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# Social Media Applications Affecting Students' Academic Performance: A Model Developed for Sustainability in Higher Education

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**Abstract:** Nowadays, social media applications (SMAs) which are quite popular among students have a significant influence on education sustainability. However, there is a lack of research that explores elements of the constructivist learning approach with the technology acceptance model (TAM) in higher education. Therefore, this research aimed to minimize the literature gap by examining the SMA factors used for active collaborative learning (ACL) and engagement (EN) to affect the students' academic performance in measuring education sustainability, as well as examining their satisfaction from its use. This study employed constructivism theory and TAM as the investigation model, and applied a quantitative method and analysis through surveying 192 university students at King Faisal University. Using structural equation modeling (SEM), the responses were sorted into nine factors and analyzed to explain students' academic performance in measuring education sustainability, as well as their satisfaction. The results were analyzed with structural equation modelling; it was shown that all the hypotheses were supported and positively related to sustainability for education, confirming significant relationships between the use of SMAs and the rest of the variables considered in our model (interactivity with peers (IN-P), interactivity with lecturers (IN-L), ACL, EN, perceived ease of use (PEOU), perceived usefulness (PU), SMA use, student satisfaction (SS), and students' academic performance (SAP).

**Keywords:** social media applications (SMAs); students' academic performance; sustainability for education; structural equation modelling (SEM)

## 1. Introduction

The use of social media applications (SMAs) in learning design in higher education may offer diverse educational advantages. For the technology acceptance model (TAM), it facilitates a significant relationship between student satisfaction (SS) and students' academic performance (SAP) [1]. Additionally, the perceived ease of use (PEOU) and perceived usefulness (PU) of SMAs help learners to become more understanding, active, and engage with peers and lecturers [2]. PEOU and PU are statistically significant predictors of satisfaction and acceptance [3,4]. However, SMAs provides challenges in students' academic transition from academy- to university-level educational experiences, which might hinder the SAP on measuring education sustainability [5]. Furthermore, learners who were interactive in the groups stated that they found help to solve problems based on learning [6]. Furthermore, using SMAs could increase learning achievement in active collaborative learning (ACL) environments [7]. Therefore, students have to track and analyze the collaboration patterns that occur

during ACL. ACL and motivating cognitive skills, reflection and metacognition, are fundamental to SMAs for learning [8]. The current research looks at the issues of education sustainability by using SMAs, thus, some studies have demonstrated that a higher level of learning was achieved as a result of using SMAs for student assignments [9]. Similar to many other countries, Saudi Arabia has been hit by the SMA phenomenon [10–12]. However, there is a lack of research on SMA use in Saudi Arabian higher education. Therefore, the current study attempted to minimize the literature gap by examining the use of SMAs for ACL and engagement (EN) to enhance the SAP on measuring education sustainability. The Web 2.0 family are an important part of our daily life activities, with SMAs connecting millions of people, allowing resource sharing, information sharing, collaboration and communication [6]. The model of this study was developed on the basis of the theory of constructivism [13] and the TAM model [14]. This research is also a new step in the research carried out thus far under the two frameworks of constructivism and TAM, whose first results show that ACL is influential in EN and students' academic performance on measuring education sustainability [10,11]. Previous studies have reported negative attitudes towards SMAs from students who believe that most SMAs do not assist them in achieving SAP [15] and are burdensome [16]. Alenazy et al. [17] reported skeptical attitudes of students toward using SMAs to aid them on measuring education sustainability. Others, such as [18], argued that students had a positive attitude toward learning activities combined with SMAs, even though they still preferred direct contact with peers and lecturers. Therefore, additional investigation is needed in the area of attitude antecedents towards SMA use for ACL and on measuring education sustainability [19]. Both psychological and emotional problems such as fear, discomfort, anger, insecurity, and sadness were reported as results of cyberstalking and cyberbullying via SMAs [20–22]. SMAs use effect SAP and ACL on measuring education sustainability however, some users' get risk of being affected by cyberstalking and cyberbullying [20,23]. Therefore, the present research attempts to address this gap in the literature by conducting an investigation on the usage of SMAs for the purposes of sustainability in education that influences both academic performance and student satisfaction. Additionally, these research gaps are related to the fact that earlier models have focused either on interactive elements or perceptual aspects but not both in developing a model [4,8,10]. There is a lack of models regarding student satisfaction and academic performance including the utilization of SMAs in Saudi Arabian higher education [11,21]. Hence, this research aimed to minimize the literature gap by examining the SMA factors used for active collaborative learning (ACL) and engagement (EN) to affect the students' academic performance on measuring education sustainability, as well as their satisfaction from its use.

## 2. Research Model and Hypotheses Development

To facilitate this research, we developed a model illustrated later in Figure 1, which shows the impact of SMA use on interaction, ACL and EN at the King Faisal University. Figure 1 shows the relationship between interactivity with peers (IN-P) and EN, interactivity with lecturers (IN-L) and EN, ACL and EN, PEOU, PU of SMAs and integration of SMAs for EN among students. Based on previous studies related to the constructivist theory and the TAM model [14,24], this research developed 14 hypotheses of how SMAs can affect SAP in Saudi Arabian higher education. Moreover, frameworks that illustrate the adoption of SMAs are based on a temporary element and its impact on sustainability issues are not available for higher education. Accordingly, this research attempts to combine crucial features from the constructivist learning approach and TAM with sustainability for education. See Figure 1.

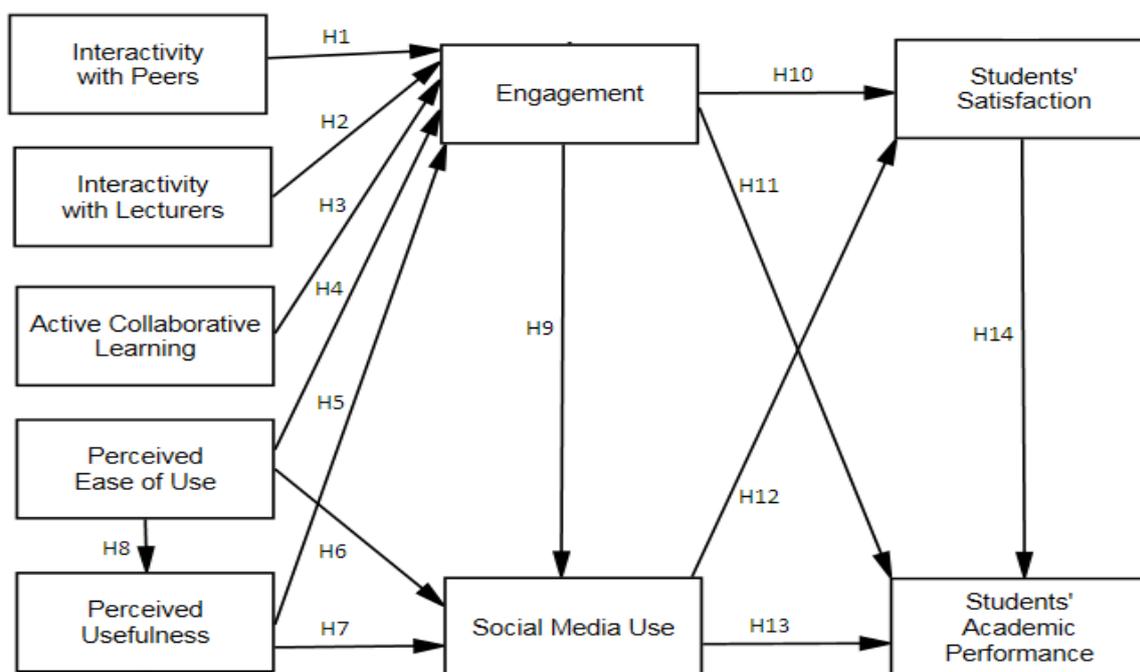


Figure 1. Research model.

### 2.1. Factors of IN-P and IN-L

SMA for learning allow the promotion of discussion among students and lecturers about content and tasks [25]. It has been observed that students in online environments spend more time using SMA to complete their learning processes [26]. These interactions in educational contexts may promote EN in learning communities both for collaboration and communication [27]. Previous studies [28] showed that interaction with group members and peers has a significant relationship with ACL and EN, which could support the idea that IN-P and IN-L affect SAP. Therefore, this research suggested the following hypotheses:

**Hypothesis 1 (H1).** A significant relationship between IN-P and EN.

**Hypothesis 2 (H2).** A significant relationship between IN-L and EN.

### 2.2. ACL

ACL is a situation in which two or more students learn together (e.g., face-to-face or computer-mediated, synchronous or asynchronous) [29]. The effect of SMA use on IN-P facilitates communication and knowledge creation, and thus facilitates ACL [30]. In this regard, SMA enable the creation of spaces for the construction of knowledge as long as it extends learning out of the classroom [26]. Teachers are then responsible for creating a learning design that enhances ACL through SMA [31]. First, the selection of SMA is important, as it is known that different SMA have unique characteristics [32]. Second, the design of elements such as the task or assessment, which can act as facilitators or as barriers for collaboration, should also be considered [33]. Furthermore, online ACL in massive open online courses (MOOCs) has been observed to be positively influenced by the extended confirmation model (ECM), which shows SS, and PU [34]. In previous research stages, the hypothesis about the significant relationship between ACL and EN was supported [4]. Therefore, this research suggested the following hypothesis:

**Hypothesis 3 (H3).** A significant relationship between ACL and EN.

### 2.3. PEOU

TAM, the adaptation of Fishbein and Ajzen's [35] theory of reasoned action by [14], has had a great impact in research measuring the acceptance of technology and SMAs for learning. In TAM, PEOU and PU are major predictors of intention and behavioral usage [36]. PEOU refers to the degree to which an individual believes that the use of a particular technology does not require much effort [14], and in most TAM models, it is considered as linked to ease of use [14]. Early research observed that SMAs that can enhance student learning processes are easy to use [37]. As TAM is a combination of PEOU and PU and other personal and contextual factors, there exists a wide range of TAM variations that combine in diverse ways all these elements along with SAP [36]. In this regard, our model relates fundamental TAM elements such as PEOU and PU along with students' EN, satisfaction and students' academic performance. Therefore, this research suggested the following hypotheses:

**Hypothesis 4 (H4).** *A significant relationship between PEOU and EN.*

**Hypothesis 6 (H6).** *A significant relationship between PEOU and SMA use.*

**Hypothesis 8 (H8).** *A significant relationship between PEOU and PU.*

### 2.4. PU

PU refers to the degree to which a person perceives that the use of a particular technology may influence her or his performance [14]. If a person finds an SMA service useful, he or she will start thinking about it in a positive way [38]. Hsu, Hwang, Chuang, and Chang [39] showed that students using open networks perceived their usefulness and had high intentions to use the online resources. PU was observed as the largest influencer to adopting mobile technology [40–42]. Furthermore, in educational contexts, usefulness was observed by [43] as one of the most relevant factors for teachers to adopt SMAs in their lessons. Therefore, this research suggested the following hypotheses:

**Hypothesis 5 (H5).** *A significant relationship between PU and EN.*

**Hypothesis 7 (H7).** *A significant relationship between PU and SMA use.*

### 2.5. Students' EN

Students' EN is described as the level of emotional involvement and motivation to collaborate during learning [44] as well as the time and work students invest in learning tasks [45]. Furthermore, the personalization SMAs enable and the learning design itself may engage students in knowledge construction, which eventually involves higher levels of perceived learning [46]. When students are engaged in the learning tasks, their performance and results improve [12,44,47,48]. Therefore, this research suggested the following hypotheses:

**Hypothesis 9 (H9).** *A significant relationship between EN and SMA use.*

**Hypothesis 10 (H10).** *A significant relationship between EN and SS.*

**Hypothesis 11 (H11).** *A significant relationship between EN and SAP.*

### 2.6. SMA Use

The use of SMAs contributes to the improvement of students' academic performance on measuring education sustainability, which is positively related to SS [8,15,49]. Therefore, this research explored the connection between these different elements in light of Saudi Arabian higher education. SMAs are helpful in enhancing SAP [43], as learners have increased the popularity of SMA usage among students

and lecturers. In literature, SMAs are argued to provide opportunities in learning enhancement through assistance in social learning, encouraging interaction between students and instructors, which enhances ACL and EN [2,43]. Therefore, this research suggested the following hypotheses:

**Hypothesis 12 (H12).** *A significant relationship between SMA use and SS.*

**Hypothesis 13 (H13).** *A significant relationship between SMA use and SAP.*

### 2.7. SS

Satisfaction has been described as the degree to which students' expectations about teaching and teachers are met [44]. It has also been described as the degree to which a person is pleased with previous usage of technology [50,51]. Research has stated that there is satisfaction when learners feel they have achieved learning and they meet their own expected outcomes [51]. SMAs can provide students with opportunities for enjoyment and reduce feelings of isolation, thus providing them with more opportunities for interaction for learning [44]. Thus, this research focuses on the connection between SS and SAP. Therefore, this research suggested the following hypothesis:

**Hypothesis 14 (H14).** *A significant relationship exists between SS and SAP.*

### 2.8. SAP

Students' academic performance on measuring education sustainability is about the achievement of educational aims in terms of the acquisition of knowledge and the development of skills [44]. There is little research on SMAs and students' academic performance [8]. Thus, the current research aimed to explore the relationship among constructivism theory and TAM model to measuring students' academic performance on education sustainability. Therefore, this research considered IN-P and IN-L, ACL, PEOU and PU to be independent variables, and EN and SMAs use to be mediator variables, and the dependent variables were SS and SAP, see Figure 1.

## 3. Research Methodology

For the purpose of the study, we distributed 255 questionnaires, of which 227 were retrieved from the respondents; after the manual analysis of the questionnaires, 12 of 227 questionnaires were respondents incomplete—"students did not finish the survey"—and had to be dropped, making the remaining number 215. Of the remaining 215 questionnaire copies, 11 had missing data—"missing values in the survey"—when entered into SPSS and 12 contained outliers—"the data an abnormal distance from other values in a random sample"—making the number of remaining useable questionnaires 192. Such exclusions were recommended by [52], who related that outliers could lead to inaccurate statistical results and have to be eliminated. For the purpose of the study, we developed a conceptual model using the constructivism theory and TAM model to monitor SS and SAP in adopting the model for education sustainability. The questionnaire was sent to two experts to evaluate the validity content; the experts were selected based on their expertise and research interests in the adoption of studies, such as expertise on validity content was recommended by [52]. This study investigated the opinions of students on the use of SMAs for ACL and EN to measure SAP in Saudi Arabian higher education, and adoption of the model for education sustainability. The questionnaire used in the present study consisted of both open- and closed-ended questions; 39 questions were designed to collect background information (see Appendix A).

The questionnaire was distributed manually, and the respondents were asked to fill it in anonymously to obtain their feedback on SMA use for ACL and EN, and their view of its influence on SS and ASP on measuring education sustainability. The King Faisal University granted written consent for the data collection, and students could withdraw from the questionnaire at any time without consequences. The collected data were analyzed with structural equation modelling via IBM SPSS

Statistics version 23, and Amos version 23. A total of 192 completed questionnaires were obtained from students, of whom 78 (40.6%) were male and 114 (59.4%) were female. From the respondents, 35 (18.2%) were in the age range of 18–19, 82 (42.7%) were in the age range of 20–21, 50 (26.0%) were in the age range of 22–23, and 25 (13.0%) were over 24 years of age. With regard to the educational background of the undergraduate students, 41 (21.4%) were in level one, 30 (15.6%) in level two, 41 (21.4%) in level three, whereas 80 (41.7%) were in a level four program. The majority of the respondents (94.3%) used SMAs for ACL and EN to affect education sustainability, and the remaining (5.7%) had no interaction with SMAs (see Table 1).

**Table 1.** Demographic profile of respondents.

	Categories	Frequency	%	Cumulative %
<b>Gender</b>	Male	78	40.6	40.6
	Female	114	59.4	100
<b>Age</b>	18–19	35	18.2	18.2
	20–21	82	42.7	60.9
	22–23	50	26	87
	Above 24	25	13	100
	Level 1	41	21.4	21.4
<b>Degree</b>	Level 2	30	15.6	37
	Level 3	41	21.4	58.3
	Level 4	80	41.7	100
	<b>SMAs Use</b>	Actual Use of SMAs	181	94.3
	No use	11	5.7	94.8

#### *Data Collection and Measurement Model*

The questionnaire in this research was adopted from previous researchers for measuring a model. An interaction factor was measured using three items recommended by [2,30,53]. The four items used to measure ACL were adapted from [8,54]. Four items were constructed to assess EN, and these were based on recommendations made by [33,55,56]. In addition, PEOU and PU were measured using six items from [14]. Moreover, four items adapted from [33,57] were used to measure the students' use of SMAs. Four items to investigate SS were constructed from the work of [8,19,58]. Finally, five items of SAP were evaluated using items based on the suggestions of [8,59,60].

## **4. Results and Analysis**

### *4.1. Measurement and Model Analysis*

Kline [61] and Hair et al. [52] suggested the model estimation to be predicted through the maximum likelihood estimation procedures by using the goodness-of-fit guidelines such as normed chi-square, chi-square/degree of freedom, incremental fit index, Tucker–Lewis coefficient, comparative fit index, the parsimonious goodness of fit index, the root-mean-square residual and the root mean square error of approximation, as proposed by [52,62]. Thus, in this research, the measurement model was examined through unidimensionality, reliability, convergent validity and discriminant validity. Table 2 contains the summary of the goodness-of-fit indices used to evaluate the measurement model of SMAs adoption for education sustainability. Table 3 contains the constructs, items and confirmatory factor analysis results (see the questionnaire in Appendix A), and Table 4 displays discriminant validity.

Discriminant validity in this research evaluated SMA adoption for education sustainability by three criteria: correlation index among variables is less than 0.80 [52], the value of average variance extracted (AVE) of each construct is equal to or greater than 0.5, average variance extracted (AVE) of each construct is higher than the inter-construct correlations associated with that factor [63]. Moreover, the constructs, items and confirmatory factor analysis results factor loading of 0.5 or greater is acceptable, Cronbach's alpha  $\geq 0.70$ , and composite reliability  $\geq 0.70$  [52].

**Table 2.** Summary of goodness-of-fit indices for the measurement model.

Type of Measure	Acceptable Level of Fit	Values
Chi-square ( $\chi^2$ )	$\leq 3.5$ to 0	2753.98
Normed chi-square ( $\chi^2$ )	More than 1.0 and less than 5.0	2.143
Root-mean-square	Close to 0 (perfect fit)	0.034
Incremental fit index	$\leq 0.90$	0.914
Tucker–Lewis co-efficient	$\leq 0.90$	0.908
Comparative fit index	$\leq 0.90$	0.914
Root mean square error	Below 0.10 a very good fit	0.040

**Table 3.** Constructs, items and crematory factor analysis results.

Constructs and Items		Factor Loading	Composite Reliability	Average Variance Extracted	Cronbach's Alpha
IN-P	SMA facilitate interaction with peers.	0.784	0.864	0.601	0.896
	Gives me the opportunity to discuss with peers.	0.795			
	Allows the exchange of information with peers.	0.825			
IN-L	SMA facilitate IN-L.	0.705	0.922	0.641	0.752
	Gives me the opportunity to discuss with lecturers.	0.840			
	Allows the exchange of information with lecturers.	0.798			
ACL	I felt that I actively collaborated in my experience.	0.755	0.839	0.562	0.868
	I felt that I have co-created my own experience.	0.796			
	I felt that I had free reign to co-create my own experience.	0.753			
	I am satisfied with active collaboration in my research.	0.891			
EN	I engage in interactions with my peers.	0.835	0.861	0.604	0.838
	I engage in interactions with my lecturers.	0.784			
	I learned how to work with others effectively.	0.720			
	I am satisfied with the EN in my study.	0.850			
PEOU	I feel that using SMA will be easy in my studies.	0.762	0.874	0.630	0.870
	I feel that using SMA will be easy to incorporate in my studies.	0.704			
	I feel that using SMA makes it easy to reach peers.	0.862			
	I feel that using SMA makes it easy to reach lecturers.	0.795			
	Using SMA is clear and understandable.	0.861			
	SMA does not require a lot of my mental effort.	0.838			
PU	I believe that using SMA is useful for learning.	0.773	0.928	0.607	0.878
	I feel that using SMA will help me to learn more.	0.758			
	I believe that using SMA enhances my effectiveness.	0.622			
	SMA enable me to accomplish tasks more quickly.	0.870			
	SMA enhance my learning performance.	0.786			
SMU	SMA enhance effectiveness in my study.	0.855	0.874	0.631	0.791
	I use SMA for interaction with my peers.	0.713			
	I use SMA for interaction with my lecturers.	0.706			
	I use SMA for ACL.	0.766			
SS	I use SMA for EN.	0.819	0.917	0.677	0.814
	I enjoy the experience of SMA use with peers.	0.779			
	I enjoy the experience of SMA use with lecturers.	0.727			
	I am satisfied with using SMA for learning.	0.641			
SAP	I am satisfied with using SMA to improve my study.	0.826	0.929	0.643	0.857
	Has improved my comprehension of the concepts studied.	0.859			
	Has led to a better learning experience in this module.	0.774			
	SMA have allowed me to better understand my studies.	0.794			
	SMA is helpful in my studies and makes it easy to learn.	0.831			
SMA improve my academic performance.	0.803				

**Table 4.** Discriminant validity

	IN-P	IN-L	ACL	EN	PEOU	PU	SMU	SS	SAP
IN-P	0.874								
IN-L	0.799	0.891							
ACL	0.706	0.657	0.876						
EN	0.745	0.706	0.665	0.792					
PEOU	0.727	0.711	0.655	0.635	0.820				
PU	0.626	0.711	0.666	0.617	0.797	0.799			
SMU	0.756	0.700	0.670	0.634	0.754	0.670	0.837		
SS	0.777	0.730	0.647	0.709	0.793	0.680	0.698	0.829	
SAP	0.770	0.729	0.694	0.686	0.715	0.610	0.664	0.714	0.846

4.2. Structural Equation Model Analysis

The influence of interactive factors on SAP and of TAM model factors on SMA use for ACL and EN were examined by employing a path modelling analysis. The results are illustrated and discussed in conjunction with the hypothesis testing results. In the next step of the structural equation model, the authors ran CFA to test the structural model. Thus, Figure 2 shows the structural model (T-values), and Figure 3 shows the valid model and the suitability to test the proposed hypotheses. Table 5 shows the structural model; from the table, it can be clearly seen that the model’s key statistics are very good, indicating a valid model and the suitability to test the proposed hypotheses. The results of this research confirm that SMA use positively affects SS and SAP on adoption model in education sustainability, and they show that all hypotheses were supported. Moreover, the results provide support for the structural model and hypotheses regarding the directional linkage between the model’s variables. The parameters of the unstandardized coefficients and standard errors of the structural model are shown in Table 5.

Table 5. Regression weights.

H	I	R	D	Estimate	SE	CR	t	p	Result
H1	IN-P	→	EN	0.088	0.042	2.098	0.147	0.036	Supported
H2	IN-L	→	EN	0.137	0.059	2.327	0.156	0.020	Supported
H3	ACL	→	EN	0.335	0.071	4.742	0.511	0.000	Supported
H4	PEOU	→	EN	0.199	0.076	2.612	0.276	0.009	Supported
H5	PU	→	EN	0.185	0.074	2.494	0.246	0.013	Supported
H6	PEOU	→	SMU	0.272	0.081	3.373	0.362	0.000	Supported
H7	PU	→	SMU	0.193	0.081	2.394	0.248	0.017	Supported
H8	PEOU	→	PU	0.806	0.038	21.39	0.840	0.000	Supported
H9	EN	→	SMU	0.184	0.073	2.511	0.176	0.012	Supported
H10	EN	→	SS	0.477	0.052	9.108	0.481	0.000	Supported
H11	EN	→	SAP	0.419	0.063	6.684	0.366	0.000	Supported
H12	SMU	→	SS	0.290	0.064	4.516	0.304	0.000	Supported
H13	SMU	→	SAP	0.268	0.067	3.974	0.243	0.000	Supported
H14	SS	→	SAP	0.361	0.072	4.999	0.313	0.000	Supported

Notes: I: independent; R: relationship; D: dependent; CR: critical ratio; t: t-value; p: p-value; SE: standard error. H: hypothesis.

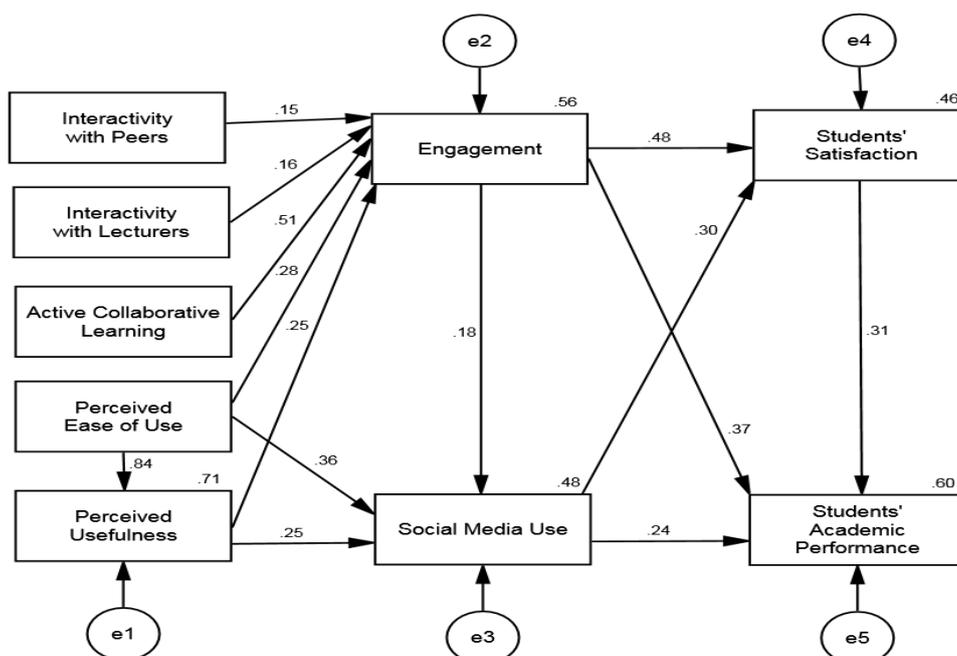


Figure 2. Results of the structural model (T-values).

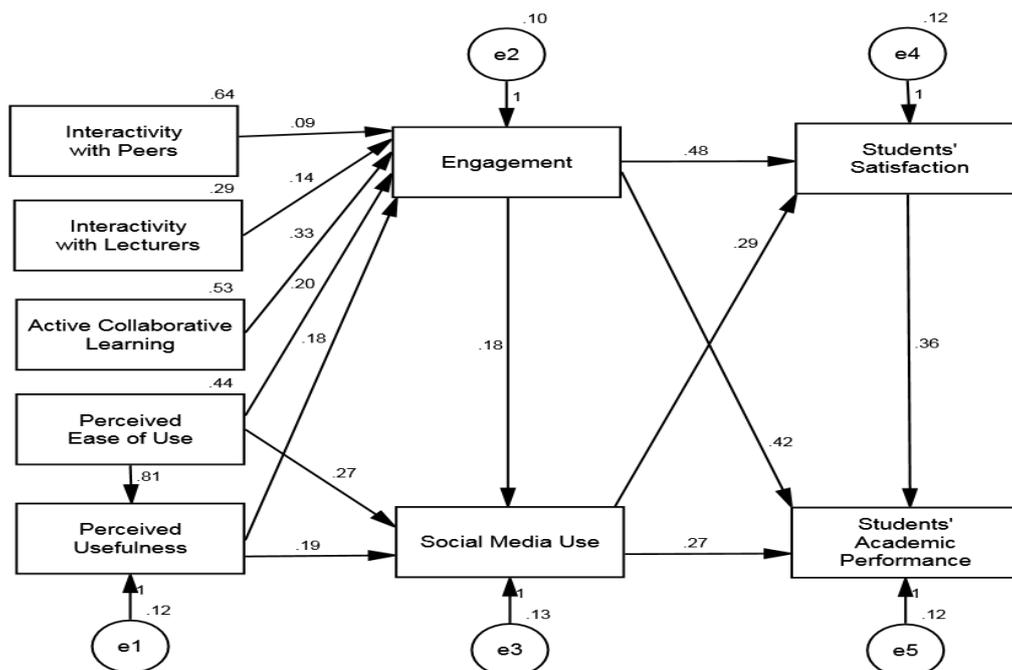


Figure 3. Results of the structural model (hypothesis testing).

### 4.3. Results of Hypothesis Testing

The results of this research, shown in Table 5 and Figures 2 and 3, confirm that IN-P positively and significantly related with EN ( $\beta = 0.888, t = 0.147, p < 0.001$ ). Thus, Hypothesis 1 is supported, indicating the impact of SMAs use on students' interaction and EN for education sustainability. Moreover, IN-L positively and significantly related with EN ( $\beta = 0.137, t = 0.156, p < 0.001$ ). Hence, hypothesis 2 is supported, indicating the impact of SMA use on students' IN-L and EN. Next, the results confirmed that ACL positively and significantly related with EN ( $\beta = 0.335, t = 0.511, p < 0.001$ ). Consequently, hypothesis 3 is supported, indicating the impact of SMA use on ACL and EN on education sustainability. Moving on to the fourth hypothesis, the results show that PEOU positively and significantly related with EN ( $\beta = 0.199, t = 0.276, p < 0.001$ ). Therefore, hypothesis 4 is supported, indicating the ease of SMA use for EN among students. Similarly, the results show that PU positively and significantly related with EN ( $\beta = 0.185, t = 0.246, p < 0.001$ ). Thus, hypothesis 5 is supported. The sixth hypothesis proposed that PEOU positively and significantly related with SMA use ( $\beta = 0.272, t = 0.362, p < 0.001$ ). Thus, hypothesis 6 is supported, indicating the ease of SMA use for interaction, ACL, and EN among students. Next, hypothesis 7 confirmed that PU positively and significantly related with SMA use ( $\beta = 0.193, t = 0.248, p < 0.001$ ). Hence, hypothesis 7 is supported, indicating that SMA use is useful for interaction, ACL, and EN among students' adoption for education sustainability. The results further show that PEOU positively and significantly related with PU ( $\beta = 0.806, t = 0.840, p < 0.001$ ). Therefore, hypothesis 8 is supported. Moving on to the mediator factors of the model, the results show that EN positively and significantly related with SMAs use ( $\beta = 0.184, t = 0.176, p < 0.001$ ). Thus, hypothesis 9 is supported, indicating the effect of SMA use on EN among students. Moreover, the results show that EN positively and significantly related with SS ( $\beta = 0.477, t = 0.481, p < 0.001$ ). Therefore, Hypothesis 10 is supported, indicating the impact of SMA use on interaction, ACL, and EN among students. Furthermore, the result of this research confirmed that EN positively and significantly related with SAP ( $\beta = 0.419, t = 0.366, p < 0.001$ ). Hence, Hypothesis 11 is supported, indicating that the impact of SMAs use for interaction, ACL, and that EN affects SAP positively an adoption for education sustainability. The second factor is the relationship between SMA use and SS and SAP for education sustainability. The results show that SMA use positively and significantly related with SS ( $\beta = 0.290, t = 0.304, p < 0.001$ ). Thus, Hypothesis 12 is supported, indicating that the

impact of SMA use on interaction, ACL, and EN affects SS positively. Additionally, the next hypothesis confirmed that SMA use positively and significantly related with SAP ( $\beta = 0.268$ ,  $t = 0.243$ ,  $p < 0.001$ ). Therefore, Hypothesis 13 is supported, indicating that the impact of SMA use for interaction, ACL, and EN affect SAP positively. Finally, Hypothesis 14 proposed that SS positively and significantly related with SAP ( $\beta = 0.361$ ,  $t = 0.313$ ,  $p < 0.001$ ). Consequently, Hypothesis 14 is supported, indicating that the impact of SS with SMAs use for interaction, ACL, and EN in turn affects SAP positively adoption for education sustainability.

## 5. Discussion and Implementation

In this research, SMA use adoption for education sustainability in higher education learning activities was confirmed to have a positive effect on SS and SAP, which represents a supporting reason to enhance the educational use of SMAs in Saudi Arabian higher education. These results are aligned with previous reported that SMA adoption for education sustainability positively influences students [4,10,11,27,33,64]. The findings also provide two significant contributions to the constructivism theory and TAM model in the context of education sustainability [10,64]. Therefore, they suggest enhancing SMA use adoption for education sustainability in higher education, SMAs facilitate interaction with peers and lecturers, engagement, and collaboration that enhances student education sustainability. In addition, managers should provide students with support in using SMAs for education sustainability. Furthermore, all hypotheses were accepted, which contradicts what some past studies have reported regarding the negative impact on SAP related to the usage of SMAs [45]. However, previous researchers provided evidence of a positive impact on SAP, noting that the majority of students reported positive perceptions in their courses, including increased ACL, EN and exchange of information compared to face-to-face courses [2,10,21,24,27,64]. The contributions of this research lie in several areas of theoretical, implementation, and empirical analysis. It is worth mentioning that theories are located within and generated from within practice, which in turn acts as grounds for the development of new theories and new practices understood in the context of Saudi Arabia's adoption for education sustainability. It is noted that this may be the first time that constructivism theory has been used in Saudi Arabian higher education, in particular to explore the impact of SMAs on EN to affect SAP adoption for education sustainability. The research has revealed that constructivism theory was an effective theory to be used in conjunction with TAM for the effects of SMA use on students' EN on SAP in Saudi Arabian higher education.

### 5.1. Limitations of the Research

Regardless of its contribution to the research field, the limitations of the research should also be acknowledged. One of them is the sample, which includes only students at a specific higher education level and from a specific Saudi Arabian university; the results could be different in other contexts, even in the same country.

### 5.2. Conclusions

In general, the proposed extension to constructivism theory can also be valid to all cultures, and the research showed that TAM is moveable and can be utilized to examine the use of SMAs for EN in diverse cultures, such as Saudi Arabia in this case. No research so far had been conducted in Saudi Arabian higher education using SMAs for EN to affect SAP through constructivism theory. Thus, the use of constructivism theory in this research could be considered as a major contribution and strongly suggests the variables to use SMAs for ACL and EN among students' adoption for education sustainability, as well as the TAM model in this research could be considered as a major contribution and strongly suggests the variables to use SMAs for PEOU and PU among students' adoption for education sustainability. Another consideration from the research is that it is based on the students' perceptions, which is not always the same thing as real implications in action. The significance that students give to the use of SMAs and their positive assessment related to its possible educational use; future work should study planning guidelines for teachers on ACL with the use of SMAs in different

fields. If elements such as IN-P, IN-L and ACL have a positive impact on students' EN as well as on SS and SAP, as supported by the confirmation of our hypotheses, these are actions that should be boosted in learning activities planned in courses. That can be done, for example, by including activities that involve peer feedback and teacher feedback, and group work. In addition, SMAs that focus on adoption for education sustainability, which means simple, familiar and easy to handle applications, should be carefully selected for learning scenarios in higher education. Future studies in this area must also take into account the teachers and other higher education stakeholders regarding adopting the use of SMAs for education sustainability. Finally, comparing and exploring views from and with other countries could also enrich the results obtained in this research and generate a broader view of how this topic is being dealt with in higher education.

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## Appendix A

**Table A1.** Questionnaire.

Factors	Items	Questions
Interactivity with Peers	IN-P1	SMAs facilitate interaction with peers.
	IN-P2	SMAs give me the opportunity to discuss with peers.
	IN-P3	SMAs allow the exchange of information with peers.
Interactivity with Lecturers	IN-L1	SMAs facilitate interaction with lecturers.
	IN-L2	SMAs give me the opportunity to discuss with lecturers.
	IN-L3	SMAs allow the exchange of information with lecturers.
Active Collaborative Learning	ACL1	By using SMAs I felt that I actively collaborated in my experience.
	ACL 2	By using SMAs I felt that I have co-created my own experience.
	ACL3	By using SMAs I felt that I had free reign to co-create my own experience.
	ACL4	By using SMAs I am satisfied with active collaborative in my research.
Engagement	EN1	By using SMAs I engage in interactions with my peers.
	EN2	By using SMAs I engage in interactions with my lecturers.
	EN3	By using SMAs I learned how to work with others effectively.
	EN4	By using SMAs I am satisfied with the EN in my studies.
Perceived Ease of Use	PEOU1	I feel that using SMAs will be easy in my studies.
	PEOU2	I feel that using SMAs will be easy to incorporate in my studies.
	PEOU3	I feel that using SMAs makes it easy to reach peers.
	PEOU4	I feel that using SMAs makes it easy to reach lecturers.
	PEOU5	Using SMAs is clear and understandable.
	PEOU6	SMAs do not require a lot of my mental effort.
Perceived Usefulness	PU1	I believe that using SMAs is useful for learning.
	PU2	I feel that using SMAs will help me to learn more.
	PU3	I believe that using SMAs enhances my effectiveness.
	PU4	SMAs enable me to accomplish tasks more quickly.
	PU5	SMAs enhance my learning performance.
	PU6	SMAs enhance effectiveness in my studies.
Social Media Use	SMU1	I use SMAs for interaction with my peers.
	SMU2	I use SMAs for interaction with my lecturers.
	SMU3	I use SMAs for active collaborative learning.
	SMU4	I use SMAs for engagement.
Students' Satisfaction	SS1	I enjoy the experience of using SMAs with peers.
	SS2	I enjoy the experience of using SMAs with lecturers.
	SS3	I am satisfied with using SMAs for learning.
	SS4	I am satisfied with using SMAs to improve my studies.
Students' Academic Performance	SAP1	Has improved my comprehension of the concepts studied.
	SAP2	Has led to a better learning experience in this module.
	SAP3	SMAs have allowed me to better understand my studies.
	SAP4	SMAs are helpful in my studies and make it easy to learn.
	SAP5	SMAs improve my academic performance.

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