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Interpreting students' perception of the e-Learning environments: determining optimal Cut-off Points for the e-Learning Educational Atmosphere Measure (EEAM)

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Abstract

There is a need for institutions to evaluate their e-Learning educational atmosphere to improve students' learning experiences. The E-Learning Educational Atmosphere Measure (EEAM) is a comprehensive tool focusing on the students' perception of the e-Learning environment. To be able to verbally interpret the results of the measure for better comprehension and more effective and consistent usage, it is essential to establish clear cut-off scores. We aimed to determine the optimal cut-off points for the EEAM scores by plotting them as the ROC curves versus a single global rating question. The findings showed that while the range of the possible EEAM scores was 40 to 200, cut-off points of equal or below 127, between 127 to 152, and equal or above 152 indicated students' perception of the e-Learning atmosphere as "poor to weak", "moderate", and "good to excellent" respectively. The Area Under the Curve for scores that reflected the "poor to weak" state was 0.875 (p-value=0.000) with a sensitivity of 84.8% and a specificity of 70.0%. This area was 0.947 (p-value=0.000) for the "good to excellent" state with a sensitivity of 100% and a specificity of 82.1%. Our findings are useful in studying, evaluating, and monitoring the e-Learning educational atmosphere of institutions or comparing the results of multiple settings.

KEYWORDS: e-Learning, Educational Atmosphere, Educational Environment.

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1. Introduction

E-Learning has been deployed by many higher education institutions for many years and the number of universities with clear strategies or policies for implementing e-Learning, its strategic utilization, and its uptake in regular teaching contexts has been rising (Gaebel et al., 2018). Although this trend began years ago, the recent disruption in education systems, caused by the COVID-19 pandemic, accelerated the adoption of e-Learning strategies more than before (Bevins et al., 2020; Gewin, 2020; Rose, 2020). This massive transition of academic institutions and programs towards utilizing more distant and e-Learning environments has raised quality concerns and made it a necessity for universities to evaluate their delivered e-Learning systems and services (Bevins et al., 2020). One example of such evaluations is assessing the e-Learning educational atmosphere of the institution.

In theories of adult learning, education is as much about setting the learning environment as it is about imparting specific knowledge and skills. Figure 1 shows a

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schematic representation of the educational environment within the educational process (Harden et al., 1999; Hutchinson, 2003).

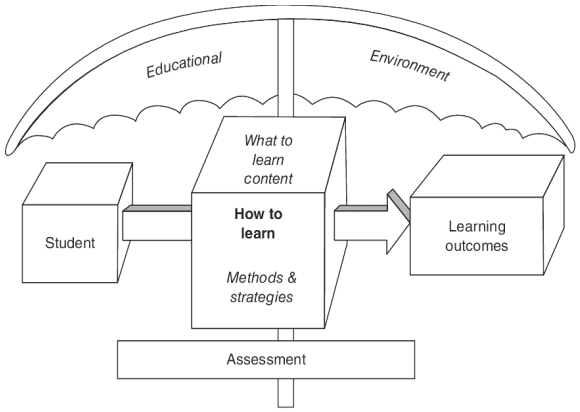

Figure 1 - The relation of the educational environment within the educational process (Adapted from Harden et al. 1999).

Students' perception of the learning environment, also known as "educational atmosphere", as the spirit of teaching and learning activities, have been shown to impact numerous educational outcomes: it is shown to be a main determinant of the students' academic behavior (Genn, 2001); A better educational atmosphere is also reported to be positively associated with higher academic achievements, learning satisfaction (Chan et al., 2018; Genn, 2001; Miles et al., 2012), perceived well-being and quality of life (Chan et al., 2018; Miles et al., 2012), academic aspirations (Miles et al., 2012), resilience, mindfulness, readiness for practice, peer collaboration, and less anxiety among students (Chan et al., 2018). A positive perception of the educational atmosphere within the international contexts has also been shown to improve students' social integration (Jean-Francois, 2019). On the other hand, a negative perception of the educational atmosphere has been reported to increase feelings of isolation and related academic dropouts (Rovai, 2002).

Understanding and evaluating the educational atmosphere is, therefore, an important part of curriculum development. Such evaluation is necessary to assess the departments' performance, identify possible areas of improvement, and facilitate the creation of an atmosphere that is conducive to learning (Jalili et al., 2014).

Considering the importance of the concept, multiple instruments have been developed for the assessment of educational atmosphere in various contexts. Due to the differences between face-to-face and online learning systems, different instruments have been developed to evaluate their atmosphere (Lee & Lee, 2008).

Using a valid and reliable instrument for quantitative measuring of the educational atmosphere offers several advantages as compared to qualitative assessment approaches, such as providing an overview of the institution's general educational environment status and details on the specific components and subscales, monitoring changes, evaluating interventions' effectiveness over time in an individual institution, and drawing comparisons between different institutions (Chan et al., 2018).

Despite these advantages, there is usually a lack of consistency in analyzing, interpreting, and categorizing the results of such opinion-based measures. To ensure an effective and consistent use of these measures for both evaluation and publication purposes, it is essential to develop uniform and clear guidelines to interpret their results (Miles et al., 2012). One common solution is to set up appropriate cut-off points which also provide a verbal interpretation and better comprehension of the results of the instruments. A cut-off point provides a categorical boundary on a continuous measure to allow intuitive interpretations of higher and lower scores (Barua, 2013).

Among multiple instruments available in the literature, the "E-learning Educational Atmosphere Measure (EEAM)" is a valid and reliable instrument, specifically tailored for assessing the educational atmosphere as perceived by the students in current e-Learning settings. The EEAM is a comprehensive instrument, adaptable to a wide range of e-Learning environments (Mousavi et al,, 2020). However, as any opinion-based measure, there is a need for developing clear guidelines for effective and consistent interpretation of its results. To the best of our knowledge, no optimal cut-off points for the EEAM have yet been identified.

In this study, we aimed to determine the appropriate cut-off points for the EEAM scores by using the Receiver Operating Characteristic (ROC) analysis to allow more effective and consistent interpretation of students' perceptions of the e-Learning environments.

2. Theoretical Background

We briefly review the existing literature in three sections: First, a brief overview of some of the most popular instruments for the assessment of educational atmosphere in traditional and e-Learning settings is presented; second, the use of cut-off points for such tools is discussed; and third, a method to optimize cut-off points, the Receiver Operating Characteristic (ROC) analysis, which we used in this study is reviewed.

2.1 Instruments for the Assessment of Educational Atmosphere

As mentioned earlier, educational environment is an important aspect of the curriculum and a crucial factor in the success of a program, and the students' perceptions of it heavily impact the quality of learning (Mohammad et al., 2010). As a result, multiple

instruments have been designed and validated to assess it within different educational settings. On the other hand, the widespread uptake of e-Learning environments in the past decade has led to the development of specifically-designed tools which are compatible with the e-Learning and distance education contexts (Mousavi et al,, 2020).

Among the most widely-utilized tools for traditional settings, the "Dundee Ready Educational Environment Measure (DREEM)" was specifically developed and validated for the assessment of the educational environment in undergraduate medical schools. The 50-item DREEM questionnaire was developed through a Delphi panel and has been validated and used in multiple settings and languages around the world (Miles et al., 2012; Sue Roff et al., 1997). The 40-item "Postgraduate Hospital Educational Environment Measure (PHEEM)" questionnaire was developed through a similar procedure and with a focus on hospital-based learning environments in health professions education (Susanne Roff et al., 2005). PHEEM has also been widely used and validated in different clinical settings (Jalili et al., 2014).

Among more recently developed instruments which have included e-Learning and distance education elements, the "Web-based Learning Environment Instrument (WEBLEI)" (Chang & Fisher, 2001), the "Online Learning Environment Survey (OLES)" (Trinidad et al., 2005), and the "Online Learning Environment Survey (OLLES)" (Clayton, 2007) were developed in blended-learning settings, combining traditional face-to-face classroom with online teaching tools and communication platforms. Another similar instrument, the "Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)" was developed to assess high school classroom environments in which computer-based tools such as internet forums and emails were used to aid teaching. However, they did not have a completely integrated e-Learning system (Aldridge et al., 2004). Another measure, the "Distance Education Learning Environments Survey (DELES)" was also developed to assess the distant learning environments; however, they were not necessarily enriched with e-Learning tools (Walker & Fraser, 2005).

The instrument we used in this study, the "E-learning Educational Atmosphere Measure (EEAM)" is a more recently developed questionnaire, specifically designed to assess the educational atmosphere of the current e-Learning systems. The EEAM was developed through multiple in-depth interviews with e-students and e-teachers involved in online MSc and PhD degree programs. In addition to the validity and reliability of the instrument, the EEAM is suitable for interactive e-Learning courses or programs that are delivered via a learning management system (LMS) and implement various synchronous and asynchronous strategies. It is also compatible with a wide range of educational contexts. These attributes make it more useful for the assessment of different types of e-Learning systems and programs (Mousavi et al., 2020).

2.2 Cut-off Points for Educational Atmosphere Measures

Most of the tools that are developed to evaluate the educational environment in traditional or e-Learning contexts are interpreted based on the total score and the scores obtained in each subscale (Mousavi et al,, 2020).

Among those for the evaluation of traditional settings, the 50-item DREEM questionnaire is the most popular and well-known instrument and consists of five subscales: 1) students' perception of learning, 2) students' perception of teachers, 3) students' academic self-perceptions, 4) students' perception of atmosphere, and 5) students' social self-perceptions. The authors reported the achieved total and subscale scores as a percentage of maximum possible scores, without providing further recommendations on how to interpret them (Sue Roff et al., 1997). Subsequently, two of the authors provided guidance on the appropriate cut-off values to interpret the overall DREEM score, each five subscale scores, and individual items at three levels of "especially strong", "could be improved", and "needs particular attention". (McAleer & Roff, 2001; Miles et al., 2012).

To the best of our knowledge, none of the instruments for the measurement of the educational atmosphere in e-Learning or technology-enhanced distance learning settings has determined clear cut-off points to effectively interpret their results.

2.3 Determining Cut-off Points by ROC Analysis

There are different methods for setting cut-off points to interpret the results of instruments, discussed by researchers in medicine, psychology, human resource, management, and education, such as Mean ± 2SD, the Youden Index, and the Receiver Operating Characteristics (ROC) analysis (Şahin Sarkın & Gülleroğlu, 2019). While there is no such thing as the "best" method, the ROC analysis has been frequently used for various psychometric and clinical diagnostic measures (Archer et al., 2013; Cho et al., 2021; Dunstan & Scott, 2019; Hajian-Tilaki, 2013; Lane et al., 2015; Larzelere et al., 2004; Nanishi et al., 2015; Oliveira et al., 2015; Şahin Sarkın & Gülleroğlu, 2019). Diagnostic accuracy and optimal cut-off points are considered as the two main outcomes of the ROC analysis. The ROC curves graphically plot sensitivity (true positive rate on the y-axis) versus 1-specificity (false positive rate on the x-axis) at every possible cut-off value. Subsequently, the Area Under the Curve (AUC) is used as the accuracy index to interpret the ROC curves. As it summarizes the overall location of the curve, the AUC can be taken as a general measure of sensitivity and specificity. The maximum AUC value of 1 means that the test is perfect in differentiation; whereas an AUC value of 0.5

indicates the minimum discriminatory power (Hajian-Tilaki, 2013). Optimal identification of the cut-off points requires simultaneous assessment of sensitivity and specificity as they dichotomize the scores to provide a binary classification. The optimal cut-off value is the point that classifies most of the individuals correctly (Unal, 2017).

There are multiple approaches for determining cut-off points according to the ROC analysis. In situations where there is considerable inter-subject variability and no gold standard reference test to compare with the results of the current instrument, a suggested solution is to determine the optimal cut-off points based on the participants' response to a direct question assessing the measured entity (Oliveira et al., 2015).

This study explores the appropriate cut-off scores for interpreting students' perceptions of the e-Learning environment as measured by the EEAM instrument through optimizing sensitivity and specificity by ROC analysis.

3. Methods

3.1 Participants

Participants were 126 MSc students of Medical Education, Educational Technology and e-Learning in Medical Education. The ages ranged from 21 to 41 years, with a mean of 29.90 years (SD = 4.32). 56.3% (71 participants) and 43.7% (55 participants) identified as female and male, respectively. Informed consent was obtained from the participants as they voluntarily submitted the survey. Ethical approval was granted by the Ethics Committee at Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1400.595).

3.2 Measure

The EEAM is a 40-item instrument. Each item has a five-point Likert-type rating, i.e., "totally agree", "agree", "neutral", "disagree" and "totally disagree" (rated from 5 to 1). The instrument covers the following six constructs as the domains of e-Learning educational atmosphere: 1) program effectiveness (e.g. learning academic-related knowledge and skills, attractive contents, and proper assessment), 2) teaching quality (e.g. appropriate use of e-teaching tools, strategies, and methods, taking advantage of the LMS capabilities, providing effective and in-time feedback), 3) ethics and professionalism (e.g. respecting social and cultural diversity, observing copy-right and intellectual property issues, tutor support), 4) learner support (e.g. technical and administrative support, educational counselling, access to digital library), 5) safety and convenience (e.g. user-friendly LMS), and 6) awareness of the rules (e.g. administrative regulations, educational and research guides). A higher total score indicates a better educational atmosphere as perceived by the respondents (Mousavi et al,, 2020).

To provide a refenrece for the ROC analysis in the absence of a gold-standard measure, an additional information on educational atmosphere was obtained from the same participants using a single global rating question: "How do you perceive the school's educational atmosphere in general?" with five response options: "The educational atmosphere is not good at all."; "There are problems in the educational atmosphere."; "The positive points of the educational atmosphere are somehow equal to the negative ones."; "The educational atmosphere is good."; and "The educational atmosphere is excellent."

3.3 Data Collection

Data from the EEAM and the single global rating question was collected online from the participants. After the first round of data gathering, we followed up the participants who had not filled the questionnaire and asked them to participate in the online survey.

3.4 Variables

The main outcome variable was the educational atmosphere, represented by the total EEAM score and treated as a continuous variable. The single question was used to analyze the distribution of the EEAM scores. Two cut-off points for the measure were determined by using the ROC curve, resulting in three educational atmosphere categories, i.e., "poor to weak", "moderate", and "good to excellent".

3.5 Statistical Analysis

Statistical analysis included descriptive statistics, the ROC curve analysis, ANOVA, and correlation coefficient. The significance level was set at 5% for all tests.

To calculate the ROC curves, we first coded the responses to the single question as a binary variable in order to distinguish between "poor to weak" and other categories. This dichotomization resulted in defining a cut-off point that identified respondents who believed that the atmosphere was "poor to weak". In other words, individuals who had selected the choices of "The educational atmosphere is not good at all." and "There are problems in the educational atmosphere." in response to the single question, were assigned to the "group 1" and all other participants to the "group 2" category.

Then, we applied a different binary categorization in order to distinguish between "good to excellent" and others. The respondents who had chosen the choices of "The educational atmosphere is good." and "The educational atmosphere is excellent." were assigned to the "group 1", and the rest to the "group 2" category. These two dichotomizations provided a basis for determining the cut-off points to identify individuals

who believed that the atmosphere was "poor to weak" and "good to excellent".

Finally, the scores between these two cut-off points were considered as "moderate" perception of the educational atmosphere by the participants.

In addition, we used the Shapiro–Wilk test to assess the normality of the data and ANOVA test to associate EEAM scores to the responses to the single question.

The Statistical Package for the Social Sciences (Armonk, NY: IBM Corp. IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0) was used to conduct the statistical analysis.

4. Results

In total, 119 individuals filled out the EEAM and answered the global rating question (response rate of 94.4%). A statistically significant relationship was found between the total EEAM scores and the responses to the global rating question (r = 0.695, P-value = 0.000). Higher EEAM scores were more likely to be for the respondent whose choices were "The educational atmosphere is good" and "The educational atmosphere is excellent"; whereas lower scores were more likely to be for those who had chosen "The educational atmosphere is not good at all." and "There are problems in the educational atmosphere." Table 1 shows the details. The results of the ANOVA test showed significant differences between the EEAM scores in the groups based on the response to global rating question (Sum of squares = 24473.794, F = 37.019, P-value = 0.000).

Choices of the global rating question	Number of responses	Mean EEAM score*	SD**
The educational atmosphere is not good at all.	0	0	0
There are problems in the educational atmosphere.	20	116.8	17.43
The positive points of the educational atmosphere are somehow equal to the negative ones.	44	134.2	15.12
The educational atmosphere is good.	42	146.7	13.86
The educational atmosphere is excellent.	13	168.3	12.46
Total	119	139.4	20.55

* Out of 200, ** Standard Deviation

Table 1 - The mean EEAM scores based on the participants' responses to the global rating question.

Two cut-off points were determined based on the responses to the global rating question and the ROC curve analysis which resulted in classifying the EEAM scores into three educational atmosphere categories: "poor to weak", "moderate" and "good to excellent".

The AUC for the scores that reflect the "poor to weak" state was 0.875 (p-value = 0.000). The lower EEAM cut-off point which gave the best compromise between sensitivity (84.8%) and specificity (70.0%) was at 127 points. Figure 2 and Table 2 show the details of determining the lower EEAM cut-off point by optimizing sensitivity and specificity based on responses to the global rating question.

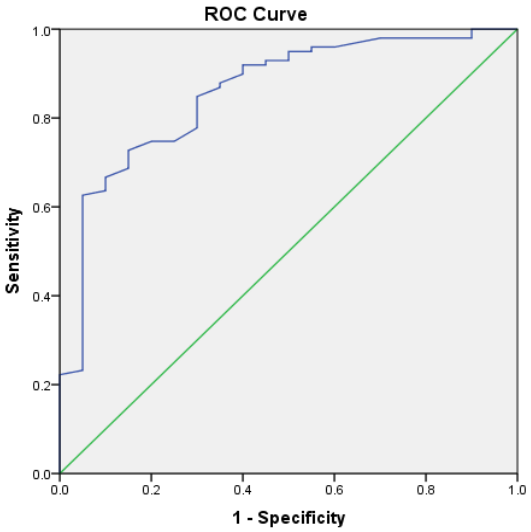

Figure 2 - Receiving Operating Characteristic (ROC) curve for the lower cut-off point of EEAM which is the score of 127.
Area Under the Curve (AUC) = 0.875 (p-value=0.000)

EEAM scores	"Poor to weak" versus "moderate" and "good to excellent"	
	Sensitivity	1 - Specificity
120.0000	0.899	0.400
122.0000	0.879	0.350
124.5000	0.869	0.350
127.0000*	**0.848**	**0.300**
128.5000	0.838	0.300
129.5000	0.808	0.300
130.5000	0.798	0.300
131.5000	0.778	0.300
132.5000	0.747	0.250
133.5000	0.747	0.200
134.5000	0.727	0.150
135.5000	0.687	0.150

Table 2 - Determination of the lower EEAM cut-off point.
*A score of 127, representing the best compromise between sensitivity (0.848) and specificity (0.700), was chosen as the lower cut-off point (in bold).

The second ROC curve for the binary categorization of "good to excellent" state from others had an AUC of 0.947 (p-value=0.000) and the upper EEAM cut-off point of 152 points corresponded to a sensitivity of

100% and a specificity of 82.1%. Figure 3 and Table 3 show the details of determining the upper EEAM cut-off point by optimizing sensitivity and specificity based on responses to the global rating question.

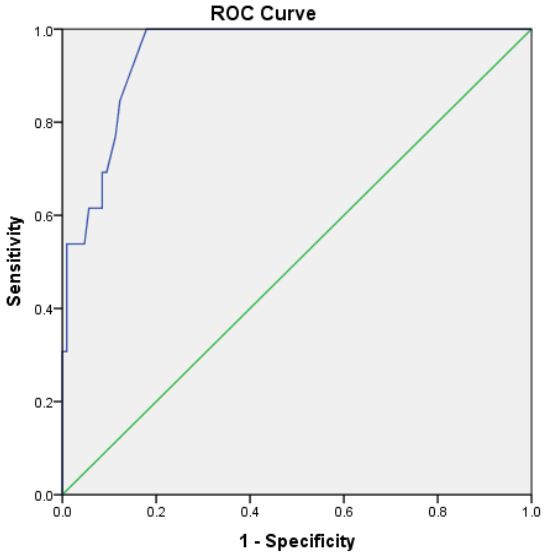

Figure 3 - Receiving Operating Characteristic (ROC) curve for the upper cut-off point of EEAM which is the score of 152.
Area Under the Curve (AUC) = 0.947 (p-value= 0.000)

EEAM scores	"Poor to weak" and "moderate" versus "good to excellent"	
	Sensitivity	1 - Specificity
145.5000	1.000	0.340
146.5000	1.000	0.330
147.5000	1.000	0.302
148.5000	1.000	0.283
149.5000	1.000	0.255
150.5000	1.000	0.245
151.5000	1.000	0.189
152.5000*	**1.000**	**0.179**
154.0000	0.923	0.151
155.5000	0.846	0.123
156.5000	0.769	0.113
157.5000	0.692	0.094
158.5000	0.692	0.085
159.5000	0.615	0.085
161.0000	0.615	0.066

Table 3 - Determination of the upper EEAM cut-off point
*A score of 152, representing the best compromise between sensitivity (1.000) and specificity (0.821), was chosen as the lower cut-off point (in bold).

Finally, from a range of 40 to 200, the cut-off points of equal or below 127, between 127 to 152, and equal or above 152 indicated students' perception of the educational atmosphere as "poor to weak", "moderate", and "good to excellent" respectively. Figure 4 shows the optimized lower and upper EEAM cut-off points on the basis of the Receiver Operating Characteristic (ROC) curve analysis for the responses to the single global rating question.

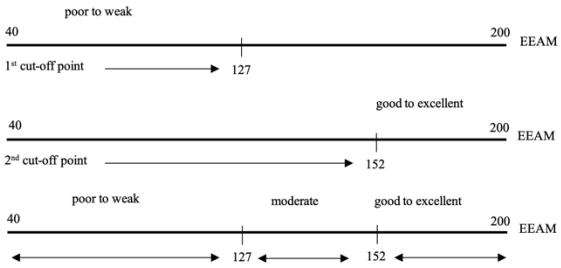

Figure 4 - Lower and upper cut-off points of EEAM (scores ranging from 40 to 200).

5. Discussion

This study aimed to determine the optimal cut-off points for interpreting the e-Learning educational atmosphere via the EEAM instrument, by plotting them as the ROC curves, versus responses to a single global rating question. While the range of possible EEAM scores is 40 to 200, points of equal or below 127 and equal or above 152 indicate the students' perception of educational atmosphere as "poor to weak" and "good to excellent" respectively. The EEAM scores in between these two cut-off points represent a "moderate" perception of educational atmosphere.

Among the educational atmosphere measures for e-Learning settings, we chose the EEAM due to its comprehensiveness, specific design based on e-Learning environments, and compatibility with a wide range of educational settings (Mousavi et al,, 2020). However, to enable a more effective and consistent interpretation, and provide a verbal description for numerical categories of the resulted scores, we used ROC analysis, a statistically supported method, to determine the optimal cut-off points (Oliveira et al., 2015).

Despite the importance of evaluating educational environment as a part of academic institutions' good practice (Soemantri et al., 2010), we could only find one tool, DREEM, that described clear cut-off points for its obtained scores. (McAleer & Roff, 2001; Miles et al., 2012). However, no clear statistical methodology was described for defining these cut-off values.

Our study has some significant implications for both educational evaluation and future research purposes. Setting EEAM cut-off points provides consistency in its analysis and increases the interpretability of its results. The cut-off points not only create direct meaning and relevance even in a single measurement attempt and in one institution but also provide a standard of comparison

among institutions and are a clear benchmark for educational institutions' performance. Furthermore, it offers a measure of accountability for authorities to evaluate the educational atmosphere of their institutions. Also, the determined cut-off-points enhance the EEAM tool's utility in educational research and interventions. Finally, the method discussed in this study for cut-off-point determination can be applied to any opinion-based instrument.

Apart from the benefits, this study has some limitations. There was a lack of a previously existing gold standard for measuring the educational atmosphere in e-Learning settings. So, we could test neither convergent validity that is the correlation between two instruments, nor discriminant validity that is showing no correlation at all. This limitation led us to use a single global rating question as a reference for the ROC analysis. Moreover, the participants of this study were MSc students of specific disciplines in a country. We suggest further research in different e-Learning settings and with more participants' variety to confirm the generalizability of the findings.

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