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The Usage of Bio-Chem Kit for Supporting Student's Engagement in Understanding Biogeochemical Cycles

Penggunaan Kit Bio-Chem untuk Menyokong Penglibatan Pelajar dalam Memahami Kitaran Biogeokimia

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ABSTRACT

Environmental education is essential since the issue of environmental degradation has raised global attention and concern. The principles of ecology course will teach students basic environmental principles and knowledge necessary for future environmental administrators. In disseminating the knowledge to the students, the educators faced challenges in engaging with the students regarding large and complex information, such as the topic of the biogeochemical cycle. Employing an infographic, BIO-CHEM KIT, could help students understand the topic more meaningfully. This study aims to assess the infographic's effectiveness (BIO-CHEM KIT) in delivering the concept of the biogeochemical cycle among first-year students of the Bachelor of Environmental Administration. As for the evaluation, an empirical investigation method was adopted, and items were developed based on the Technology Acceptance Model (TAM) and Student Course Engagement Questionnaire (SCEQ). The evaluation results first indicate that Perceived Usefulness, Perceived Ease of Use, and Attitude toward Infographics significantly and positively affect student engagement. Second, Attitude toward Infographics is the most significant predictor of student engagement. By this research, infographics are more effective and permanent in the minds. This teaching method can transmit

information to increasingly widespread use, and thus, the conventional form of lectures might transform into accessible, understandable courses with much more infographics.

Keywords: Student Engagement; Perceived Usefulness; Perceived Ease of Use; Attitude Towards Infographics; Technology Acceptance Model

ABSTRAK

Pendidikan alam sekitar adalah penting kerana isu kemerosotan alam sekitar telah menimbulkan perhatian dan kebimbangan global. Melalui kursus prinsip ekologi, pelajar akan mempelajari prinsip asas alam sekitar dan pengetahuan yang diperlukan untuk pentadbir alam sekitar pada masa hadapan. Dalam menyebarkan pengetahuan kepada pelajar, para pendidik menghadapi cabaran untuk mendapatkan perhatian pelajar terutamanya dalam penyampaikan maklumat yang besar dan kompleks, seperti topik kitaran biogeokimia. Menggunakan maklumat grafik, BIO-CHEM KIT, boleh membantu pelajar memahami topik dengan lebih bermakna. Kajian ini bertujuan untuk menilai keberkesanan infografik (BIO-CHEM KIT) dalam menyampaikan konsep kitaran biogeokimia dalam kalangan pelajar tahun pertama Ijazah Sarjana Muda Pentadbiran Alam Sekitar. Bagi penilaian pula, kaedah penyiasatan empirikal telah digunakan, dan item penilaian telah diwujudkan berdasarkan Model Penerimaan Teknologi (TAM) dan Soal Selidik Penglibatan Kursus Pelajar (SCEQ). Keputusan penilaian terlebih dahulu menunjukkan bahawa penglibatan pelajar dipengaruhi secara signifikan dan positif oleh Kegunaan Infografik, Kemudahan Penggunaan Infografik, dan Sikap terhadap Infografik. Kedua, Sikap terhadap Infografik ialah faktor yang paling ketara dalam mempengaruhi penglibatan pelajar. Dengan penyelidikan ini, boleh dikatakan bahawa maklumat grafik lebih berkesan dan kekal di dalam minda. Kaedah pengajaran ini boleh menghantar maklumat kepada penggunaan dengan meluas, dan dengan itu, bentuk kuliah konvensional perlu berubah menjadi kursus yang boleh diakses dan difahami.

Kata kunci: Penglibatan Pelajar; Kegunaan Infografik, Kemudahan Penggunaan Infografik, Sikap terhadap Infografik; Model Penerimaan Teknologi

INTRODUCTION

Nowadays, cutting-edge technology, creative, innovative, dynamic teaching approaches, and entertainment are the main criteria that attract students' attention in higher education institutions. In line with this situation, a paradigm shift needs to be done, including in the context of teaching and learning. The present generation has grown up in an era of information at their fingertips (Rashid & Yadav, 2020). In addition, before the COVID-19 pandemic, the learning process was conducted face-

to-face. However, after the emergence of COVID-19 at the end of 2019, the learning process has changed to online learning. Now it is a challenge for educators and students; like it or not, all of them must accept online learning (Dwivedi et al., 2020). Educators can employ many approaches and techniques in promoting student engagement in online learning. The use of infographics is gaining popularity due to its features and textual presentation, which are interesting, concise, informative, persuasive, and easy to read (Piotti & Murphy, 2019).

According to the Oxford English Dictionary, a combination of infographic words carries the meaning of a presentation description of information or data. Complex information or data can be visually displayed through infographics, combining elements such as shapes, symbols, graphics, images, illustrations, and text (Ozdamli & Omdal, 2018). The information displayed can also be presented to the reader quickly and easily understood (Yuvaraj, 2017). The usage of an infographic could help to improve student understanding of a particular topic since it can summarize complex information, and it can be used for other purposes such as remembering information, showing the relationship between concepts, and the transfer of a process and an event (Elena Gallagher et al., 2017). Infographics help capture attention and are widely used in delivering instructional content, which is abstract, complex, and dense (Chicca & Chunta, 2020; Provvidenza et al., 2019). Each student processes information differently, and the diversity in thinking will influence students to act differently. For instance, if students have insufficient knowledge, thinking, and learning performance, they require a medium to stimulate them to connect it with knowledge cognitively. Recognizing that fact, using infographics could cater to student's cognitive abilities and is also seen to have the potential to determine the success of teaching and learning. Identifying each student's cognitive style can fail in teaching and learning.

Although many empirical studies are being done on the use of technology in institutions of higher learning, studies on the use of infographics in teaching are minimal. A plethora of research has urged educators to employ advanced and interactive teaching strategies that could enhance student participation, brainstorming, engagement, interactive, and others. BIO-CHEM KIT was introduced and aimed to facilitate learning activities by using the graphic visual presentation of information and knowledge related to the subjects in a simpler, quicker, and more effective way. BIO-CHEM KIT is designed, which combines two learning methods comprising online quizzes and technology usage of QR codes to facilitate the teaching and learning process.

The contents consist of the essential elements in the subject of the principles of ecology, with the simplified versions of six main areas of the biogeochemical cycles (i.e., tectonic cycle, rock cycle, nitrogen cycle, phosphorus cycle, hydrogeological cycle, and carbon cycle) that students need to know. An online quiz is provided to test and examine the infographic's effectiveness. Besides, innovation also injects the

element of technology usage through the graphic visual presentation using the QR Code. All the infographic data contents will be made available in the QR Code, which aims to facilitate the teaching and learning activities in a simpler, easier, and fun way. BIO-CHEM KIT is introducing to first-year students of the Bachelor of Environmental Administration at the Faculty of Administrative Science and Policy Studies, Universiti Teknologi MARA (UiTM) Seremban 3 campus. It has been introduced to those who undertake the principles of ecology subject. BIO-CHEM KIT is appropriate for all levels of students in varied settings, such as in the classroom and online environments. Figure 1 displays a sample infographic, BIO-CHEM KIT.

Figure 1: Sample Infographic BIO-CHEM KIT

The primary purpose of this study is to examine the factors that influence student engagement in an online class through the adoption of an infographics approach. To identify the factors influencing acceptance and attitudes toward the use of infographics, the Technology Acceptance Model was applied (Davis et al., 1989). This model was chosen because previous studies have found that this model is the most influential and widely used in examining technology adaptability. This study aims to identify the influence of perceived usefulness, perceived ease of use, and attitude on student engagement in online learning. The paper is structured as follows. The second section presents and explains the research model and describes the research hypotheses. This is followed by the research method that guided the research in the third section. The fourth section presents the results of the proposed model. Finally, the fifth section discusses the main findings of the study and concludes the paper.

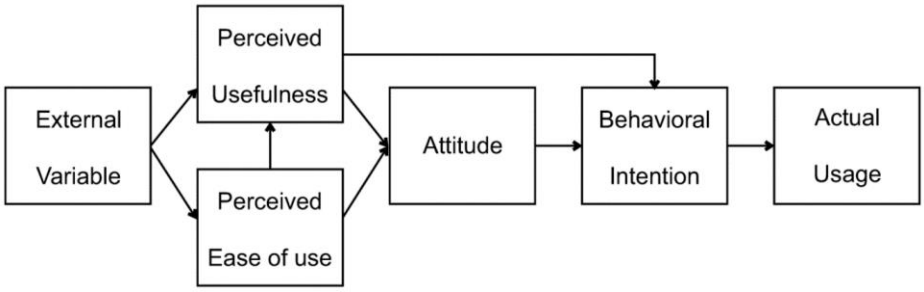
THEORETICAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

Technology Acceptance Model (TAM)

This study employs the Technology Acceptance Model (TAM) (Davis, 1989). This theory has been applied and tested in many studies due to its ability to explain the success of technology adoption. The TAM model identifies and evaluates factors influencing individual behavior toward accepting technology or information systems. The TAM model is developed from the Theory of Reasoned Action (TRA) founded by Ajzen and Fishbein (1975). TRA is built based on three primary constructs: behavioral intention, attitude toward behavior, and subjective norms. TRA discusses that a person's behavior is driven by behavioral intention, a function of an individual's attitude toward behavior and subjective norms.

Meanwhile, TAM is developed based on two main cognitive variables: perceived usefulness and perceived ease of use. According to TAM, a user's use of information technology comes directly or indirectly from behavioral intention, attitude, usefulness, and usability. The TRA and TAM models differ in the dimensions/indicators. TRA uses the dimensions/indicators: attitude toward behavior, subjective norm, behavioral intention, and actual behavior, while TAM does not use dimensions/indicators of attitude toward behavior and subjective norm. The advantage of TAM lies not only in its user behavior but also in its convenience due to the use of technology. Figure 2 shows a conceptual framework of TAM.

Figure 2: Technology Acceptance Model (TAM)



TAM aims to explain the determinants of acceptance of information-based technology in general and explain end-user behavior in information technology. Ideally, a model accompanies explanations where the researchers and practitioners can identify why particular technology and systems are unacceptable. Hence, it is necessary to take corrective steps to overcome it. A key goal of TAM is to provide a basis for determining the effect of external factors on internal beliefs, attitudes, and intentions. TAM is formulated to achieve this goal by identifying a small number of principal variables obtained from previous research on theory and determinants of

technology acceptance and using TRA as a theoretical background to model the relationship between variables.

Students' acceptance of the infographic is essential because it reflects their behavior, attitudes, and beliefs about the methods used. Perceived usefulness in TAM refers to productivity, performance, and effectiveness (Davis, 1989). These essential beliefs have been identified to explain how people's attitudes to using technology are influenced. Perceived usefulness affects the intention to use more than its influence on attitude (Davis, 1989). Next, perceived ease of use is analogized to a perception of the complexity of innovation and technologies. This study defined it as the level of student confidence that using the infographic requires little effort. According to TAM, perceived usefulness and ease of use significantly affect a person's positive or negative feelings about a specific behavior. Perceived usefulness and perceived ease of use influence behavioral intention. Technology users will be interested in using technology if they feel it is valuable and easy to use.

Empirically, many TAM studies focus on developed countries, and TAM has yet to be widely tested within developing countries (Teo et al., 2008). Consequently, Teo et al. (2008) emphasize the importance of testing the TAM in different cultures to ensure the unbiased reliability of TAM in cross-cultural settings. Additionally, the applicability of TAM is limited in educational settings, as much of the research has been carried out in non-educational contexts. Faced with these limitations, this study proposed a research model to investigate the extent of perceived usefulness, perceived ease of use, and student attitudes toward infographics on student engagement in online learning.

Usage of Infographics and its Effect on Students Engagement

The infographics help to show how to do something or how something works. Infographic visuals are used to demonstrate the steps of a process. The graphics and pictures help the reader understand the process or the complicated steps (Chicca & Chunta, 2020). It was also able to illustrate a point. Then, it motivates someone to act. Infographic is intended to motivate the reader or audience to do something (Provvidenza et al., 2019). There are three main strengths of infographics, namely: 1) attraction, 2) understanding, and 3) memory (Barlow, Webb, & Barlow, 2021). Infographics allow the reader to access information already stored in the brain. Visuals are not just about getting helps us understand and share news sources but can trigger interpretation of the reader's thoughts, interpretations, and emotions (Ozdamli & Omdal, 2018). The new delivery methods used nowadays are infographics, where images, illustrations, text, and diagrams are included. The use of infographics is more effective because it is simple and short with the support of pictures and diagrams where text summaries are used to explain sentences. Abbazio and Yang (2022) have explained that students' cognitive levels will not develop if

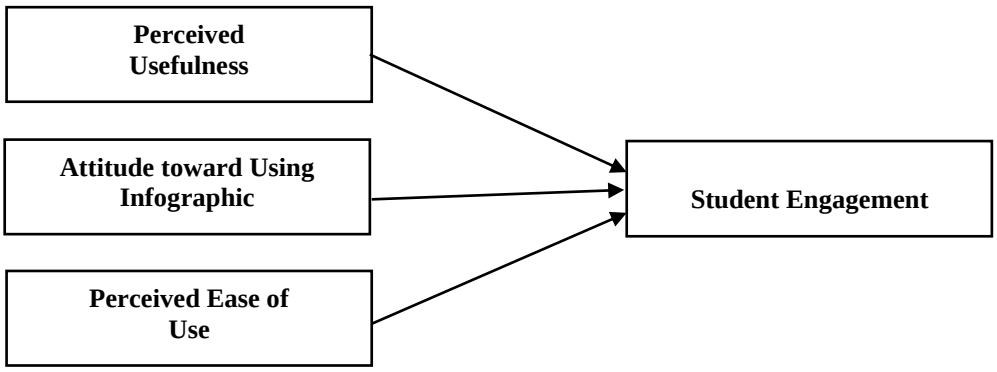
teaching aids only rely on textbooks. Conventional teaching techniques based on chalk and conversation will not be able to produce students with creative and critical thinking (Yuvaraj, 2017). Therefore, lecturers need to adapt pedagogical aspects along with technology in the teaching and learning process for students.

Additionally, according to the constructivist learning theory, practical learning is more accessible when the emphasis is placed on the student's existing knowledge and the learning environment experienced by the students (Lochner, Swenson, & Martinson, 2021). Therefore, when students are given a picture in the form of a graphic representing the lesson's content to be delivered, their existing knowledge is easier to regain. This view is acknowledged by Bicen and Beheshti (2022). Graphics not only attract the audience's attention but can also strengthen the delivery of the message. The use of interactive elements in the teaching and learning process can increase student understanding throughout the teaching and learning process in the classroom (Bicen & Beheshti, 2022; Ozdamli & Omdal, 2018).

Conceptual Framework

TAM Model was developed based on two main cognitive variables: the perception of practical use and ease of use. According to TAM, the perception of practical use and ease of use will influence the attitude toward infographics. After that, it will influence the behavior that becomes the actual use of the system. The TAM model was widely used and developed by other researchers. As shown in Figure 3, this study has modified the TAM model by examining the influence of perceived usefulness, perceived ease of use, and attitude toward infographics on student engagement.

Figure 3: Conceptual Framework of Adaptation Studies from the Acceptance Model (Modification of the TAM Model)



METHODOLOGY

To ensure the selected respondents have specific criteria (i.e., had experience in learning principles of ecology subject), the study respondents consisted of 57 students that were selected using purposive sampling. The instrument used in this study is a questionnaire. The questionnaire is divided into Part A, and Part B. Part A is related to the informant's demographics. Part B relates to students' perceived usefulness, perceived ease of use, and attitude toward infographics on student engagement. Part B questions are accompanied by five Likert scale rating categories to be chosen by the informant, namely (5) Strongly Agree, (4) Agree, (3) Neutral, (2) Disagree, and (1) Strongly Disagree. The instruments for this study are measured and adapted based on past studies such as Davis et al. (1989) and Gonida, Voulala, and Kiosseoglou (2009) (see Table 1).

Table 1: Measurements of Variable

Construct	Item	Reference
Perceived Usefulness	• Using the BIO-CHEM KIT improves my learning performance. • Using the BIO-CHEM KIT increases my learning outcome. • Using the BIO-CHEM KIT enhances my desire to produce the desired result in my learning. • Using the BIO-CHEM KIT is helpful in my learning.	Davis et al. (1989).
Perceived Ease of Use	• I find the BIO-CHEM KIT to be flexible to be used. • The BIO-CHEM KIT functionality and interface are clear and understandable. • Interacting with the BIO-CHEM KIT does not require much mental effort. • Overall, I believe that the BIO-CHEM KIT is easy to use.	Davis et al. (1989).
Attitude	• Using the BIO-CHEM KIT is a good idea. • I like learning with the BIO-CHEM KIT. • I look forward to those aspects of my learning that require using the BIO-CHEM KIT.	Davis et al. (1989).

Student Engagement	• I am taking good notes in the classroom. • I am listening carefully in the classroom. • I am making sure to study regularly. • I am having fun in the classroom. • I participate actively in small-group discussions. • I am helping fellow students. • I asked questions when I needed help understanding the lecturer.	Gonida, Voulala, & Kiosseoglou (2009).

Data were analyzed using Statistical Package for Social Science (SPSS) program. According to Sekaran and Bougie (2016), the instrument of a study is considered to have an acceptable internal consistency if the value of Cronbach's alpha coefficient for each internal scale of the instrument exceeds 0.70 (α value> 0.70). Pearson's correlation test and multiple regression were used to determine whether there was a significant relationship between perceived usefulness, perceived ease of use, attitude towards infographics, and student engagement. To determine whether Pearson correlation and multiple regression could be used, the normality test must be done to see if the data is normally distributed (parametric) or not normal (non-parametric). The skewness (± 2) and kurtosis test (± 7) were used to see the distribution of the data to determine the normality of the data (Kline, 2005). The respondent's answer scale is analyzed based on the mean score value. The mean score value obtained from each dimension of the study will determine the level of each dimension based on the mean range, as shown in Table 2.

Table 2: Level According to the Value of Mean Study Score

Mean Score	Interpretation
1.00 –1.80	Very Low
1.81 –2.60	Low
2.61 –3.40	Moderate
3.41 –4.20	High
4.21 –5.00	Very High

FINDINGS

Section B covers the respondent's background, namely gender, and age. From the results, it can be explained that there are female students, as many as 45 (78.9%), and male respondents 12 (21.1%). Then, most of the respondents were from the age group of 18-20 (n= 52, 91.2%). As shown in Table 3, perceived usefulness with mean = 4.61, standard deviation = 0.46, and the level of score interpretation at a very high level. Then, perceived ease of use with mean = 4.63, standard deviation = 0.45, and the level of score interpretation at a very high level, and attitude with mean = 4.79, standard deviation = 0.40, and the level of score interpretation at a very high level. Finally, student engagement with mean = 4.53, standard deviation = 0.56, and the level of score interpretation at a very high level. In this study, the questionnaire instrument was evaluated using Cronbach's Alpha to determine the reliability value of all the items in the research construct. An alpha value of 0.75-0.92 has high reliability because it is close to an alpha value of 1.00, while items with an alpha value of < 0.60 show a low level of reliability (Sekaran & Bougie, 2016).

Table 3: Mean, Normality, and Reliability Results

Variable	M	SD	Skewness	Kurtosis	Cronbach's Alpha	No. of Items
Perceived Usefulness	4.61	0.46	-0.96	0.20	0.89	4
Perceived Ease of Use	4.63	0.45	-0.95	-0.24	0.75	4
Attitude	4.79	0.40	-1.96	2.70	0.85	3
Student Engagement	4.53	0.56	-1.26	0.97	0.92	7

Table 4: Correlation Results

		Student Engagement
Perceived Usefulness	Pearson correlation	0.600**
	Sig.	0.000
	N	57
Perceived Ease of Use	Pearson correlation	0.476**
	Sig.	0.000
	N	57
Attitude	Pearson correlation	0.738**
	Sig.	0.000
	N	57

The correlation coefficient statistically measures covariance or association between two variables. The magnitude of the correlation coefficient ranges from +1. The correlation coefficient shows the linear relationship's strength and the relationship's direction between two random variables. The two variables have a unidirectional relationship if the correlation coefficient is positive. This means that if the value of variable X is high, variable Y will also be high.

On the other hand, if the correlation coefficient is negative, then the two variables have an inverse relationship. This means that if the value of variable X is high, variable Y will be low, and vice versa. Based on Table 4, it is known that there is a positive correlation between the variable perceived usefulness and student engagement is 0.600 (p<0.05). Then, there is also a positive correlation between the variable perceived ease of use (r=0.476, p<0.05) and attitude (r=0.738, p<0.05) with student engagement.

Table 5: Regression Results

Variable	Beta	Sig.	Tolerance	VIF
Perceived Use	0.218	0.194	0.484	2.068
Perceived Ease	-0.076	0.640	0.512	1.955
Attitude	0.640	0.001	0.468	2.137
R^2	0.567			
Adjusted R^2	0.528			
F Change	14.423			
Sig.	0.000[b]			

The multicollinearity test looks at the magnitude of VIF and Tolerance. The results of VIF value variables are less than ten, and the Tolerance value is more than 0.01. Therefore, the equation model is independent of the symptoms of multicollinearity. Multiple linear regression analysis used correlation coefficient tests (R) and determination (R^2) to determine the percentage of the contribution of independent variables' influence simultaneously to the dependent variable. From Table 5, the value of R^2 is a significant value of 0.567. Therefore, 56.7% of student engagement changes in this study resulted from perceived use, perceived ease, and attitude. At the same time, another 43.3% rate is influenced by other factors. This result's most robust independent variable was an attitude (β=0.640, p=0.001).

DISCUSSION AND CONCLUSION

The study employed the TAM, which coincides with the need for a study researching behavior and acceptance of infographics. Infographics are graphic designs that incorporate data visualization, illustrations, text, and images into a format that can provide a comprehensive explanation. Students' academic

achievement and engagement can be improved using interactive infographics due to their material richness, multimedia approach, and interactivity that stimulate and communicate with learners' senses and positively affect their acquisition of information (Bicen & Beheshti, 2022; Ozdamli & Omdal, 2018). This research contributes to the general knowledge related to an individual's behavior to accept or reject a new approach. Based on the research conducted, it can be concluded that the use of an interactive approach by lecturers not only attracts students to continue actively learning, but students will also be more focused and better understand the content of the subjects learned when the lecturers use elements such as video, graphics, audio, and animation compared to using purely descriptive text. Therefore, its use can be applied in all types of subjects taught in universities to produce students who are not only highly knowledgeable but, at the same time, literate in terms of the use of Information and Communication Technology (ICT), which is highly demanded in this era of globalization.

This study gives implications from a practical point of view to institutions and lecturers practicing the preparation and development of infographics. The designers must focus on the cognitive style of each learner. The design of those approaches must consider the diversity of information presentation methods to meet the various cognitive styles. Then, the university management needs to provide sufficient training for the lecturers. Educators should be able to use editing and drawing application such as Canva, Medibang Paint Pro, Autodesk Sketchbook, and others since they can provide facilities for students to understand or receive information related to the subject taught by the lecturer. It is difficult for lecturers to create infographics that attract people's attention to read them. The lecturers also need to be creative in choosing the suitable font and size of the writing and learn how to organize information so that the reader can quickly understand the information. In addition, virtual learning using the dimensions of e-Learning, Edmodo, Padlet, and various applications accessed through mobile devices should be exposed to the lecturers regularly and intensively so that they can practice it.

This study can help certain parties, especially lecturers and university management, use alternative ICT materials by applying interactive multimedia applications that integrate text, graphics, video, audio, and animation to help convey knowledge in the teaching and learning process. This will encourage lecturers to integrate the latest methods in universities to diversify teaching methods compared to relying on conventional teaching methods or based solely on 'chalk and talk.' At the same time, the use of interactive multimedia in teaching and learning today can produce lecturers and students who are technologically literate.

The findings of this study also contribute to enrichment literature through the role of perceived usefulness, perceived ease of use, and attitude towards infographics on student engagement. Although past studies have examined and employed the TAM model, this study can add to the understanding of the role of the TAM model by testing the influence of its variable on student engagement. However, several limitations in the study design may affect the interpretation of the findings research. First, a cross-sectional study was conducted to get the respondent's perceptions of the determinants that affect student engagement. Cross-sectional studies have many advantages, such as design being more straightforward, cheaper, and enabling form data collection in a short period. However, this method provides limited information about any changes that may occur during the period. Therefore, it is suggested that future studies use a longitudinal design to ensure comprehensive data is obtained. Other than that, all variables in this study are measured using an instrument obtained from one source, i.e., a student. Therefore, the issue of common method variance may affect findings. The discussion of research findings will be more comprehensive if the perception of the influence of factors also considers the views of lecturers or universities. Therefore, it is suggested that future studies consider various methods or sources to minimize common method variance. The researcher also suggests that future study consider other aspects than the influence of perceived usefulness, perceived ease of use, and attitude towards infographics on student engagement. In addition, more accurate statistical analysis methods can be used in the advanced study, for instance, structural equation modeling or hierarchical linear regression, to see more in-depth analyses that may contribute to student engagement.

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