, and the participants who marked the items randomly ($N = 129$) were excluded from the data set. Adequacy and consistency of the items were investigated by reviewing the results of the Kaiser–Meyer–Olkin (KMO) test and Bartlett's test of sphericity to find out whether the data collected for EFA were suitable for the factor analysis (Pett et al., 2003). Before the initiation of EFA, the normality levels of the data were checked, and outlier data control was performed (Tabachnick & Fidell, 2012). EFA was implemented after these assumptions were confirmed and arrangements were made. EFA results were checked, and items with factor loading below 0.40 and items in two different factors with the difference between their factor loading below 0.10 were excluded (Field, 2009; Gürbüz & Şahin, 2017; Hair et al., 2010).

In the second stage, CFA was executed. CFA is an analysis performed to determine whether the structure formed by implicit variables associated with the variables observed is supported by data (Tabachnick & Fidell, 2012). Firstly, the control items in the online form were examined, and the participants who marked items randomly ($N = 111$) were excluded from the data set. Whether goodness of fit conditions was provided was checked, and Cronbach's alpha and Guttman split-half reliability coefficients were calculated for the reliability analysis. The correlation of each item of the scale with the factor was investigated, and it was determined whether the item served the purpose of the factor and

whether the item served the purpose of the factor was investigated. Finally, an independent samples *t*-test was executed to determine the levels of the distinctiveness of the items, that is, to examine whether there was a significant difference between the responses given by the students constituting the highest and lowest 27% in terms of the scale average to the items.

Results

Exploratory Factor Analysis (EFA)

For EFA, the results of the KMO test and Bartlett's test of sphericity were reviewed to see whether the data set provided the required assumptions. The data are considered "superb" if the KMO value is 0.90 and above, "great" if between 0.80 and 0.90, "good" if between 0.70 and 0.80, "mediocre" if between 0.50 and 0.70 and "insufficient" if below 0.50. The result of Bartlett's test of sphericity needs to be at a significant level ($p < 0.05$) (Field, 2009). The KMO coefficient was 0.96, and the sampling was sufficient for EFA. To identify the suitability of the sphericity distribution of the data set for EFA, the results of Bartlett's test of sphericity were examined ($x^2(1081) = 18{,}441.8$, $p < 0.001$), and this assumption was also confirmed. To check the normality levels of the items in the data set, the skewness and kurtosis values were examined, and all the items were found to be within the range of normal distribution (-1.96; + 1.96). For the assumption of multivariate normality, the Mahalanobis distance coefficients of the whole data set were reviewed, and no outliers were determined ($p > 0.001$). Finally, the correlation coefficients between the items were lower than 0.90, and no multicollinearity problems were observed. Since all the assumptions were confirmed for EFA, the analysis was continued.

EFA was performed over 67 items in the draft scale. As a result of the Varimax rotation technique analysis, a total of 20 items were excluded from the scale as there were no sufficient items in the factor ($N_{item} < 3$), their factor loading was low (< 0.40), and the difference in the factor loading received by the items in more than one factor was low (< 0.10). For factor formation, the eigenvalues were determined as 1 (Henson & Roberts, 2006). As a result of EFA, a 6-factor structure was formed, as understood from the Scree Plot graphic in Fig. 2.

In light of EFA, the variance of the scale that explains the feature examined is expected to be above 50% (Merenda, 1997). In this study, the variance explained by the scale consisted of six factors and 47 items, after rotation was obtained as 63.45%. These factors were labeled as social, instructional, technological, emotional, behavioral, and withdrawal, respectively. Factor loads ranged between 0.455 and 0.794.

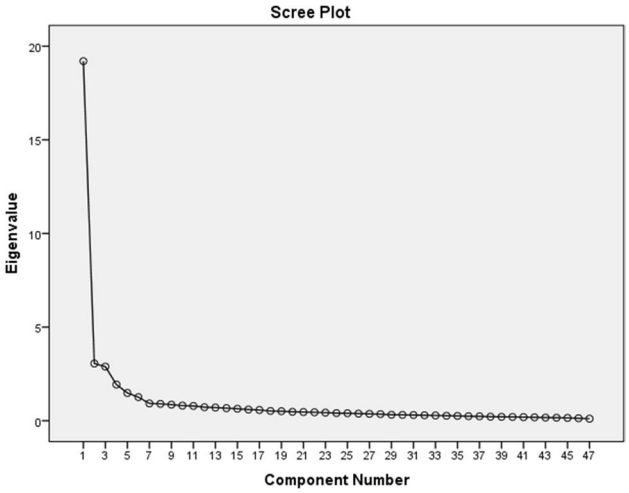

Fig. 2 Scree plot graphic

Items in the factors that emerged after EFA, factor loadings, eigenvalues, and percentages of explained variances are presented in Table 3.

As seen in Table 3, the eigenvalue of the "Social" factor is 8.33, and the amount of contribution to variance is 17.68%. This factor consists of five items, and the factor loads of these items vary between 0.522 and 0.651. The "Instructional" factor consists of 12 items, and factor loads vary between 0.558 and 0.790. The eigenvalue is 6.29, and the contribution to variance is 13.83%. The third factor is "Technological", consisting of five items, and factor loads vary between 0.649 and 0.794. The eigenvalue of this factor is 6.29, and the amount of contribution to variance is 13.38%. The "Emotional" factor includes 11 items, and factor loads are between 0.455 and 0.751. The eigenvalue of this factor is 3.77, and its contribution to variance is 8.03%. The fifth factor is "Behavioral", which includes 11 items. The factor loads of the items vary between 0.574 and 0.741. The eigenvalue of this factor is 2.81, and the amount of contribution to variance is 5.97%. The last factor is "Withdrawal", consisting of three items, and factor loads are between 0.683 and 0.749. The eigenvalue of the "Withdrawal" factor is 2.14, and its contribution to variance is 4.56%. The scale structure obtained as a result of EFA is visualized in Fig. 3.

Confirmatory Factor Analysis (CFA)

The draft scale, which initially consisted of 67 items, turned into a structure including 47 items and six factors after eliminating 20 items following EFA. First-order CFA was performed with the data collected from the new sample to confirm the factor structure and construct validity of the 47-item scale, which appeared after EFA. As a result of first-order CFA, the factor loading of Item 26 was low (< 0.40) and

Table 3 Rotated component matrix

Factor	Items	S	I	T	E	B	W
Social	I1	.631					
	I2	.606					
	I4	.565					
	I5	.651					
	I8	.522					
Instructional	I11		.677				
	I12		.743				
	I15		.694				
	I16		.790				
	I17		.769				
	I18		.767				
	I19		.764				
	I20		.611				
	I24		.558				
	I26		.692				
	I28		.709				
	I35		.615				
Technological	I30			.677			
	I31			.649			
	I32			.794			
	I33			.743			
	I34			.672			
Emotional	I21				.455		
	I40				.561		
	I41				.692		
	I42				.678		
	I44				.610		
	I45				.733		
	I47				.658		
	I48				.561		
	I49				.751		
	I55				.670		
	I58				.553		
Behavioral	I53					.680	
	I57					.646	
	I59					.643	
	I60					.574	
	I61					.624	
	I62					.613	
	I63					.651	
	I64					.741	
	I65					.731	
	I66					.703	
	I67					.702	
Withdrawal	*I43						.749
	*I46						.743
	*I50						.683
Eigenvalues		8.33	6.29	6.29	3.77	2.81	2.14
Explained variance		17.68	13.83	13.38	8.03	5.97	4.56

$N = 536$, *Reverse coded items; *S* Social; *I* Instructional; *T* Technological; *E* Emotional; *B* Behavioral; *W* Withdrawal

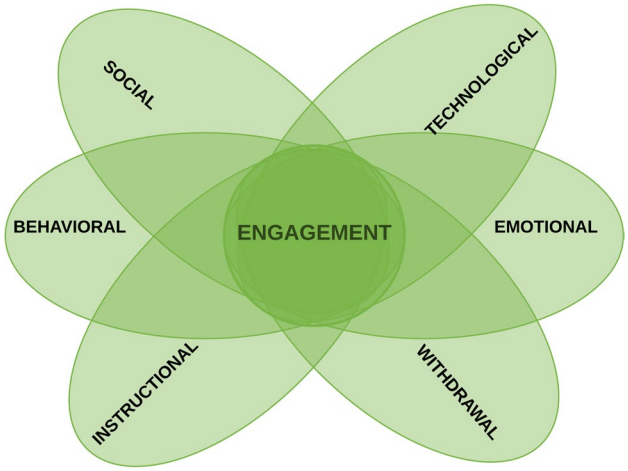

Fig. 3 LOCES structure acquired after EFA

therefore, they were excluded from the scale. The model fit, which was established after examining the model goodness of fit indices obtained through first-order CFA analysis, was assessed. The goodness of fit indices were $x^2(951) = 2649.37$, $p < 0.001$, CMIN/DF = 2.78, RMSEA = 0.06, SRMR = 0.06, CFI = 0.91, IFI = 0.90, GFI = 0.81. CMIN/DF seems perfect, and RMSEA, SRMR, CFI, and IFI values are acceptable (Seçer, 2015). GFI was lower than 0.85. However, this value depends on the size of the sampling. It can be tolerated since the other values are good (Mulaik et al., 1989; Sharma et al., 2005). First-order CFA results are given in Fig. 4.

Convergent and discriminant validity analyses were applied to examine the construct validity of the model obtained as a result of first-order CFA. Composite reliability (CR), average variance extracted (AVE), and square roots of the AVEs were examined to evaluate construct validity. The value of CR above 0.70 is considered acceptable, and the value of AVE above 0.7 is considered very good, whereas the level of 0.5 is deemed acceptable (Hair et al., 2010). In this study, the values of CR were higher than 0.75, and the values of AVE were higher than 0.5 (see Table 4). Therefore, these values indicate the construct validity of LOCES.

Second-order CFA was conducted to determine whether the dimensions obtained as a result of the first-level factor analysis represent the high-level concept of "live online class engagement". As a result of the second-order CFA, the sub-dimensions of the scale which are instructional ($\beta = 0.82$, $p < 0.00$), social ($\beta = 0.79$, $p < 0.00$), behavioral ($\beta = 0.78$, $p < 0.00$), technological ($\beta = 0.84$, $p < 0.00$), emotional ($\beta = 0.84$, $p < 0.00$), and withdrawal ($\beta = 0.49$, $p < 0.00$) were confirmed to represent engagement together. The model fit indices of second-order CFA were obtained as $x^2(960) = 2751.52$, $p < 0.001$, CMIN/DF = 2.86, RMSEA = 0.06, SRMR = 0.07, CFI = 0.90, IFI = 0.90, GFI = 0.80. These values indicate that the model created as a result of the second-order CFA is acceptable/perfectly compatible with the data (see Fig. 5). In other words, all factors confirm student engagement.

As a result, a scale consisting of 46 items and six factors was obtained, and its construct validity was confirmed. Standardized regression weight values of the scale items are presented in Table 5.

Factor-item correlation coefficients are presented in Table 6. The coefficients vary between 0.63 and 0.90. The fact that all coefficients are correlated at a significant and high level ($r > 0.5$) indicates that the items are suitable for the scale's factors and general purpose.

Over the data set subjected to CFA to determine the distinctiveness levels of the items, whether the responses were given by the students with the highest ($f = 136$, 27%) and the lowest ($f = 136$, 27%) averages to the items significantly differed. First, the reverse-coded items were transformed, and all items were averaged and put in descending order. Independent samples t-test was implemented to compare the highest and lowest groups, and the analysis results are presented in Table 7. According to these findings, the discriminating powers of all the items were significant. The significant difference between the two groups shows that the items have discriminatory power. Thus, the scale can be viewed as discriminating.

Reliability Analysis Results

Internal consistency analysis was performed with the data set collected at the second stage of the research to determine the reliability level of the scale. Cronbach's alpha and Guttman split-half reliability analysis results are given in Table 8.

The reliability coefficients of all factors are above 0.70. This reliability level is adequate and acceptable (Bland & Altman, 1997; Taber, 2018). Moreover, the reliability coefficient of the whole scale was 0.97. In line with these findings, the scale can be viewed as highly reliable.

Discussion and Conclusion

Although the literature on student engagement in face-to-face educational environments exists, the information related to engagement in digital learning platforms, especially in LOCs, is limited. In this study, engagement in LOCs was focused on, and the LOCES scale was developed to determine the engagement levels of HE students. For this purpose, a draft scale consisting of 67 items and seven factors was first developed in line with the literature review, distance education, educational psychology, and opinions of assessment experts. Data were collected from 1039 university students, separately for EFA and CFA. As a result

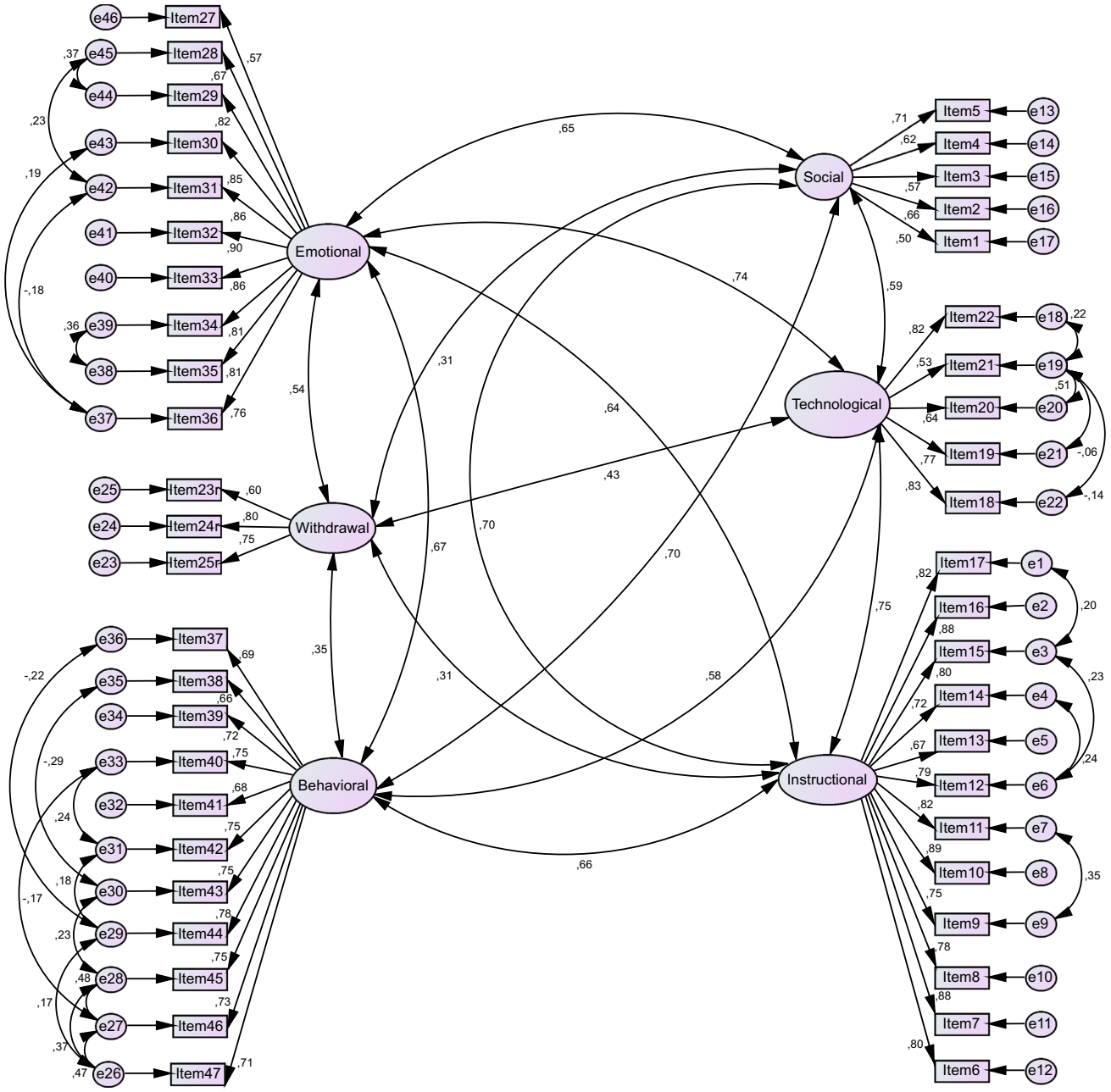

Fig. 4 First-order CFA diagram

Table 4 Convergent and discriminant validity result

	CR	AVE	Instructional	Social	Behavioral	Technological	Emotional	Withdrawal
Instructional	.956	.643	.802					
Social	.750	.495	.699	.703				
Behavioral	.924	.524	.664	.700	.724			
Technological	.845	.547	.748	.592	.579	.739		
Emotional	.945	.637	.636	.646	.671	.736	.798	
Withdrawal	.761	.519	.309	.306	.349	.432	.544	.720

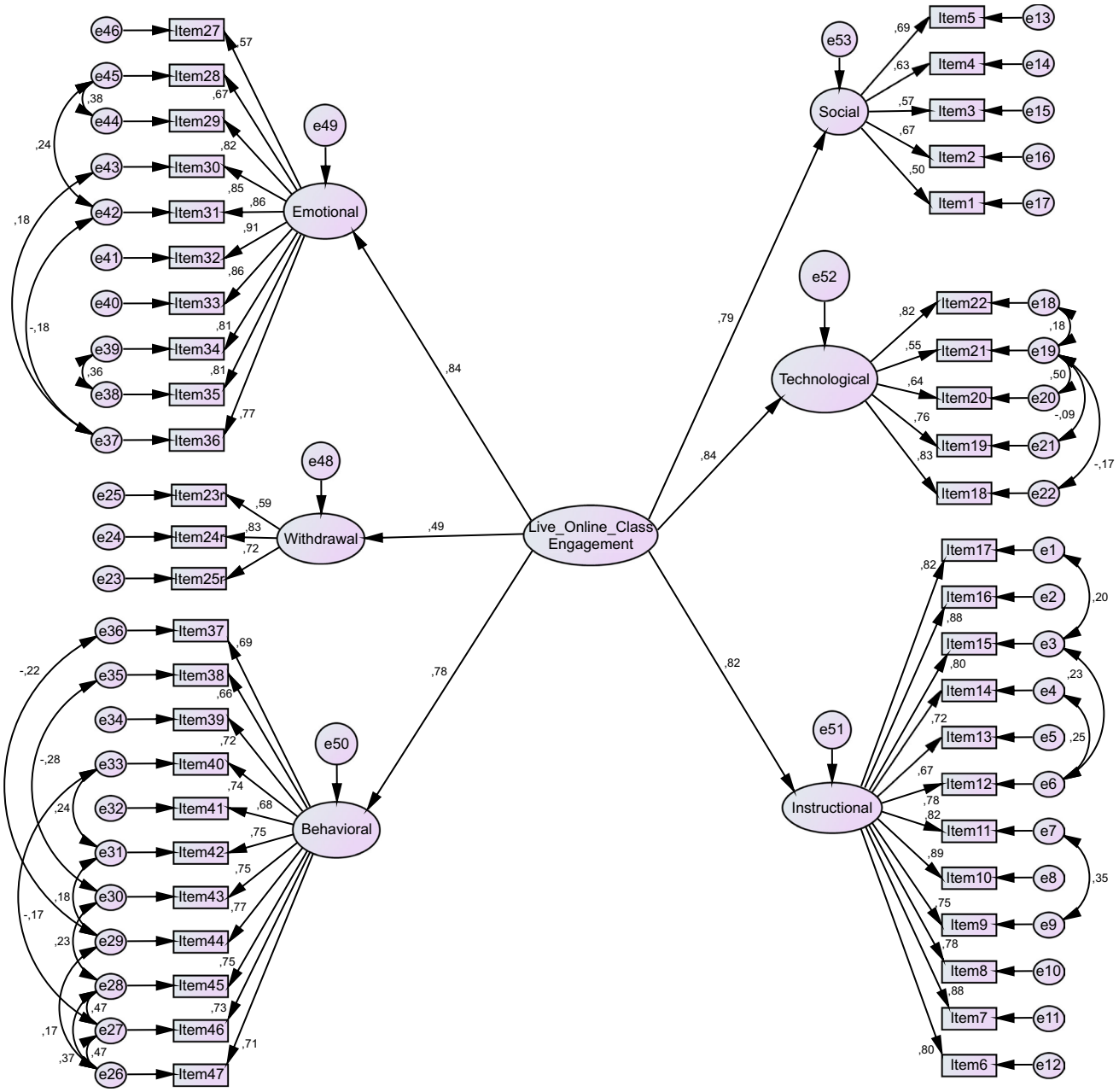

Fig. 5 Second-order CFA diagram

of validity and reliability analyses, a 6-factor and 46-item structure was obtained (See Appendix-A).

The total variance explained was found to be 63.45%. LOCES is a five-point Likert-type scale. The acquired factors were labeled as "social", "instructional", "technological", "withdrawal", "emotional" and "behavioral" based on the literature. In the "Social" factor, five items refer to the levels of communication of students with each other or lecturers in LOCs. In the "Instructional" factor, twelve items measure the lecturer's pedagogical competency, command of the live class platform, and the suitability of the content and material presented by the lecturer. In the "Technological" factor, five items designate the usability and quality of the live class platform and the level of technical opportunities in general. In the "Withdrawal" factor, three negative items determine the distraction, the teacher's monologue state, and the tendency to drop out. The "Emotional" factor consists of 10 items and aims to explore the students' feelings (desire to learn, satisfaction, being considered important, feeling good, etc.) in live classes. Finally, the behavioral factor determines the student's active status and class-related behavioral level in the live class period.

Table 5 Standardized regression weights of items by second-order CFA results

Social		Instructional		Technological		Withdrawal		Emotional		Behavioral	
Item1	.50	Item6	.80	Item18	.83	Item23	.59	Item27	.57	Item37	.69
Item2	.67	Item7	.88	Item19	.76	Item24	.83	Item28	.67	Item38	.66
Item3	.57	Item8	.78	Item20	.64	Item25	72	Item29	.82	Item39	.72
Item4	.63	Item9	.75	Item21	.55			Item30	.85	Item40	.74
Item5	.69	Item10	.89	Item22	.82			Item31	.86	Item41	.68
		Item11	.82					Item32	.91	Item42	.75
		Item12	.78					Item33	.86	Item43	.75
		Item13	.67					Item34	.81	Item44	.77
		Item14	.72					Item35	.81	Item45	.75
		Item15	.80					Item36	.77	Item46	.73
		Item16	.88							Item47	.71
		Item17	.82								

$N = 503$

Table 6 Item-factor correlation analysis

Social		Instructional		Technological		Withdrawal		Emotional		Behavioral	
Item	*r*	Item	*r*	Item	*r*	Item	*r*	Item	*r*	Item	*r*
Item1	.63	Item6	.81	Item18	.79	*Item23	.75	Item27	.63	Item37	.67
Item2	.76	Item7	.88	Item19	.78	*Item24	.82	Item28	.76	Item38	.70
Item3	.67	Item8	.79	Item20	.83	*Item25	.80	Item29	.87	Item39	.75
Item4	.75	Item9	.79	Item21	.76			Item30	.86	Item40	.77
Item5	.72	Item10	.89	Item22	.83			Item31	.87	Item41	.74
		Item11	.84					Item32	.90	Item42	.79
		Item12	.83					Item33	.86	Item43	.77
		Item13	.71					Item34	.85	Item44	.80
		Item14	.75					Item35	.85	Item45	.80
		Item15	.83					Item36	.77	Item46	.76
		Item16	.88							Item47	.78
		Item17	.84								

Correlation coefficients of all items are significant at the .01 level, * Reverse coded items

Table 7 The discriminating power of items

Social		Instructional		Technological		Withdrawal		Emotional		Behavioral	
Item	*t*	Item	*t*	Item	*t*	Item	*t*	Item	*t*	Item	*t*
Item1	9.28	Item6	12.05	Item18	19.40	*Item23	8.42	Item27	18.64	Item37	20.72
Item2	13.42	Item7	16.74	Item19	15.76	*Item24	12.49	Item28	17.36	Item38	14.32
Item3	10.99	Item8	14.39	Item20	14.49	*Item25	9.55	Item29	25.45	Item39	14.66
Item4	10.65	Item9	15.42	Item21	12.10			Item30	26.12	Item40	16.62
Item5	13.89	Item10	14.51	Item22	22.65			Item31	23.47	Item41	10.83
		Item11	16.39					Item32	29.39	Item42	16.13
		Item12	9.83					Item33	25.18	Item43	10.03
		Item13	10.97					Item34	24.70	Item44	13.90
		Item14	11.67					Item35	26.43	Item45	10.46
		Item15	12.18					Item36	23.45	Item46	12.13
		Item16	16.05							Item47	10.15
		Item17	13.95								

All items are significant at the .01 level, * Items reverse coded

Table 8 Reliability coefficients of LOCES and factors

Factor	Number of items	Cronbach's alpha	Guttman split-half
Social	5	.75	.71
Instructional	12	.96	.93
Technological	5	.86	.81
Withdrawal	3	.79	.72
Emotional	10	.94	.93
Behavioral	11	.92	.83
Total	46	.97	.87

In the draft scale, there are "peer", "content", "teacher", "technological", "emotional", "cognitive" and "behavioral" dimensions, but this structure partially changed after EFA. In the initial draft, the cognitive, content, peer, and teacher factors, the items were distributed to other factors. The "instructional" dimension appeared after some items in the content and teacher factors came together. Scale studies on the engagement of HE students in the literature are seen to include teacher (Gunuc & Kuzu, 2015; Matthews et al., 2017) and content (Matthews et al., 2017) factors. However, the instructional factor emerged to replace these two factors in this study. Accordingly, the instructional factor can cover the dimensions related to "teacher" and "content".

Another new factor that appeared after EFA is the social factor. This factor was formed when some items in the peer and teacher factors before EFA came together. Some items expressing teacher-student communication in the teacher factor and some items in the peer factor were gathered in the same category and labeled "social". In some scales in the literature (Appleton et al., 2006; Gunuc & Kuzu, 2015; Zhoc et al., 2019), the teacher, teacher-student relationship or peer factors are available. The items in these factors are related to the social relationship of the students with their peers and the teacher. Thus, it is seen that the social factor in LOCES reflects the teacher-student and student–student interaction (Gašpar & Mabić, 2015) and can determine the social engagement level (Chakraborty & Muyia Nafukho, 2014), which is a significant element in increasing student engagement.

Unlike the engagement scales in the literature (Zhoc et al., 2019; Gunuc & Kuzu, 2015), the inclusion of withdrawal and technological factors in this scale is considered important. "Withdrawal" was created when two items from the emotional factor and one item from the cognitive factor came together. In the behavioral engagement scale that Hospel et al. (2016) developed, withdrawal is a subfactor. Withdrawal, non-completion and unsatisfactory learning processes are significant indicators of disengagement (Appleton et al., 2006; Farrell & Brunton, 2020; Kahu et al., 2020). The emergence of the technological factor, unlike other scales, is one of the significant outputs of this study. In LOCs, both the platforms' features and technological opportunities (phone, computer, internet speed, etc.) can affect engagement (Chakraborty & Muyia Nafukho, 2014; Chen et al., 2010; Chen, 2020). The emergence of the technological factor points to the importance of technological competency in LOCs. Therefore, this factor is assumed to carry the potential of contributing to HE in terms of the revision, consolidation, or renewal of the live class platforms. The emotional and behavioral factors, which exist in most studies on HE students' engagement, also appeared in LOCES, which we developed in this study. Emotional engagement is defined as enjoying the lessons more and as motivation and determination, and behavioral engagement as the task-related behaviors of the students (Chiu, 2022; Fatawi et al., 2020; Liu et al., 2019; Northey et al., 2015; Skinner et al., 2008). To sum up, LOCES can be said to comply with the literature and represent the structure of the engagement variable.

Limitations and Areas of Future Research

It is assumed that the LOCES will make significant contributions to the literature regarding measuring the engagement levels of the students in LOCs within HE. Its methodology is strong because data were collected from separate sampling groups for both EFA and CFA during the development process of this scale, while diversity was ensured by collecting data from various universities, departments, and education levels. However, this scale was developed in Turkish and for the sampling of HE. Hence, adaptation, reliability, and validity studies need to be conducted in K-12 or different languages/cultures. LOC engagement of HE can be interpreted over the scale's total score (see Fig. 5), or subfactors can also be used as an independent scale (see Fig. 4). Finally, data collection at a time when universities switched to distance education due to the pandemic can be evaluated as a limitation. Infrastructure problems in practice, inequality of opportunity, sustainability, or problems related to university policies (Yang, 2020) may have been reflected in the scale structure. Future research may consider this limitation and further the relevant research attempts during ordinary conditions.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11528-023-00849-7.

Authors' Contributions Ömer Koçak conceived and designed the study, collected the data, performed the data analysis and drafted the manuscript. İdris Göksu conceived and designed the study, collected the data, and critically revised the manuscript. All authors read and approved the final manuscript.

Data Availability The research data (phase 1, phase 2) that support the findings of this study are available at https://figshare.com/s/4a16ca756ff4a65087c7.

Declarations

Ethics Approval Ethical approval has been received from the Social and Human Sciences Ethics Committee in Ataturk University (Approval ID: 88656144–000-E.2000326592).

Informed Consent We provided informed consent to the participants and they voluntarily participated in the research via Google Form.

Conflict of Interest The authors declare that they have no conflict of interest.

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