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Research Article

VALIDITY OF ENGAGEMENT INSTRUMENT DURING ONLINE LEARNING IN MATHEMATICS EDUCATION

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Abstract
The purpose of the current study was to assess the validity of the engagement instrument during online learning in mathematics education. This study used a survey research design as its approach. The participants of the current research were 203 Generation Z students in West Nusa Tenggara Barat, Indonesia. Convenience sampling techniques were used to assess who had completed the online survey. Three procedures were used to analyse the data in this research: exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and Rasch analysis. EFA revealed that online engagement instrument had two sub-components; behavioural engagement and emotional engagement. At the same time, the CFA results showed that the model fit indices established the first- and second-order model's two-factor structure. Finally, the results of the showed that the online engagement instrument's item and person reliability were good. The findings indicate that there is a potential for enhancement even though the Rasch analysis largely supported the results of EFA and CFA. The current research's novelty is that it provides a valid and reliable instrument to assess student`s engagement during online learning in a mathematical education context. The use of the current instrument can ensure the accuracy, reliability, and credibility of research related to student engagement during online learning in mathematics education.

Keywords: Confirmatory Factor Analysis, Engagement, Exploratory Factor Analysis, Rasch Analysis, Z Generation

INTRODUCTION

The construction industry serves as a cornerstone for economic development and public welfare in modern societies, with Myanmar being no exception. Since the liberalization of its economy and the influx of foreign investment in the early 2010s, Myanmar has seen a surge in construction activities,

especially in major urban centers like Yangon and Mandalay (Soe et al., 2022). These cities are burgeoning with infrastructure projects, residential constructions, and commercial developments, signaling the industry's crucial role in the nation's progress.

The integration of technology in 20th century increases the number of students' participation in online learning (Kannadass et al., 2023; Peng, 2017). Students are eager to go for online learning due to its flexibility, mobility, equal opportunity and convenience (Hu & Li, 2017). Research has revealed that educational technology assists the engagement of online learner (Kahn et al., 2016), meanwhile online learning implementation enables social interaction as in face to face class using the synchronous conferencing technique (McBrien et al., 2009). The huge interest in online learning has created researcher awareness in student online learning engagement as many have started to focus on how students learn in an online learning setting as to uncover student unique needed in online learning implementation (Richardson & Newby, 2006).

There is a need to identify the student online learning engagement because online learning has been identified as a new phenomenon in education where students have less opportunity to directly interact with institution member (Martin & Bolliger, 2018). Therefore, this approach was adopted as the barometer of classroom achievement and rated as one of school improvement activity outcomes. Students with high engagement relate to high quality learning result. Identifying student online learning engagement also assists the teacher to regulate timely stimulation for student in reflecting and promoting their engagement during the learning process (Peng, 2017). However, there was a challenge in identifying student engagement in online learning which is the teacher's inability to detect student engagement directly where students with less skills in technological sector seem to have less engagement in the classroom activity.

Engagement in mathematics education is a significant challenge globally, particularly in online learning environments (Hidayat et al., 2024; Joshi et al., 2022). The subject's abstract nature and the high cognitive load it imposes on students contribute to its reputation as difficult. This issue is intensified in virtual classrooms, where sustaining student interest and motivation becomes more problematic. The absence of direct, face-to-face interaction often leads to feelings of isolation, decreasing student participation and making it difficult for educators to assess comprehension and offer immediate feedback. Moreover, the intricate nature of mathematics necessitates well-planned instructional approaches to keep students engaged and help them effectively understand the material in an online setting (Stein et al., 2020).

Concerning validity and reliability, prior research on student engagement has been mainly assessed by one or both of factorial analysis namely exploratory factor analysis and confirmatory factor analysis, Doğan (2014) used exploratory factor analysis to develop a scale for student engagement which consists of three dimensions. However, since the scales are not tested with confirmatory factor analysis, there is no discussion about the factor discrepancy between the scale with the observed data. This has resulted in the issue of whether the items of every factor really delineate the factor or not use EFA and CFA at once (Lee et al., 2019; Mindrila et al., 2017); the researchers used EFA to examine the factor structure and CFA to verify the suitability of the factor structure. However, the use of EFA and CFA accordingly did not account for the nonlinearity of rating scale steps. As such, the Rasch measurement model needs to be implemented to perform a rigid construct validation method. This research will use the combination of the three model. It will be the perfect combination where exploratory factor analysis will frame the structure of the model, confirmatory factor analysis will test the model with strong empirical basis and Rasch evaluation model will be the construction of statistical approach which separates the person and the item estimated (Rahayu et al., 2020).

Based on the above explanation, it can be concluded that no prior research has applied rigorous validation techniques to validate online learning engagement instruments. As such, the goal of the current research is to validate a student engagement instrument for online learning using a combination of three analytical techniques: exploratory factor analysis (EFA), confirmatory factor analysis (CFA), and Rasch analysis. This approach provides an ideal framework: EFA will establish the model's structure, CFA will test the model with robust empirical support, and Rasch analysis will offer a statistical method to differentiate between person and item estimates (Rahayu et al., 2020). This combination aims to yield significant insights into student engagement in online learning. This study contributes to the existing knowledge by applying EFA, CFA, and Rasch analysis to test the instrument specifically for Generation Z in the Indonesian context. The primary objective of this study is to evaluate the validity of the engagement instrument for online learning among Gen-Z students.

Validating this scale is essential to confirm that it functions as a valid and reliable tool for Generation Z in Indonesia. With the ongoing evolution of online learning in Indonesia, especially in mathematics education, the availability of courses at *Universitas Terbuka* (Open University) and the use of Zoom meetings for supplementary classes across many universities underscore the need for strong assessment instruments. These tools must be tailored to the specific characteristics and learning environments of this digital-native generation. The combination then will provide considerable information regarding student online learning engagement. The present work contributes to the body of knowledge by applying EFA, CFA and Rasch analysis modelling to test the instrument for the Indonesian context, in particular the Gen-Z students.. The purpose of the current study, which involved students of the Generation Z, was to assess the validity of the Engagement Instrument during online learning.

LITERATURE REVIEW

Engagement

Student engagement is defined as the interaction between resources, energy and effort (Martin & Bolliger, 2018) that are produced by student and institution in order to enhance the learning result, develop student development and institution prestige (Watkins, 2021). Student engagement refers to the interest, curiosity and passion expressed by student during the learning process or within course contents. The terms have been widely recognized in education which are introduced as how students get involved or interested within the learning process and how they connect with the class member and institution. Student engagement is a multi-dimensional process which concerns three scopes namely behaviour engagement, emotion engagement and cognitive engagement. Behaviour engagement refers to student involvement in class activity, emotional engagement indicates the students' affective behaviour with other classroom members and cognitive engagement refers to student evaluation classroom materials which concern the relevancy and principle (Buelow et al., 2018). The emphasis of online learning is not limited to extend information. It also includes the participation of student in interacting with peers, instructor and materials, the learning outcome might be in collaborative form where a group of student cooperatively solve problems, practise new skills or create a product. Therefore the aim is to provide student with positive experiences as well as giving the student a chance to be active learner (Marshall & Wolanskyj-Spinner, 2020) the inability to give that chances in online learning is the reason for student isolation, dropout, retention and graduation rating in online learning activity.

Student engagement is related with personal development because the student will stay engaged if they still have self-belief which reveals their own abilities in accomplishing the goals learning (Zepke & Leach, 2010). It can be a predictor to measure their learning interest and self-development which means that their tendency to learn the subject is the indication they learn more about it. The engagement theory reveals that it is essential to provide student meaningful interaction and a worthwhile task to enhance learning engagement. Peers and instructors have raised the need to create a planning and supporting engagement in order to make the students feel secure in the class during the learning process (Bagriacik Yilmaz & Banyard, 2020). This is because the environment circumstances created by class members is significantly essential to create meaningful learning experiences. The roles of peers and instructor is not limited in the classroom but it also occurs outside the classroom where they can discern experiences such as curricular development activities, tutorials, conference or meeting and also engage in societies and social clubs (Harrington, 2009). Besides the environment support, motivation and self-efficacy also influence the student learning engagement (Farrell & Brunton, 2020) where the two elements are able to produce encouragement to accomplish the learning objective. By being actively involved in classroom activity, this will encourage the feeling of connectedness which improve the students' willingness to become active in class, encourage successful persistency and the students can also experience real world success. These interactivity and community awareness result in high-quality guidance and better learning outcomes (Martin & Bolliger, 2018).

Learning outcome is significantly influenced by student engagement. Redmond et al. (2018) state that the learning outcome can be accomplished by the students if they engage in behaviour, affective and cognitive levels during the learning process. Being engaged in the behaviour level can be defined as participation, effort and persistency, while being engaged in the affective level means having interest which later increases the motivation, enjoyment and result to the level of commitment. Finally,

the cognitive level can be perceived by presenting a mental activity which results in the competency in cognitively processing and establishing present and previous experiences.

There is a strong relationship between instrument measurement with student engagement research. Student engagement instrument measurement analysis is needed where it might significantly contribute to instrument engagement research base (Li, 2022). The instrument measurement produces validity for the teacher instructional strategies (Callahan et al., 2020) which involves the student in the learning process. Furthermore, if the instrument is yet to be validated within the population, the researcher cannot assume the validity and reliability of the results' interpretation. The formulation of instrument in student engagement research not only provides insight into the student engagement itself but also to how students perceive their experience in study location, which are both the major conceptual models in the instrument formulation. Therefore, it is important to evaluate carefully the psychometric characteristics of any engagement instrument because one of the challenges of student engagement research is the lack of measurement instrument possessing good psychometric premises. Specifically, the instrument measurement in cognitive engagement aspect is beneficial. It will assist the researcher to better comprehend this varying research base, provide more information of the essence of this construct and illustrate worthy resources for practitioners and researchers regarding the traditional and cutting-edge method in apprehending cognitive engagement (Li, 2022).

Online Learning Engagement

Student engagement with materials, instructors and peers is not determined by lack of contact as in traditional learning spaces. The presence in online learning concerns the participation and interaction which is defined as the dynamic interplay of thought, emotion and behaviours. Redmond, et al. (2018) propose a framework for online learning engagement. Social engagement and the social interaction grasp in the form of student talking about themselves and their condition which are integrated with the social media platform, and in a practical way the students can build a social community forum. Cognitive engagement is defined as the active process of learning. Redmond et al. (2018) differentiated the level of cognitive engagement in online learning as surface cognitive engagement which is indicated by student judgement and justification but without any further clarification or contribution. On the other hand, the deep cognitive engagement is identified as the ability to integrate multiple concepts, integration of justification and ability to support their ideas which is showed by their online posts containing justification, comparation and solution. Behaviour engagement is specified as students' communication interest during the online learning process and their effort to find their personal relevancy which is performed by the intention to seek for help or provide help to other peers. Collaborative engagement is established in the form of discussion, tutoring and group discussion which is conducted online because of geographical case. The emotional engagement can be identified within the student attitude, enthusiasm, interest, anxiety or enjoyment during online learning process.

Validity and Reliability of Engagement Instrument

Ensuring the validity and reliability of an engagement instrument in mathematics learning is essential for accurately measuring students' involvement and participation. Engagement studies can be conducted using qualitative methods (e.g., Moon, & Ke, 2020; Roche et al., 2023) or quantitative methods (e.g., Irvine, 2020; Joshi et al., 2022). The study by Joshi et al. (2022) focused on assessing engagement in the context of COVID-19 in Nepal, utilizing four factors: behavioral, cognitive, social, and emotional engagement. The standardized factor loadings ranged from 0.65 to 0.98, and item reliabilities were between 0.85 and 0.99, indicating that the items were strong indicators of the latent factors. Reliability was measured using Cronbach's alpha, with an overall reliability of 0.94. The reliabilities for each dimension were 0.87 for behavioral engagement, 0.85 for social engagement, 0.88 for cognitive engagement, and 0.87 for emotional engagement, demonstrating strong internal consistency across all factors. Irvine (2020) conducted a study in Canada to measure secondary students' engagement in mathematics learning, focusing on four constructs: cognitive, behavioral, emotional, and agentic engagement. The reliability of these constructs, assessed using Cronbach's alpha, showed values of 0.86, 0.85, 0.90, and 0.87, respectively, indicating a high level of internal consistency. On the other hand, Xu (2024) examined undergraduate students' engagement with calculus in China, but the study did not provide any information on the validation of the instrument used.

Z-Generation

The Z generation was the first generation born into a globally (internet) connected world and therefore they live and breathe technology as they tend to be digital natives, fast decision makers and highly connected (Asrial et al., 2024; Csobanka, 2016). What differentiates the Z generation with other generations is that they manage to be more connected to digital and electronics world and they identify themselves as digital and technology centric. Technology has been integrated into their daily lives which tend to influence their thinking pattern (Cadiz et al., 2024; Ferri et al., 2020). Due to their intense interaction with technology, there are many designations which refer to Z generation such as the post millenars, the Facebook generation, digital natives, switcher, dotcom children, net-generation, connection-generation, digital-generation and responsibility-generation (Csobanka, 2016). The Z generation refers to those who were born from 1995 which is coincidentally aligned with the beginning of the World Wide Web which marks the beginning of digital and internet era.

There is demand from the Z generation to integrate technology into their learning environment as they are more sophisticated into technology and self-directed compared to the previous generation (Marshall et al., 2020; Mosca & Curtis, 2019). It is because of their characteristics of mobile technology intelligence, unlimited wide range of information and their tendency to create and distribute message digitally. All these make them have their own way of learning. Besides that, there is fast growth of technology which has caused social change that can be seen from the phenomena of full-automation, artificial intelligence and digitalization, which have affected the quality of human life and strategic intelligence which form part of the economy and the development of human itself (Roblek et al., 2019). Therefore in the part of human development, educators should strengthen critical thinking and adjust the instructional approach to maintain student engagement in the educational process (Mosca & Curtis, 2019). A specific strategy and a sharp method need to be set up for the learning process for the Z generation. For example, distance learning and collaborative online learning can possibly improve student engagement and student understanding during the learning activity (Khalid, 2019).

Online Learning

Most researchers accept that technology is the salient part of the definition of online learning which is indicated as the functional medium to make over education and magnify interaction (Mohd Saad et al., 2023; Singh & Thurman, 2019). Online learning utilises technology or media to supply, assist and enhance learning and teaching and entails communication between student and teacher by utilizing online contents (Jabar et al., 2022). Simply, online learning is defined as the instructional approach that is delivered using digital devices to support online learning (Ferri et al., 2020). Some features provided in online learning are whiteboards, chat room, pools, quizzes, forum discussion and survey that are used as the communication tools between the teacher and student or a way to transmit the material content (Mukhtar et al., 2020). A more explicit explanation is given by Mayer (2018) in which he is concerned about the part of what, why and how of online learning. The first categorisation of ‘what’ concerns the material comprising words in spoken or printed form or graphics such as photos, diagrams, illustration, animation or video. The second categorisation of ‘why’ concerns the instructional intention which causes the particular change in the student knowledge. The third categorisation of ‘how’ concerns the medium such as the computer-based devices which include computer, laptop, tablet, smartphone, or virtual reality. Online learning includes some learning activity such as commencing an online discussion forum, managing personal or group project assessment and conducting physical or online assessment (Wei & Chou, 2020).

The integration of online learning is concentrated in the migration of conventional media such as book and paper to the computer-based media as the venues that support the innovative learning approach (Mayer, 2018) which provides accessibility, convenience and flexibility (Wu et al., 2018). However, in terms of research, this is not about the technology that is provided but it is about the best way to take advantage in that kind of possibility. Some facets that can be considered in evaluating online learning are 1). Devices to access internet, 2) The content knowledge in the interaction between students with peer or instructor, 3) The rapid change in technology and 4) The characteristics of student which are the gender, race, self-discipline and prior education (Dumford & Miller, 2018). Furthermore, the method to guide student with different perception and student readiness are also important to be concerned and known by educational researchers and practitioners (Mayer, 2018) as all the aspects can configurate the learning experiences and impact the overall student engagement.

Online learning has own challenge and constraints, Harrington (2009) divide challenges in online learning to (1) technological challenge such as access to infrastructure like devices, internet connection, and teacher lack of knowledge in using technology (2) pedagogical challenge, which refers to the need to set up teaching material such as images, animation and games to engage and maintain student motivation, and lack of feedback and evaluation system, (3) social challenge, lack of home environment learning convenience and parent support. It presents challenges for students who come from poor families, for example, as they are only able to access the online learning material by phone. This limits them to access the massive content in online learning because some learning content are not available to reach using phone (Adnan & Anwar, 2020). The current development of technology helps to minimize the challenges and constraints of online learning through the development of online learning platforms. According to Singh and Thurman (2019), technology through online learning platform has several roles in online learning such as (1) providing tools that can be utilized by teachers to enhance student learning success, (2) assisting the improvement of productivity, (3) supporting teaching and learning activities through devices such as computer and hand-held devices, (4) offering materials for teaching and learning activities, (5) facilitating 24/7 learning activities, (6) build 21st century skill.

According to Li (2022), the ideal role of online learning platform is the ability to rejuvenate student interest to learn, provide information about student activity through history using the platform, provide tools that teachers can utilize to evaluate student engagement, and provide a place for discussion. Furthermore, Ouadoud et al. (2021) mention several characteristics of online learning platform namely (1) creating course and test, (2) managing teaching and learning documents, (3) managing cooperative documents between teacher and students, (4) observing or checking students learning and evaluation, (5) facilitating work tools, (6) making communication tools available. Cacheiro-Gonzalez et al. (2021) added that several aspects need to be considered in using online learning platform which are pedagogical functionalities, instructional design and didactic interaction.

RESEARCH METHOD

This study used a survey research design as its approach. This design not only aligns with the study's primary objectives but also provides significant benefits, such as reducing completion time and enhancing response rates, especially when engaging with a larger target population (Story & Tait, 2019). In order to examine the validity and reliability of the engagement instrument for the Z generation in West Nusa Tenggara Barat, Indonesia, we used a cross-sectional survey study method. A cross-sectional study is one that examines a group of people at one particular point in time to reveal the attitudes, perspectives, behaviours, or attributes of the population (Hidayat et al., 2023). The population for this research consists of Generation Z individuals, born between 1995 and 2012, residing in West Nusa Tenggara Barat, Indonesia. This generation was chosen due to their strong suitability for online learning, as they are the first cohort to grow up in a globally connected, internet-driven world. As digital natives, they demonstrate a higher level of technological proficiency and self-directed learning abilities compared to previous generations (Bagdi et al., 2023). The population of the current research is Z generation in West Nusa Tenggara Barat, Indonesia. The participants were limited to Z generation who were born between 1995 to 2012. The sample comprised junior high school students, senior high school students and university students. Due to the nature of the research, convenience sampling techniques were used to assess who had completed the online survey. The participants of this study were 203 students in Nusa Tenggara Barat, Indonesia. The ratio of participants with the variables was 20:1 which exceeds the acceptable ratio for factorial analysis (Watkins, 2018). The sample size and its ratio to the number of instrument items are crucial as they ensure that the dataset is suitable for factor analysis (Shrestha, 2021) and contribute to the stability of the factor scores (Schreiber, 2021). 5% of the participants were university students, 20.4% were junior high school students and 7.1% were senior high school student. The characteristics of the sample can be seen in the table below. Table 1 shows the internal consistency reliability of the biology test.

Table 1. Descriptive statistics of sample

Sample	N	Percentages
Level of education	203	100%
Junior high School	43	21.2%
Senior High school	15	7.4%
University	145	71.4%
School location	203	100%
In the city	97	47.8%
In the village	106	52.2 %
Gender	203	100%
Male	73	36%
Female	130	64%
Type of School	203	100%
Public School	109	53.7%
Private School	94	46.3%

The data were collected using an online survey. The survey was disseminated using the Google form which was sent via the WhatsApp group application. The survey included demographic information from participants and featured 10 Likert scale items to assess student engagement in online learning, adapted from the work of Skinner et al., (2009) and Inda-Caro et al. (2018). Previous research has demonstrated exceptional validity and reliability for this instrument. The survey included school demographics and 10 Likert scale items of student online learning engagement adopted from (Inda-Caro et al., 2018) with a 5-point scale (1= strongly disagree, 5= strongly agree). There were two constructs in this instrument, namely emotional engagement and behavioral engagement. The current research focused on emotional engagement and behavioural engagement. This was because both were categorized as the central engagement indicator. Other than that, emotional engagement proved as one of the stronger factors of student achievement but the least studied (Wara et al., 2018). Other factors were behavioural engagement related to student participation in classroom, student motivation in academic task and student participation in school activity (Nguyen et al., 2016). The ten items were classified into five items of behavioural engagement and five items of emotional engagements. A researcher had translated the questionnaires from English before the items were used in pilot study. Then, the items were translated back to Indonesian by three experts.

The data was identified and analysed using the Statistical Package for the Social Science (SPSS) version 26.0. Three procedures were used to analyse the data in this research namely the exploratory factor analysis (EFA), confirmatory factor analysis (CFA) and Rasch analysis. Since the researcher had no prior knowledge of the factor that underlie the data, EFA was used to frame the structure of the student online learning engagement during the Covid 19 pandemic (Mindrila et al., 2017). These models of testing can be used together where firstly factor analysis was applied to identify the factor structure. Then the confirmatory factor analysis was used to test the factor of the model. EFA was performed to identify the internal attribute or known as the hypothetical construct that underlie the data. EFA was used to investigate the correlation among the measured variables and to model these relationships with one or more unobserved variables (Goretzko et al., 2019; Hidayat et al., 2021; Qudratuddarsi et al., 2022). EFA assisted in inspecting the data whether the data measured reflected a single construct or the distinct subset of measured data represented a few different constructs (Watkins, 2018).

The researcher tested the appropriateness of using EFA for this research by making the assumption test using Barletts test of sphericity and Kaiser- Meyer –Olkin test. Both were utilized to investigate the adequately large relationship within the data to perform EFA. Barletts test of sphericity was used to see if the data was suitable for factor analysis and Kaiser- Meyer -Olkin test was used to determine the sampling adequacy. If the value of Barletts test of sphericity was significant ($p < .0001$), this indicated that the data set was not an identity matrix (Watkins, 2018). The value of Kaiser-Meyer-Olkin test ranged from 0 to 1 with the value of .60 and above as accepted (Watson, 2017).

EFA was performed with the factor analysis method of the principal axis factorial as this method helped to determine the number of common factors that reflected a common variance within a correlation matrix (Howard, 2015). The researcher used the method to construct the model of the data

and determine which factor should be retained in the analysis by considering eigenvalue and Screeplot. The eigenvalue was used to determine which factor should be retained. If the factor has eigenvalue 1 or above, it is retained in the analysis (Larsen & Warne, 2010), and the assumption then will be supported by the Screeplot. The researcher rotated the factor to achieve the closest estimation to the simple structure using the varimax rotation. This was used because it optimized the variance beyond all the factors (Watson, 2017). The interpretation of the factor sees the communalities and factor loading of each variable. The acceptable items should have communalities in between .40 to 1.0. and the intercorrelation item or factor loading is above .50 (Watkins, 2018). If the items gain these standard values, the items remained in the structure. If not, then the items would be deleted from the structure model.

The main use of CFA is to construct validity evaluation such as validate the structure of a model. CFA helps to identify clearly the model framed (Jackson et al., 2009). CFA identifies whether the latent variable really determines the observed variable as previously framed or not (Shek & Yu, 2014). In the current research, the researcher used CFA to examine if the structure of online learning engagement was able to fit with an observed data set utilizing IBM SPSS Amos version 24. Two models of CFA were employed. The first order model was modelled from the literature review and EFA analysis (Harrington, 2009). This model had two dimensions. Next, the researcher developed the second-order model where the two dimension of student online learning engagement worked on the higher order model variable. In order to validate the model, the researcher checked the goodness of fit. The evaluation of goodness of fit was done using a range of model of fit indices such Root Means Square Error of Approximation (RMSEA) (<.06 to .08), the comparative fit index (CFI) (≥.90) and Tucker Lewis Index (TLI) (≥.90), chi square test (p), x2/degrees of freedom (<.50). Finally, using WINSTEPS version 3.73 and the Rasch analysis, the research questions were also computed. We presented unidimensionality, separation, item bias, rating scale, reliability in Rasch analysis and fit statistics.

For the purpose of Rasch analysis, once the data was collected, it was organized using Microsoft Excel in preparation for the analysis with Winsteps version 3.7.3. The analysis aimed to evaluate reliability, separation, item fit statistics, and conduct a unidimensionality test. A reliability coefficient greater than 0.65 is expected, while a separation index above 1.5 is considered acceptable (Qudratuddarsi et al., 2019). According to Boone et al. (2014), several fit statistics are crucial for assessing construct validity. These include: (a) the acceptable range for Correlation Points (Pt Mean Corr), which should be between 0.4 and 0.85; (b) the acceptable range for infit and outfit mean square (MNSQ) values, which should be between 0.5 and 1.5. Items were considered unsuitable if their Z score (ZSTD) was below -2.0 or above 2.0. Finally, Rasch-based Principal Component Analysis of Model Residuals (PCA-R) was used to assess unidimensionality. The measure was deemed unidimensional if the Rasch factor accounted for more than half of the total variance in the engagement instrument, and the eigenvalue of the first contrast or secondary factor was below 2.0 (Bravini et al., 2016).

RESULTS AND DISCUSSION

Exploratory Factor Analysis

The researcher started the EFA by considering 10 items of student online learning engagement, 5 items represented behavioural engagement and 5 items represented emotional engagement. The acceptability to use EFA for this research was displayed within the result of KMO and Barletts test of sphericity. The result found that the acceptable KMO value was .918 which indicated the adequate number of items for this factorial analysis. This was strengthened with significant (<.001) value of Barletts test of sphericity which rejected the null hypothesis and thus indicated that the correlation matrix was not the identity matrix. Table 2 shows the exploratory factor analysis result.

Table 2. Exploratory factor analysis result

Factor	Dimension	Items	Communalities	Eigenvalue	% of variance	components	
						1	2
Student engagement	Behavioural engagement	X1	.610	5.609	52.011	.695	
		X2	.361			.551	
		X3	.531			.681	
		X4	.603			.674	
		X5	.643			.754	
	Emotional engagement	X6	.577	1.016	5.966		.607
		X7	.713				.779
		X8	.539				.704
		X9	.591				.637
		X10	.630				.520

As delineated in Table 2 and Figure 3, the male respondents notably outnumbered the female counterparts, indicating a gender-skewed industry landscape in Myanmar.

Firstly, we will look at the communalities which represent the amount of the observed variance shown by the common factor. In the current research, the value of communalities ranged from .361 to .713 with one item eliminated from further analysis because the value of communalities was below .40 (X2=.361). Next, two factors in this research had eigenvalues exceeding 1 which indicated both factors were retained in the analysis. The first factor had an eigenvalue of 5.609 (explaining 52.011% of the variance) correlating to behavioural engagement, and the second factor had an eigenvalue of 1.016 (explaining 5.966% of the variance) correlating to emotional engagement. The screeplot (Figure 1) backed up the decision to retain the two factors, hence both factors were maintained in the analysis.

Factor loading shows how much the variable contributes to the factor. In the current research, all items were registered by the acceptable number of factor loading which exceeded .50. The value ranged between .520 to .779. The highest loading factor was X5 (.754) (Behavioural engagement) while the lowest loading factor was X2 (.551) (Behavioural engagement). The highest loading factor was X7 (.779) (Behavioural engagement), while the lowest loading factor was X10 (.520) (Behavioural engagement). The factor loading of all items were more than .50.

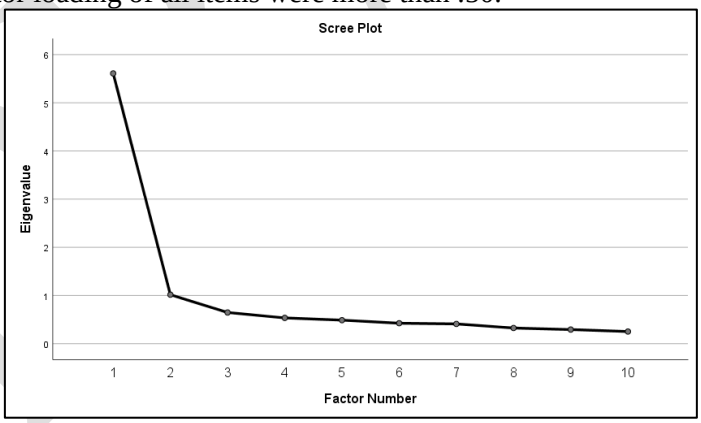

Figure 1. Scree Plot of 10 items student online learning engagement

Confirmatory Factor Analysis

The result of EFA suggested two factor structures of student online learning engagement, which were behavioural engagement with four items and emotional engagement with five items. The first order model was incorporated with two online learning engagement namely behavioural engagement and emotional engagement. The second order model was called the online learning engagement scale. The initial goodness of fit for the first model was Chi-square= 67.078, TLI= .943, CFI= .958, and RMSEA= .088 thus disclosing the standard value for the model of data fit. The factorial items for the first order varied from .666 to .798 where all the factor loadings exceeded .50 as the standard of acceptance. Other than that, the correlation between the factor was .850 and the variance was significant at .694. This indicated that the model was not independent so the CFA model portrayed in the Figure 2

was the final model for the first order model which depicted the structure of student online learning engagement.

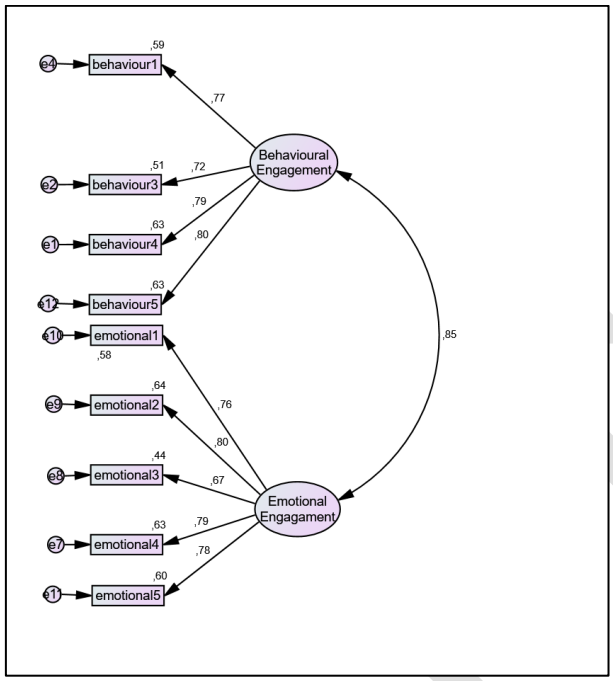

Figure 2. Scree Plot of 10 Items Student Online Learning Engagement

The second model order estimated the goodness of model data fit as the following: Chi-square=67.807, TLI= .947, CFI= .959, and RMSEA=.086, thus revealing the acceptable standard value of model data fit. The item factorial for the second model order ranged from .509 to .900. All the factor loadings exceeded .50 as the standard of acceptance. The path coefficient for emotional engagement was .90 and behavioural engagement was .95. To conclude, the CFA model portrayed in the Figure 3 is the final model for the second order model which depicted the structure of student online learning engagement.

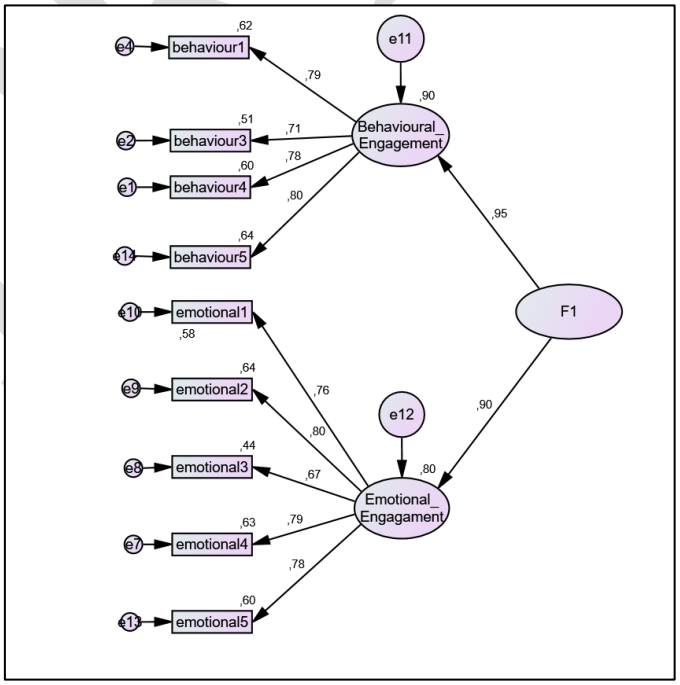

Figure 3. The final second order model for student online learning engagement

Table 3 shows the comparison of goodness of fit between the first order model and the second order model. The two models had quite similar goodness of fit indices where both gained an acceptable standard. Based on the table, the second order model for student online learning engagement attained better values compared to the first order model goodness of fit. The goodness of fit indices for the first order model of student online learning engagement were less appropriate.

Table 3. The first and the second order model comparison

Goodness of fit	Criterion	Model	
		First order	Second order
Chi- square		67.078	67,807
TLI	≥.90	.943	.945
CFI	≥.90	.958	.959
RMSEA	<.06 to .08	.088	.086

Rasch

Reliability portrays the consistency of instrument to measure student's engagement in which there were three types of reported reliability based on the Rasch model. Its reliability was item reliability (.84), person reliability (.82) and Cronbach's alpha (.91), which was bigger than a minimum of 6.5 (Table 4). Student engagement instrument showed adequate reliability as well as satisfactory separation. Separation depicts the ability of item and person to be ramified into some groups. A bigger score of 1.5 was needed to be considered as having good separation. Item and person separation for student engagement during online learning was 2.25 and 4.72, thus fulfilling the requisite score. The good quality of instrument can also be seen from the significance of the chi square test, delineating the instrument model fit to Rasch measurement.

Table 4. Reliability and separation

Indicator	Value
Item Reliability	0.84
Person Reliability	0.82
Cronbach's Alpha	0.91
Item separation	2.25
Person Separation	4.72

Mean Square (MNSQ) refers to the size of discrepancies (i.e., randomness) which must be in the range of .6 to 1.7. The results of Rasch analysis described the good fit of both infit and outfit MNSQ, ranging from .75-1.56 with 1.00 average score. The excellent results reflected the dearth of overfit and underfit Rasch measurement theory. Another standard as the proof of construct validity and the fitting test of instrument toward the Rasch measurement model was point measure correlation (PT Mea Corr), detecting polarity items intended to test the extent to which the construction of constructs manages to achieve its goal. The value must be positive to be considered having good fit, while negative and zero values show that the items did not function well. The results of analysis for this study was .62 (minimum) and .75 (maximum) as in Table 5.

Table 5. Mean square and point measure correlation

Item	Measure	Infit MNSQ	Outfit MNSQ	PT Mea Corr
B1	-.62	.81	.79	.70
B2	-.11	1.43	1.56	.62
B3	.00	1.08	1.14	.69
B4	-.22	.83	.82	.72
B5	-.68	1.01	1.00	.67
E1	.35	.91	.91	.75
E2	.31	.90	.91	.74
E3	.94	1.34	1.33	.70
E4	.17	.92	.92	.73
E5	-.13	.77	.75	.74

As an additional proof of how much the instrument explained latent variables, the Rasch model reported the unidimensionality result based on the residual Principal Component Analysis (PCA). Its score portrayed the relationship among the score of items within the student engagement instrument during online learning. The minimum score to be explained by the raw score was 24%, while the result of this study was 48.8% in total. The raw variance was explained by items (25.5%) with an eigenvalue of 5.0 and persons (25.3%) with an eigenvalue of 4.5, showing that the students' engagement instrument for Indonesian student context could measure intent variables and there was no need to check the second construct as supported by the unexplained variance in the first contrast lower than 15%. Table 6 shows the standardized residual variance (unidimensionality).

Table 6. Standardized residual variance (unidimensionality)

	In eigenvalue units	Empirical	Modeled
Total raw variance in observations	19.5%	48.8%	49.0%
Raw variance explained by items	5.0	25.5%	25.6%
Raw variance explained by persons	4.5	23.3%	23.4%

The purpose of this study was to test the students' online learning engagement instrument. The participants were limited to the Z generation who were the students of junior high school, senior high school, and university. In this study, the EFA, CFA, and Rasch models were used to analyze and validate the online learning engagement instrument. The use of factor analysis is efficient to validate an instrument where EFA was utilised to check the dimensionality and CFA was utilised to test the specific hypothesis or theories underlined the structure of the instrument (Shrestha, 2021; Swami & Barron, 2019). To complete the instrument testing, Rasch analysis can be utilized to check the instrument reliability by considering the Cronbach`s Alpha, item and person reliability, and item and pearson separation (Siew & Saidi, 2019). Rasch modelling, EFA, and CFA integration create a balanced link when evaluating an instrument. Other similar studies that utilized factor analysis and Rasch jointly were conducted by (Testa et al., 2021) who validated a new instrument regarding the participation and engagement scale (PES), and Aljaberi et al. (2022) who examined the construct validity of the IES-R. The findings of this study showed that, according to West Nusa Tenggara respondents, the online learning engagement instrument's items were completely acceptable and adaptable for assessing students' engagement towards online learning. The online learning engagement instrument successfully and internally consistently captured the two main aspects of online learning engagement. Moreover, by analyzing the online learning engagement instrument's item and response quality in detail, the Rasch analysis added confirmation to these findings. This suggested that the tool may be extensively used without regard to the grouping factors.

In factor analysis, the number of factors to retain should be taken into consideration where it can be determined by the number of eigenvalue greater than 1 (Nordholm et al., 2020). For the current research, the eigenvalue greater than 1 confirm two factors namely behavioural engagement and emotional engagement. The factors were further tested to validate the structure of the instrument. In the result, no item of student emotional engagement was eliminated and the structure was adjusted to fit the context. An aspect which needed to be considered was the number of factor loadings. This represented the strong relation between variable with the indicator. The item X10 which was the item of emotional engagement, was the lowest value for factor loading with .52. This was very close to the standard .50. This standard was chosen because according to Schreiber (2021), a research with a number of sample around 200 needs a factor loading of at least .50. This was stated by (Testa et al., 2021) who emphasized factor loading on .50 and above as the minimum factor loading standard acceptance. Sarsar and Kisla (2016) suggest that to ensure the student is emotionally engaged in the online classroom, the teacher should determine the efficient strategy to build good communication and interaction with the students during the class. This can help the teacher to maintain the focus of the student and it can also assist students to be more motivated during the online learning classroom. However, one item in behavioral engagement was eliminated. The result of the exploratory factor analysis showed that item X2 had communalities .361. This indicated that 36% of the variance in item X2 variable accounted for the two subconstructs in this research. In the exploratory factor analysis research, the number of communalities need to be considered because the communalities help to identify which item to appear to belong or not belong to the factor (Knekta et al., 2019). The item with high communalities is being

accounted for fairly well, while those with low commonalities are not (Hoi et al., 2021). In the current research, the item X2 which had communalities below the standard was removed from further analysis. The reason behind the low number of communalities might be due to the core nature of human behavior. Behavioral engagement is considered as content overlap and it is less well defined. It might be caused by the behavioral variable for each participant which is not persistent from moment to moment and tend to be determined by situation and feeling.

Therefore, the current research validates the engagement instrument for online learning in Mathematics Education among Generation Z, identifying two factors: emotional engagement with 5 items and behavioral engagement with 4 items, totaling 9 items. The novelty of this research lies in providing a valid and reliable engagement instrument for maths education, tested with a combination of robust statistical validation techniques—exploratory factor analysis, confirmatory factor analysis, and Rasch analysis—which are rare in the current literature. This validated instrument can significantly impact research practices in MathematicsEeducation, as it ensures accuracy, reliability, and credibility in measuring engagement. However, the study is limited by a sample size of only 205 participants and the instrument's applicability being restricted to online math education settings. Future research should involve a larger sample and test the instrument in various contexts to broaden its applicability and effectiveness.

CONCLUSION

This study's goal was to evaluate students' online learning engagement tool among the Z generation. This result of this study contributed to measure the online learning engagement instrument employing three diverse methods, namely EFA, CFA and Rasch analysis. Overall, each sub-construct fulfilled a minimum standard of eigenvalue (1 or above), communalities (.40 to 1.0) and factor loading (>.50) for exploratory factor analysis. RMSEA (<.06 to .08), CFI, TLI (90), and degree of freedom (<.50) for confirmatory factor analysis, reliability (.84-.91), separation (1.5), MNSQ (0.6-1.7), and unidimensionality (24%) for Rasch analysis. The contribution of this research proved the use of a combination between EFA and CFA and complimented with Rasch evaluation analysis. EFA was used to inspect the underlying factor and prove the construct validity for the structure. RASCH analysis was used to test the reliability. This study resulted in an appropriate measurement scale for student online learning engagement for the Z generation. The study successfully developed a valid and reliable instrument that effectively measured student engagement in online learning for Generation Z.

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AUTHOR CONTRIBUTIONS

Conceptualization, Riyan Hidayat and Muh Khairul Wajedi Imami; Methodology, Hilman Qudratuddarsi; Software, Muh Khairul Wajedi Imami; Validation, Muh Khairul Wajedi Imami and Z.Z.; Formal Analysis, Muh Khairul Wajedi Imami; Investigation, Mohd Rashid Mohd Saad; Resources, Mohd Rashid Mohd Saad; Data Curation, Hilman Qudratuddarsi; Writing – Original Draft Preparation, Riyan Hidayat; Writing – Review & Editing, Riyan Hidayat; Visualization, Sibo Liu; Supervision, Riyan Hidayat; Project Administration, Hilman Qudratuddarsi;; Funding Acquisition, Riyan Hidayat, Sibo Liu

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

REFERENCES

Adnan, M., & Anwar, K. (2020). Online learning amid the COVID-19 pandemic: Students' perspectives. *Journal of Pedagogical Sociology and Psychology, 1*(2), 45–51. https://doi.org/10.33902/jpsp.2020261309

Aljaberi, M. A., et al. (2022). Rasch modeling and multilevel confirmatory factor analysis for the usability of the impact of event scale-revised (IES-R) during the COVID-19 pandemic. *Healthcare, 10*(10), 1858. https://doi.org/10.3390/healthcare10101858

Asrial, A., Syahrial, S., Sabil, H., Ryan, J., Lamb, M., Cox, R., Emmitt, M., & Rahmi, R. (2024). Science teacher's book: Analyzing elementary school students' character values. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 180–187. https://doi.org/10.22437/jiituj.v8i1.32766

Bagdi, H., Bulsara, H. P., Sankar, D., & Sharma, L. (2023). The transition from traditional to digital: factors that propel Generation Z's adoption of online learning. *International Journal of Educational Management, 37*(3), 695-717. https://doi.org/10.1108/IJEM-01-2023-0003

Bagriacik Yilmaz, Y., & Banyard, P. (2020). Engagement in distance education settings: A trend analysis. *Turkish Online Journal of Distance Education*. 101–120. https://doi.org/10.17718/tojde.690362

Bravini, E., Giordano, A., Sartorio, F., Ferriero, G., & Vercelli, S. (2016). Rasch analysis of the Italian lower extremity functional scale: Insights on dimensionality and suggestions for an improved 15-item version. *Clinical Rehabilitation, 31*(4), 532–543. https://doi.org/10.1177/0269215516647180

Boone, W., Staver, J., & Yale, M.S. (2014). *Rasch analysis in the human sciences.* Springer.

Buelow, J. R., Barry, T. A., & Rich, L. E. (2018). Supporting learning engagement with online students. *Online Learning, 22*(4), 313–340. https://doi.org/10.24059/olj.v22i4.1384

Cacheiro-Gonzalez, M. L., Medina-Rivilla, A., Dominguez-Garrido, M. C., & Medina-Dominguez, M. (2019). The learning platform in distance higher education: Students' perceptions. *Turkish Online Journal of Distance Education, 20*(1), 71–95. https://doi.org/10.17718/tojde.522387

Cadiz, M. C. D., Manuel, L. a. F., Reyes, M. M., Natividad, L. R., & Ibarra, F. P. (2024). Technology Integration in Philippine higher education: A content-based bibliometric analysis. *Jurnal Ilmiah Ilmu Terapan Universitas Jambi*, *8*(1), 35–47. https://doi.org/10.22437/jiituj.v8i1.31807

Callahan, C. M., Azano, A. P., Park, S., Brodersen, A. V., Caughey, M., Bass, E. L., & Amspaugh, C. M. (2020). Validation of instruments for measuring affective outcomes in gifted education. *Journal of Advanced Academics, 31*(4), 470–505. https://doi.org/10.1177/1932202x20929963

Csobanka, Z. E. (2016). The Z generation. *Acta Technologica Dubnicae, 6*(2), 63–76. https://doi.org/10.1515/atd-2016-0012

Doğan, U. (2014). Validity and reliability of student engagement scale. *Bartın Üniversitesi Eğitim Fakültesi Dergisi, 3*(2), 390–390. https://doi.org/10.14686/BUEFAD.201428190

Dumford, D., & Miller, A. L. (2018). Online learning in higher education: Exploring advantages and disadvantages for engagement. *Journal of Computing in Higher Education, 30*(3), 452–465. https://doi.org/10.1007/s12528-018-9179-z

Farrell, O., & Brunton, J. (2020). A balancing act: A window into online student engagement experiences. *International Journal of Educational Technology in Higher Education, 17*(1), 1–19. https://doi.org/10.1186/s41239-020-00199-x

Ferri, F., Grifoni, P., & Guzzo, T. (2020). Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies, 10*(4), 1–18. https://doi.org/10.3390/soc10040086

Goretzko, D., Pham, T. T., & Bühner, M. (2019). Exploratory factor analysis: Current use, methodological developments and recommendations for good practice. *Current Psychology, 40*(7), 3510–3521. https://doi.org/10.1007/s12144-019-00300-2

Harrington, D. (2009). *Confirmatory factor analysis*. Oxford, UK: Oxford University Press.

Hidayat, R., Liu, S., Mohd Saad, M. R., & Hermandra. (2023). The role of mastery goal on life satisfaction using perma as a mediator for college students. *Emerging Science Journal*, 7, 238–252. https://doi.org/10.28991/esj-2023-sied2-018

Hidayat, R., Wan Idris, W. I., Qudratuddarsi, H., & Abdul Rahman, M. N. (2021). Validation of the mathematical modeling attitude scale for Malaysian mathematics teachers. *Eurasia Journal of Mathematics, Science and Technology Education, 17*(12), 1–16. https://doi.org/10.29333/ejmste/11375

Hidayat, R., Zainuddin, Z., & Mazlan, N. H. (2024). The relationship between technological pedagogical content knowledge and belief among preservice mathematics teachers. *Acta Psychologica, 249*, 104432. https://doi.org/10.1016/j.actpsy.2024.104432

Hoi, V. N., & Le Hang, H. (2021). The structure of student engagement in online learning: A bi-factor exploratory structural equation modeling approach. *Journal of Computer Assisted Learning, 37*(4), 1141–1153. https://doi.org/10.1111/jcal.12551

Howard, M. C. (2015). A review of exploratory factor analysis decisions and overview of current practices: What we are doing and how can we improve? *International Journal of Human-Computer Interaction, 32*(1), 51–62. https://doi.org/10.1080/10447318.2015.1087664

Inda-Caro, M., Maulana, R., Fernández-García, C.-M., Peña-Calvo, J.-V., Rodríguez-Menéndez, M. del, & Helms-Lorenz, M. (2018). Validating a model of effective teaching behavior and student engagement: Perspectives from Spanish students. *Learning Environments Research, 22*(2), 229–251. https://doi.org/10.1007/s10984-018-9275-z

Irvine, J. (2020). Positively Influencing Student Engagement and Attitude in Mathematics through an Instructional Intervention Using Reform Mathematics Principles. *Journal of Education and Learning, 9*(2), 48-75. https://doi.org/10.5539/jel.v9n2p48

Jabar, J. M., Hidayat, R., Samat, N. A., Rohizan, M. F. H., Rosdin, N. 'A., Salim, N., & Norazhar, S. A. (2022). Augmented reality learning in mathematics education: A systematic literature review. *Journal of Higher Education Theory and Practice, 22*(15). https://doi.org/10.33423/jhetp.v22i15.5570

Jackson, D. L., Gillaspy, J. A., & Purc-Stephenson, R. (2009). Reporting practices in confirmatory factor analysis: An overview and some recommendations. *Psychological Methods, 14*(1), 6–23. https://doi.org/10.1037/a0014694

Joshi, D. R., Adhikari, K. P., Khanal, B., Khadka, J., & Belbase, S. (2022). Behavioral, cognitive, emotional and social engagement in mathematics learning during COVID-19 pandemic. *PloS one, 17*(11), e0278052. https://doi.org/10.1371/journal.pone.0278052

Kahn, P., Everington, L., Kelm, K., Reid, I., & Watkins, F. (2016). Understanding student engagement in online learning environments: The role of reflexivity. *Educational Technology Research and Development, 65*(1), 203–218. https://doi.org/10.1007/s11423-016-9484-z

Kannadass, P., Hidayat, R., Siregar, P. S., & Husain, A. P. (2023). Relationship between computational and critical thinking towards modelling competency among pre-service mathematics teachers. *TEM Journal*, 1370–1382. Portico. https://doi.org/10.18421/tem123-17

Khalid, F. (2019). Students' identities and its relationships with their engagement in an online learning community. *International Journal of Emerging Technologies in Learning (iJET), 14*(05), 4–18. https://doi.org/10.3991/ijet.v14i05.8196

Knekta, E., Runyon, C., & Eddy, S. (2019). One size doesn't fit all: Using factor analysis to gather validity evidence when using surveys in your research. *CBE—Life Sciences Education, 18*(1), rm1. https://doi.org/10.1187/cbe.18-04-0064

Larsen, R., & Warne, R. T. (2010). Estimating confidence intervals for eigenvalues in exploratory factor analysis. *Behavior Research Methods, 42*(3), 871–876. https://doi.org/10.3758/brm.42.3.871

Lee, J., Song, H.-D., & Hong, A. (2019). Exploring factors, and indicators for measuring students' sustainable engagement in e-learning. *Sustainability, 11*(4), 1–12. https://doi.org/10.3390/su11040985

Li, S. (2022). Measuring cognitive engagement: An overview of measurement instruments and techniques. I*nternational Journal of Psychology and Educational Studies, 8*(3), 63–76. https://doi.org/10.52380/ijpes.2021.8.3.239

Marshall, L., & Wolanskyj-Spinner, A. (2020). Covid-19: Challenges and opportunities for educators and generation Z learners. *Mayo Clinic Proceedings, 95*(6), 1135–1137. https://doi.org/10.1016/j.mayocp.2020.04.015

Martin, F., & Bolliger, D. U. (2018). Engagement matters: Student perceptions on the importance of engagement strategies in the Online Learning Environment. *Online Learning, 22*(1), 205–222. https://doi.org/10.24059/olj.v22i1.1092

Mayer, R. E. (2018). Thirty years of research on online learning. *Applied Cognitive Psychology, 33*(2), 152–159. https://doi.org/10.1002/acp.3482

McBrien, J. L., Cheng, R., & Jones, P. (2009). Virtual spaces: Employing a synchronous online classroom to facilitate student engagement in online learning. *The International Review of Research in Open and Distributed Learning, 10*(3), 1–16. https://doi.org/10.19173/irrodl.v10i3.605

Mindrila, D., An, Y., Lawrence, M., & Elemen, J. (2017). *Exploratory factor analysis: Applications in school improvement research*. NovaScience Publisher.

Mosca, J., & Curtis, K. P. (2019). New approaches to learning for generation Z. *Journal of Business Diversity, 19*(3), 66–74. https://doi.org/10.33423/jbd.v19i3.2214

Mohd Saad, M. R., Mamat, S., Hidayat, R., & Othman, A. J. (2023). Integrating technology-based instruction and mathematical modelling for STEAM-based language learning: a sociocultural and self-determination theory perspective. *International Journal of Interactive Mobile Technologies (IJIM), 17*(14), 55–80. https://doi.org/10.3991/ijim.v17i14.39477

Moon, J., & Ke, F. (2020). In-game actions to promote game-based math learning engagement. *Journal of Educational Computing Research, 58*(4), 863-885. https://doi.org/10.1177/0735633119878611

Mukhtar, K., Javed, K., Arooj, M., & Sethi, A. (2020). Advantages, limitations and recommendations for online learning during COVID-19 pandemic era. *Pakistan Journal of Medical Sciences*, 36(COVID19-S4). https://doi.org/10.12669/pjms.36.covid19-s4.2785

Nguyen, T. D., Cannata, M., & Miller, J. (2016). Understanding student behavioral engagement: Importance of student interaction with peers and teachers. *The Journal of Educational Research, 111*(2), 163–174. https://doi.org/10.1080/00220671.2016.1220359

Nordholm, D., Arnqvist, A., & Nihlfors, E. (2020). Principals' identity – developing and validating an analysis instrument in the Swedish context. *International Journal of Leadership in Education*, 1–16. https://doi.org/10.1080/13603124.2020.1804621

Ouadoud, M., Rida, N., & Chafiq, T. (2021). Overview of e-learning platforms for teaching and learning. *International Journal of Recent Contributions from Engineering, Science & IT (iJES), 9*(1), 50–70. https://doi.org/10.3991/ijes.v9i1.21111

Peng, W. (2017). Research on model of student engagement in online learning. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(7), 3127–3142. https://doi.org/10.12973/eurasia.2017.00723a

Qudratuddarsi, H., Hidayat, R., Shah, R. L., Nasir, N., Imami, M. K. W., & bin Nor, R. (2022). Rasch validation of instrument measuring Gen-Z science, technology, engineering, and mathematics (STEM) application in teaching during the pandemic. *International Journal of Learning, Teaching and Educational Research, 21*(6), 104–121. https://doi.org/10.26803/ijlter.21.6.7

Qudratuddarsi, H., Sathasivam, R. V., & Hutkemri, H. (2019). Difficulties and correlation between phenomenon and reasoning tier of multiple-choice questions: A survey study. *Indonesian Research Journal in Education| IRJE|*, 249-264. https://doi.org/10.22437/irje.v3i2.6970

Rahayu, W., Putra, M. D., Iriyadi, D., Rahmawati, Y., & Koul, R. B. (2020). A Rasch and factor analysis of an Indonesian version of the student perception of Opportunity Competence Development (SPOCD) questionnaire. *Cogent Education, 7*(1), 1–18. https://doi.org/10.1080/2331186X.2020.1721633

Redmond, P., Heffernan, A., Abawi, L., Brown, A., & Henderson, R. (2018). An online engagement framework for higher education. *Online Learning, 22*(1), 183–204. https://doi.org/10.24059/olj.v22i1.1175

Richardson, C., & Newby, T. (2006). The role of students' cognitive engagement in online learning. *American Journal of Distance Education, 20*(1), 23–37. https://doi.org/10.1207/s15389286ajde2001_3

Roblek, V., Mesko, M., Dimovski, V., & Peterlin, J. (2019). Smart technologies as social innovation and complex social issues of the Z generation. *Kybernetes, 48*(1), 91–107. https://doi.org/10.1108/k-09-2017-0356

Roche, A., Gervasoni, A., & Kalogeropoulos, P. (2023). Factors that promote interest and engagement in learning mathematics for low-achieving primary students across three learning settings. *Mathematics Education Research Journal, 35*(3), 525-556. https://doi.org/10.1007/s13394-021-00402-w

Sarsar, F., & Kisla, T. (2016). Emotional presence in online learning scale: A scale development study. *Turkish Online Journal of Distance Education*, 50–61. https://doi.org/10.17718/tojde.87040

Schreiber, J. B. (2021). Issues and recommendations for exploratory factor analysis and principal component analysis. *Research in Social and Administrative Pharmacy, 17*(5), 1004–1011. https://doi.org/10.1016/j.sapharm.2020.07.027

Shek, D. T. L., & Yu, L. (2014). Confirmatory factor analysis using Amos: A demonstration. *International Journal on Disability and Human Development, 13*(2), 191–204. https://doi.org/10.1515/ijdhd-2014-0305

Shrestha, N. (2021). Factor Analysis as a Tool for Survey Analysis. *American Journal of Applied Mathematics and Statistics, 9*(1), 4–11. https://doi.org/10.12691/ajams-9-1-2

Siew, N. M., & Saidi, S. S. (2019). Reliability and validity analysis of statistical reasoning test survey instrument using the rasch measurement model. *International Electronic Journal of Mathematics Education, 14*(3). https://doi.org/10.29333/iejme/5755

Singh, V., & Thurman, A. (2019). How many ways can we define online learning? A systematic literature review of definitions of online learning (1988-2018). *American Journal of Distance Education, 33*(4), 289–306. https://doi.org/10.1080/08923647.2019.1663082

Skinner, E. A., Kindermann, T. A., & Furrer, C. J. (2009). A motivational perspective on engagement and disaffection: Conceptualization and assessment of children's behavioral and emotional participation in academic activities in the classroom. *Educational and psychological measurement, 69*(3), 493-525. https://doi.org/10.1177/0013164408323233

Stein, H., Gurevich, I., & Gorev, D. (2020). Integration of technology by novice mathematics teachers–what facilitates such integration and what makes it difficult? *Education and Information Technologies, 25*(1), 141-161. https://doi.org/10.1007/s10639-019-09950-y

Story, D. A., & Tait, A. R. (2019). Survey research. *Anesthesiology, 130*(2), 192-202. https://doi.org/10.1097/ALN.0000000000002436

Swami, V., & Barron, D. (2019). Translation and validation of body image instruments: Challenges, good practice guidelines, and reporting recommendations for test adaptation. *Body Image,* 31, 204–220. https://doi.org/10.1016/j.bodyim.2018.08.014

Testa, I., et al. (2021). Development and validation of an instrument to measure students' engagement and participation in science activities through factor analysis and Rasch analysis. *International Journal of Science Education, 44*(1), 18–47. https://doi.org/10.1080/09500693.2021.2010286.

Wara, E., Aloka, P. J., & Odongo, B. C. (2018). Relationship between emotional engagement and academic achievement among Kenyan secondary school students. *Academic Journal of Interdisciplinary Studies, 7*(1), 107–118. https://doi.org/10.2478/ajis-2018-0011

Watkins, W. (2018). Exploratory factor analysis: A guide to best practice. *Journal of Black Psychology, 44*(3), 219–246. https://doi.org/10.1177/0095798418771807

Watkins, W. (2021). *A step-by-step guide to exploratory factor analysis with SPSS*. Routledge.

Watson, J. C. (2017). Establishing evidence for internal structure using exploratory factor analysis. *Measurement and Evaluation in Counseling and Development, 50*(4), 232–238. https://doi.org/10.1080/07481756.2017.1336931

Wei, H.-C., & Chou, C. (2020). Online learning performance and satisfaction: Do perceptions and readiness matter? *Distance Education, 41*(1), 48–69. https://doi.org/10.1080/01587919.2020.1724768

Wu, X. V., Chan, Y. S., Tan, K. H., & Wang, W. (2018). A systematic review of online learning programs for nurse preceptors. *Nurse Education Today*, 60, 11–22. https://doi.org/10.1016/j.nedt.2017.09.010

Xu, X. (2024). Student engagement and academic achievement in learning Calculus. (2024). *International Journal of New Developments in Education, 6*(2). https://doi.org/10.25236/ijnde.2024.060204

Zepke, N., & Leach, L. (2010). Improving student engagement: Ten proposals for action. *Active Learning in Higher Education, 11*(3), 167–177. https://doi.org/10.1177/1469787410379680