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In their own voices: a nationwide study of students' attitudes towards the implementation of smart learning environments in UAE schools

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Abstract

A smart learning environment (SLE) encompasses the use of advanced technology and smart pedagogical teaching skills tailored to suit students with diverse learning needs. In recent years, some countries, such as the United Arab Emirates (UAE), have formulated policies to implement SLE in their education systems. Since students are the intended beneficiaries of SLE policy, it is crucial to explore their perceptions of its implementation in a novel context. Therefore, this study explored the attitudes of students towards the implementation of SLE in the UAE. To conduct this investigation, 1857 secondary school students (grades 7 and 12) were recruited nationwide. A newly developed instrument was employed to collect data, which were then subjected to exploratory and confirmatory factor analyses to understand its dimensions and validate the factor structure, respectively. Subsequently, the mean scores were calculated and multivariate variance analysis, structural equation modelling, and moderation analysis were conducted to test three specific hypotheses. The results identified ambivalence among students regarding the implementation of SLE and significant differences between them based on their school location and study grade. Additionally, this study discussed the need for nationwide stakeholder engagement to deliberate on the scope, innovation of technological devices and necessary teacher development for efficient SLE implementation.

Keywords: Smart learning environment, Integration, Student, Policy, Learning, Technology, United Arab Emirates

Introduction

In recent years, the introduction of new technologies and ways of thinking have significantly impacted educational and training practises at various levels (Demir, 2021), ultimately resulting in smart learning environments (SLEs) becoming increasingly popular in educational settings (Dron, 2018; Temdee, 2014). While discussions on the importance of SLE are still ongoing, there is a noticeable lack of consensus regarding

its conception. For instance, one definition emphasises the use of smart technology as the foundation of SLE, with pedagogy assuming a subordinate role to digital tools (Zhu & He, 2012). Another perspective states that SLE is a "smart environment supported by smart technologies" that utilises intelligent tools and devices (Zhu et al., 2016). The focus on technological devices in these definitions downplays the significance of pedagogical aspects in developing an effective SLE, since an SLE that only involves smart digital resources would be highly inadequate (García-Tudela et al., 2021). Therefore, this study conceptualized SLEs as physical spaces that incorporate technology or digital devices and tools to enhance the learning experience (Koper, 2014; Yu & Qi, 2018). These environments aim to facilitate and accelerate learning by offering mechanisms for controlling, stimulating and supporting the various processes involved in education-related cognitive and behavioural changes (Koper, 2014).

The goal of SLEs is to create high-level digital environments that promote easy, engaged and effective learning for students (Cheung et al., 2021; Gros, 2016; Hwang, 2014; Koper, 2014; Peng et al., 2019; Spector, 2014; Sumadyo et al., 2018). Huang et al. (2013) introduced this concept in response to the demands of a new generation of students for reform in the learning environment. Compared to traditional learning environments, SLEs use a combination of learning objects and smart mobile technologies to facilitate active learning experiences tailored to suit the unique needs and contexts of individual learners (Cheung et al., 2021; Huang et al., 2013; Zhu et al., 2016). However, the end goal of SLEs is not only to facilitate the use of technology but also to ensure that each student, regardless of their ability, is provided the requisite learning support to enhance their participation and success.

Learning takes place when students are able to understand concepts and transfer knowledge into practice (Spector, 2014; Sumadyo et al., 2018). In this context, the implementation of SLE suggests the creation of a conducive environment for students to maximise their learning potential (Gros, 2016; Hwang, 2014; Koper, 2014). Such an environment makes use of a variety of tools and resources, such as intelligent agents, big data analytics, mobile technologies, augmented reality devices, and virtual learning spaces, to offer engaging and effective learning experiences (Videla et al., 2021). Moreover, SLEs can help bridge the gap between formal and informal learning settings, thus enabling students to learn at a time and place of their choice (Yu et al., 2022). SLEs promote active learning experiences and, as such, could significantly improve students' learning achievement, motivation and attitude, as well as their problem-solving abilities (Lin, 2019). Furthermore, previous studies investigating the impact of SLE on academic performance have found that students using SLEs attain significantly higher grades than those who do not (Al-Naqbi & Mustaffa, 2021; Ghasemi et al., 2018; Jena, 2013). These instances lend ample support to the implementation of SLE in the education systems of countries.

Despite the numerous advantages associated with SLEs, they require certain mechanisms to be implemented before implementation. This includes, but is not limited to, encouraging stakeholders to embrace technologies, ensuring the availability of adequate resources and finding high-quality technologies (Sumbul & Faisal, 2018). Other critical areas that educators ought to address include the integration of technology into the curriculum (Price, 2015), personalization, self-regulation, and maintaining autonomy

between informal and formal learning (Gros, 2016). Additionally, attention should be paid to providing students with personalised services to develop their interest in SLEs (Cheung et al., 2021; Zhu et al., 2016). Finally, it is crucial to consider innovative forms of assessment and the use of learning analytics in teaching (Cheung et al., 2021).

These challenges highlight the need for countries to develop systems for the effective implementation of SLE that account for the technology and human resources necessary to deliver lessons to students. Notably, countries such as the UAE have already taken the first step towards the implementation of SLE (Al-Okaily et al., 2020; Hasan et al., 2018; Huang et al., 2013; United Arab Emirates Government Portal, 2023). However, limited research has been conducted on students' experiences and attitudes towards the implementation and use of SLE. Given that students are directly affected by events or policies related to their education, this study explored their attitudes towards the implementation of SLE in the UAE.

Theoretical framework

Among the multiple scholars who have discussed their understandings of the concept of SLE (Demir, 2021; Spector, 2014; Sumadyo et al., 2018; Temdee, 2014), this study employed Spector's (2014) classification of the three foundational areas in which SLE can be developed—epistemology, psychology and technology. The components of Spector's foundational model have been cited by other theoretical lenses (Demir, 2021; Dron, 2018; Huang et al., 2013; Hwang, 2014; Peng et al., 2019; Sumadyo et al., 2018), thus supporting its use in this study.

The current study accounted for all three tenets, the first being epistemology, which pertains to the development of SLE to suit the needs of the intended target (Spector, 2014). Given that the student or the learner is at the centre of the learning process (Demir, 2021; Dron, 2018; Gambo & Shakir, 2021; Gros, 2016), the development of a new system ought to primarily advance their learning. Therefore, one of the goals of SLE is to design a system that benefits learners with different needs and in various contexts. In other words, the success of an SLE depends on successful interactions between the learner and the system (Gambo & Shakir, 2021). As a result, this study assumed that if students rate the implementation of SLE as favourable, the system can be considered as having the ability to advance their learning.

The second tenet proposed by Spector (2014) is the role of psychology in the implementation of SLE. Psychology encompasses both behaviourism and cognitivism (Spector, 2014). Notably, human behaviour has been subjected to various measurements to determine its impact. In the case of the implementation of a policy, the outcome determines its success, which can be measured from the perspectives of its stakeholders. In this study, these stakeholders are the students who are the main beneficiaries of policies such as SLE, as they would be able to provide valuable feedback on the successful use of SLE (Sumadyo et al., 2018). In other words, once students attain an in-depth understanding of the novel SLE, they would also be able to measure its effectiveness.

The last tenet mentioned by Spector (2014) is technology, which relates to the development of innovative technology to optimise learning for all students. Currently, numerous technologies are available in the market and used in schools to support teaching and learning (Huang et al., 2013; Koper, 2014; Temdee, 2014). However, an SLE environment

must comprise a technological device capable of providing guidance to students, providing corrective feedback, identifying problem areas and offering directions accordingly (Spector, 2014). This implies that devices deployed in an SLE environment should be flexible, efficient and effective (Huang et al., 2013; Spector, 2014). Moreover, these functions should also be known to students so that they can report on the contribution of these devices to their learning as compared to other technological tools.

The current study supposed that synergy between epistemology (used as proxy for attitude towards policy), psychology (used as proxy for attitude towards learning) and technology (used as proxy for attitude towards technology) is a necessary prerequisite for students to benefit from the implementation of SLE. Drawing on this context, the current study determined the effectiveness of SLE based on self-reported feedback from stakeholders—the students—who are its actual beneficiaries.

Students' attitudes towards smart learning environments

In general, attitude refers to people's thoughts and feelings about a factor that influences their behavior and actions (Haddock & Maio, 2008). While conceptualizing the theory of planned behaviour, Ajzen (1991, 2011) identified the origin of attitude as behavioural belief, which is the strongest predictor of intention towards a given behaviour. This means that when individuals exhibit a favourable attitude towards a given phenomenon, they are more likely to engage or benefit from it. In educational contexts, attitudes can significantly impact students' academic performance and their overall learning experience (Barandalla et al., 2018), considering that their effect on students' motivation, engagement and persistence towards completing academic tasks is quite significant (Cazan, 2015). In addition, attitudes can shape students' perceptions and beliefs about their own abilities and the importance of learning (Caldwell et al., 2021). As a result, understanding students' attitudes towards the different aspects of the SLE, such as technology and instructional methods, is crucial for educators and school leaders to design effective and engaging learning experiences that promote student success.

As stated above, the integration of technology into the learning process is commonly referred to as technology-enhanced learning or SLE (Yu & Qi, 2018)—an innovative educational system that combines advanced technology and data-driven approaches to create a dynamic and personalised learning experience for students (Koper, 2014; Spector, 2014). In the field of education, the terms "smart" or "intelligent" are often associated with specific spaces, such as smart universities or smart classrooms, that may draw different interpretations. However, they should not be mistaken with the mere provision of technology (hardware and software) in a physical classroom, which is commonly referred to as "technology-enriched classrooms" (Kurt, 2014; Wakil et al., 2017). Moreover, these terms can also be connected to pedagogical practices, such as smart learning and smart teaching methods (Heinemann & Uskov, 2018). Notably, in recent times, this term also pertains to leveraging the power of artificial intelligence, learning analytics and adaptive learning algorithms to tailor educational content and resources to individual students' needs. By integrating smart hardware and software technologies, an SLE serves to enhance student engagement, flexibility and motivation in their educational journey.

Most previous studies have emphasised the positive attitudes of students towards the usage of technology (e.g. tablets) in the classroom (Dron, 2018), as it enhanced their

learning experiences by offering new ways of accessing information and participating in class activities (O'Malley et al., 2014). Moreover, studies have confirmed that technology offers both convenience and flexibility in completing assignments and accessing educational resources (Pelliccione et al., 2019). Similarly, factors such as ease of use, content quality, technical support, and instructor support have been observed to play crucial roles in shaping students' attitudes towards smart learning systems (Alsabawy et al., 2016). These findings underscore the importance of accounting for the above-mentioned determinants to improve the perceived usefulness of e-learning systems and, in turn, improve students' overall experience (Alsabawy et al., 2016). Students perceived SLEs to be engaging, flexible, capable of offering both feedback and personalised support in the learning process (Nurjanah & Pratama, 2020), and useful for communicating with teachers and peers (Hasan et al., 2018). Furthermore, they appreciated the use of technology in SLEs, which they claimed made learning more effective and efficient (Nuraini et al., 2021). However, some students also expressed concerns about the technology used in SLEs, which could replace traditional face-to-face interactions with teachers and other students (Ahmad et al., 2021; Demir, 2017). In addition, some students may also encounter technological barriers, such as scarcity of technological infrastructure, limited access, lack of digital skills or insufficient training in using SLEs (Berkowsky et al., 2017; Hasan et al., 2018).

Smart learning environments in the Arab world

The last decade has seen the Arab world directing a moderate level of attention to SLEs. Although the potential benefits of SLEs have been consistently reported, Arab educational institutions face significant barriers to their implementation (Ali & Magalhaes, 2008; Assaf et al., 2022; Tlili et al., 2020), which includes policy imbalances among Arabian countries (Tlili et al., 2020). While some countries are making steady progress in developing policies for the integration of SLE into their educational systems, others lack coherent SLE policies (Tlili et al., 2020). For instance, the Arab region has low Massive Open Online Courses participation (Adham & Lundqvist, 2015), which is a result of the lack of appropriate understanding and knowledge about the utilisation of online learning resources among teachers (Assaf et al., 2022). According to Tlili et al. (2021), Arab students also face difficulties in adapting to the self-directed nature of an SLE, as it conflicts with their cultural preferences and beliefs. Additionally, since the educational culture in the Arab world is driven by competition, students would not be intent on participating in an SLE if competition was not incorporated into it. Notably, in the Arabian context, SLEs are favoured more by female students, who are usually more culturally reserved (Tlili et al., 2021). Considering the regional imbalances among Arabian countries, formulation of contextual policies has been recommended to drive the implementation of SLE (Ruipérez-Valiente et al., 2019).

Although the UAE is a pioneer in the development and implementation of SLE, studies on its students' attitudes towards SLE are scarce. One such study that conducted an SLE pilot found that students from selected schools had positive attitudes towards SLE implementation, with the students emphasising that smart technology-based learning had improved the quality of their learning process (Galil, 2014). Subsequently, Al-Naqbi and Mustaffa's (2021) study on the successful integration of SLE in schools reported a

significant relationship between smart technology and smart pedagogy, while also recommending steps to achieve synergy between the two. In the case of higher education studies, Al-Emran et al. (Al-Emran & Shaalan, 2015; Al-Emran et al., 2016) and Almekhlafi and Shaban (2021) identified mobile learning (M-learning) as an effective pedagogical tool for implementation in higher education settings in Arab Gulf nations (Al-Emran et al., 2016). In contrast, Al-Emran et al. (2016) reported significant differences in attitudes towards mobile learning (M-learning) among students and educators with regard to smartphone ownership, country and age. Nonetheless, each of these studies used a very narrow lens to study diverse attitudes towards SLEs. Specifically, in the context of the UAE, it is evident that the relationship between awareness about policy, availability of technology and students' learning has yet to be studied in detail.

During the COVID-19 pandemic, e-learning and technology were actively adapted and used in all educational contexts. For example, despite challenging circumstances during the COVID-19 pandemic, such as a lack of social interaction and technical difficulties, university students in Jordan developed a favourable attitude towards smart e-learning systems and recognised their importance in facilitating the learning process (Al-Okaily et al., 2020). Moreover, it has been noted that over 70% of students' perceptions of the usefulness of and satisfaction with e-learning systems in the UAE are influenced by the quality of information offered, the system's use, the importance of online learning, and the students' prior experiences with e-learning tools (Chaudhry et al., 2021). Similarly, Islam et al. (2023) found that students in UAE universities display positive attitudes (84%) towards utilizing the additional EdTech skills recommended by their virtual classroom (VC) teachers, signifying their motivation to continue their studies on the VC platform during the COVID-19 crisis. This research also highlighted the motivation of UAE university students to employ information and communication technology (ICT) for VC classes. Nonetheless, although studies have reported the successful integration of technology in higher education in the UAE, the same conclusion could not be made for the lower levels of education due to lack of empirical study.

In conclusion, the attitudes of students in Arab countries towards adoption of SLE are mixed (Almutairi et al., 2022; Asif et al., 2022; Shorfuzzaman & Alhussein, 2016). While some students are enthusiastic about the opportunity to access high-quality education and resources online, others have reservations due to cultural or technological barriers. However, a growing recognition of the potential benefits of SLE has been observed in the Arab region. Therefore, the current study expands on the previous literature by conducting a nationwide study of students' attitudes towards the implementation of SLE in an Arabian country—the UAE. The findings of this study could be relevant to policymakers and educators committed to the widespread adoption of SLE in the Arab region.

Contextualisation of smart learning environments in the UAE

The UAE's Ministry of Education (MOE) has implemented several policies and initiatives to promote the development of SLEs, with the aim of integrating technology into educational settings and enhancing student learning experiences. For instance, His Highness Sheikh Mohammad Bin Rashid launched the Mohammad Bin Rashid Smart Learning Initiative in April 2012 with the objective of advancing and elevating education to meet the highest standards and to serve as a fundamental element of UAE Vision 2021

(United Arab Emirates Ministry of Education, 2012). Notably, this e-learning initiative is closely intertwined with the overall digital transformation occurring across all government sectors and organisations in the country (Barakat, 2012). The initiative promotes the integration of technology into classrooms, the use of digital content and resources and the adoption of innovative teaching and learning methods. As part of this project, approximately 400 campuses in the UAE are being equipped with state-of-the-art 4G networks and smart devices loaded with educational content (United Arab Emirates Government Portal, 2023).

Apart from this, UAE Vision 2021 particularly emphasises the importance of building a knowledge-based economy that promotes innovation in various sectors, including education. In view of this, it has set the goal of providing high-quality education that is aligned with the demands of the future through the integration of technology into the learning process. Furthermore, the National Innovation Strategy of the UAE, which focuses on fostering innovation and entrepreneurship across different sectors (The Prime Minister's Office at the UAE Ministry of Cabinet Affairs, 2015), aims to promote the use of advanced technologies, such as artificial intelligence, robotics and data analytics, in education to improve teaching and learning processes. Notably, the smart learning initiatives outlined in the National Innovation Strategy of the UAE demonstrate a strong commitment to leveraging education as a catalyst for social development and progress in the future.

Through initiatives such as the Mohammed bin Rashid Smart Learning Programme, the Think Science programme, and the Emirates Skills programme, the UAE aims to empower its youth, promote innovation and equip students with the skills and knowledge necessary for the twenty-first century (The Prime Minister's Office at the UAE Ministry of Cabinet Affairs, 2015). These examples indicate that the country is taking significant steps to prepare its students for the demands of a knowledge-based economy by embracing smart learning and integrating technology into education. However, in this context, it is crucial to ensure a balanced approach that combines technology with effective pedagogy and addresses equity concerns so that all students benefit equally.

The current study

Although literature on attitudes towards SLE in different Arabian contexts exists, there is an obvious lack of nationwide research specifically focused on secondary school students' attitudes towards SLE implementation in Arab countries. This gap in the literature limits our understanding of the potential benefits or challenges that are unique to the implementation of SLEs in such a context. Furthermore, most existing studies have explored students' attitudes towards SLEs in the context of higher education (Al-Emran & Shaalan, 2015; Al-Emran et al., 2016; Almekhlafi & Shaban, 2021) or specific school grades (Galil, 2014). The limited availability of data pertaining to participants under 18 years of age due to the requirement for obtaining parental permission under strict ethical approval protocols is one of the reasons for the dearth of studies on secondary and high school students. The current study contributes to addressing this gap by offering evidence to help understand the attitudes of secondary school students towards SLE

in the UAE. To achieve this aim, the following hypotheses were proposed based on the study framework:

Hypothesis I The three tenets of the SLE framework—epistemology (attitude towards policy), psychology (attitude towards learning) and technology (attitude towards technology)—are interdependent.

Hypothesis II Interactions between epistemology and technology can help predict psychology (attitude towards learning).

Hypothesis III Demographic variables moderate the relationship between epistemology and technology that predicts psychology (attitude towards learning).

Drawing on the above hypotheses, the following research questions were put forward:

1. How do students perceive the implementation of SLE in the UAE?
2. Which demographic variables provide additional information on the attitudes of students towards the implementation of SLE in the UAE?
3. Can attitudes towards policy and technology predict attitudes towards student learning?
4. Which demographic variables moderate the relationship between students' attitudes toward policy and technology to ultimately predict their attitudes towards student learning?

Methods

Participants

The students who participated in this study were recruited from public schools across the UAE, which is a sheikhdom of seven Emirates (Abu Dhabi, Ajman, Dubai, Fujairah, Sharjah, Ras Al Khaimah and Umm Al Quwain) with an estimated population of 9.7 million people. In 2020–2021, all the Emirates together comprised 1760 public schools with 174,120 students in cycles 2 (grades 5–8) and 3 (grades 9–12) (UAE Ministry of Education, 2022). However, the participants in this study consisted of only secondary school students, as the authors believed these students would be able to offer the most accurate accounts of their learning experiences. Furthermore, simple random sampling was employed to recruit the students for this study. The participants were randomly selected from among the students who were available in school on the day of data collection, which ensured that students from heterogeneous backgrounds participated in this study (Burn, 1994).

A total of 1857 students took part in this study, among whom 51% were women (n = 949) and 49% were men (n = 908). In terms of the participants' grade level, 71% were in cycle two (grades 7–9; n = 1317), while 29% were in cycle three (grades 10–12; n = 533). The percentage of schools considered in this study with regard to their geographical locations are as follows: Abu Dhabi 17% (n = 307), Ajman 8% (n = 145), Dubai 9% (n = 170), Fujairah 14% (n = 271), Sharjah 23% (n = 425), Ras

Al Khaimah 26% (n = 489) and Umm Al Quwain 3% (n = 50) (see Table 2 for more details).

Measurement

A two-part questionnaire was formulated for data collection, of which the first part sought the demographic information of the participants—their gender, grade level, and school location. Meanwhile, the second part of the questionnaire comprised a newly developed instrument for measuring student attitude—the Smart Learning Scale (SASLS)—developed based on the components of the UAE's smart learning framework (UAE Ministry of Education, 2017), the theoretical framework guiding this study (Spector, 2014) and a comprehensive review of the literature (Agaton & Cueto, 2021; Gambo & Shakir, 2021). This instrument was composed of 15 items anchored on a five-point Likert scale (see Table 1), with all items being positively worded. Subsequently, composite means, which involved dividing the sum mean by the number of items, were obtained. A score of 4 was interpreted as a positive attitude towards SLE, as well as synergy between epistemology, psychology and use of effective technology for SLE (Spector, 2014).

Notably, the newly developed instrument was subjected to content validation by experts in the field of education technology (Mengual-Andrés et al., 2016), both in the UAE and internationally. The comments from experts regarding modifications,

Table 1 Summary of exploration factor analysis for student attitude towards smart learning scale

	Items	Factor I	Factor II	Factor III
1	I am familiar and I can understand the technology available at my school	0.33		
2	The technology available in my school matches with Students' abilities/ skills/ Interests	0.44		
3	The practice of supporting students to learn with technology in school and home has been properly implemented	0.30		
4	The current technology supports the Inclusion and Learning of all students including those with disability (determination) in Schools	0.47		
5	the current technology in schools ensures the safe and efficient use of digital resources to learn in school and the community			0.30
6	As a student, I am supported to develop technological skills needed to be a successful digital learner		0.43	
7	The existing digital learning resources and tools are accessible to students		0.58	
8	The Current use of technology in schools promotes the motivation, confidence and independence in student		0.38	
9	My teachers have a wide range of skills to teach and guide us to learn effectively using digital tool		0.42	
10	The current technology in schools supports the parental engagement with the school and the community			0.39
11	There is an official training in schools to ensure the appropriate and effective use of the online systems and tools			0.62
12	The online assessment systems are effective			0.42
13	My learning progress, feedback and performance (grades) is effectively measured with digital systems		0.32	
14	I have the appropriate ICT knowledge and skills to complete assignments and tasks through online assessment systems (e.g. Swift assess)		0.37	
15	The classrooms are equipped with reliable high-speed internet and digital tools for learning			0.85

rewriting of items and suggested edits to the demographic information were incorporated in the final version of the questionnaire that was used for data collection.

Before being implemented for this study, the 15-item SASLS was also subjected to exploratory factor analysis. An inspection of the correlation between the 15 items showed that most had a correlation coefficient of at least 0.30. Furthermore, their Kaiser–Meyer–Olkin value was found to be 0.97, exceeding the 0.60 threshold. The result of Bartlett's sphericity test was also significant ($p = 0.001$), thus supporting the factorability of the correlation matrix.

The principal component analysis identified three components with eigenvalues greater than 1, constituting 67%, 5% and 3% of the variance. In addition, observations drawn from the scree plot indicated three-point breaks, which supported the retention of the fixed three-factor structure of the scale (Fig. 1).

Subsequently, the structure of the scale was aligned with the theoretical foundations of this study. For example, factor I ($n = 4$) represented attitude towards policy, aligning with the epistemology of SLE, while factor II ($n = 6$) referred to the attitude towards learning, which corresponded to the psychology of SLE. Finally, factor III ($n = 5$) described the attitude towards technology, which aligned with the technology factor mentioned in Spector's (2014) foundations of SLE.

Furthermore, confirmatory factor analysis was conducted to validate the underlying factor structure. The initial calculation yielded fit indices: chi-square = 13.02 (CMIN = 1132, df = 0.87), comparative fit index (CFI) = 0.96, Tucker–Lewis Index (TLI) = 0.95, root mean square error of approximation (RMSEA) = 0.08, and standardised root mean square residual (SRMR) = 0.03. Moreover, the regression weight of the items was at least 0.50 for the individual items (see Fig. 1). These indices provided theoretical support and validated the underlying structure of SASLS.

Finally, the reliability test of SASLS, conducted using Cronbach Alpha, yielded the following results: total SASLS = 0.96, attitude towards policy = 0.88, attitude towards learning = 0.93 and attitude towards technology = 0.90.

Procedure

The current study and its protocols were approved by the Social Science Ethics Review Committee of the UAE Federal Ministry of Education. The Ministry of Education sent the online questionnaire for this study to schools to be completed by their students. This same process was followed by the Emirates School Establishment, which circulated the questionnaire to public schools within the Emirate of Abu Dhabi.

The data were collected between January 2022 and June 2022. The instrument was constructed in both Arabic and English to enable all students to complete it based on their preferred language of proficiency. All participants read the information statement explaining the study, its potential benefits and the risks to participation. They were assured that their identity or name would not be used in the study report and were informed about their right to withdraw from the study at any time without consequences. Furthermore, parental consent was obtained for the children participating in this study.

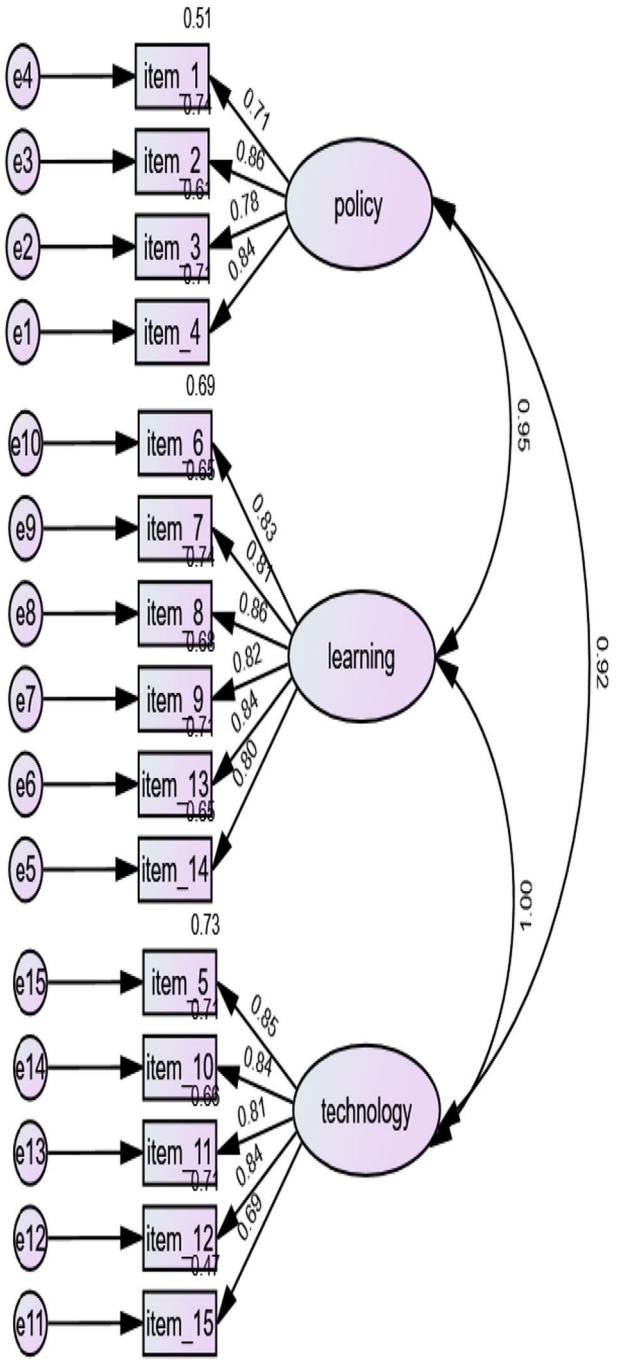

Fig. 1 Confirmatory factor analysis for the attitude of the student toward the smart learning scale

Data analysis

The data were collected through Google Forms before being imported into Microsoft Excel for cleaning. Subsequently, they were transferred to SPSS for analysis. Due to the large sample size, the data were assumed to be normally distributed (Field, 2013).

To answer research question 1, the mean scores were calculated to develop an understanding of the students' attitudes towards implementation of SLEs in the UAE.

For research question 2, multivariate analysis of variance (MANOVA) was computed to measure the differences between the participants with regard to the combined dependent variables (attitudes towards policy, leaning and technology) (Pallant, 2020). Given that the latent variables measured different aspects of the same construct, MANOVA was an appropriate choice for observing the combined and individual differences between the background variables. Therefore, a Bonferroni adjusted alpha level of 0.02 (i.e. 0.05 divided by the number of dependent variables) (Pallant, 2020) was fixed as the baseline to determine the presence of differences between the participants.

To examine research question 3, structural equation modelling (SEM), which is a kind of path analysis, was implemented to comprehend the contribution of attitude towards policy and technology in the variance in attitude towards learning. The following criteria were considered to assess the appropriateness of the model: a chi-square below 5, a CFI score, a TLI score of at least 0.92 and RMSEA and SRMR below 0.08 (Byrne, 2016; Schumacker & Lomax, 2016; Tabachnick & Fidell, 2019).

Finally, addressing research question 4 necessitated using Model 1 of Andrew Hayes' process to estimate the moderating effect (Hayes, 2022). While attitudes towards policy and technology were considered the independent variables, attitude towards learning was used as a dependent variable. Meanwhile, the demographic variables were used as moderators and the following values were set: bootstrapping at 5000, a bias confidence interval of 95% and a maximum significance level of 0.05.

Results

Attitude towards smart learning

The computation of the mean scores yielded the following outcomes: total SASL = 3.79 (SD = 0.83), attitude towards policy = 3.78 (SD = 0.86), attitude towards learning = 3.84 (SD = 0.86) and attitude towards technology = 3.73, (SD = 0.89). (see Table 2 for details related to the individual items).

Differences between students

The differences between the participants' responses were calculated using MANOVA (see Table 3). First, a significant difference was found between the participants regarding the effect of the location of their schools on the combined dependent variables (F (3, 1848) = 2.90, *Wilks' Lambda* = 0.97, p = 0.001, very small effect size, *partial eta squared* = 0.009). Even when considered individually, differences were identified between the participants with regard to the three dependent variables—attitude towards policy (F (6, 1850) = 2.89, p = 0.001, small effect size, *partial eta squared* = 0.009), attitude toward learning (F (6, 1850) = 4.64, p = 0.001, small effect size, *partial eta squared* = 0.02) and attitude towards technology (F (6, 1850) = 3.27, p = 0.003, *partial eta squared* = 0.01).

Subsequently, a post-hoc comparison was conducted using the Tukey HSD test to accurately locate the differences between the participants. Regarding attitude towards policy, disparities were identified only between the students studying in Dubai (M = 3.59, SD = 0.95) and Ras Al Khaimah (M = 3.85, SD = 0.85). However, both did not differ from their counterparts in Abu Dhabi (M = 3.68, SD = 0.95), Ajman (M = 3.79, SD = 0.88), Fujairah (M = 3.82, SD = 0.78), Sharjah (M = 3.81, SD = 0.83) and Umm Al Quwain (M = 3.84, SD = 0.76).

Table 2 Summary of the mean scores for the individual items

	Items	M	SD
	Attitude towards policy		
1	I am familiar and I can understand the technology available in my school	3.87	1.01
2	The technology available in my school matches with Students' abilities/ skills/ Interests	3.69	1.04
3	The practice of supporting students to learn with technology in school and home has been properly implemented	3.80	0.99
4	The current technology supports the Inclusion and Learning of all students including those with disability (determination) in Schools	3.75	0.99
	Attitude towards learning		
6	As a student, I am supported to develop technological skills needed to be a successful digital learner	3.82	1.02
7	The existing digital learning resources and tools are accessible to students	3.87	0.96
8	The Current use of technology in schools promotes the motivation, confidence and independence in student	3.86	0.99
9	My teachers have a wide range of skills to teach and guide us to learn effectively using digital tool	3.84	1.02
13	My learning progress, feedback and performance (grades) is effectively measured with digital systems	3.77	1.01
14	I have the appropriate ICT knowledge and skills to complete assignments and tasks through online assessment systems (e.g. Swift assess)	3.88	0.98
	Attitude towards technology		
5	the current technology in schools ensures the safe and efficient use of digital resources to learn in school and the community	3.92	0.94
10	The current technology in schools supports the parental engagement with the school and the community	3.82	1.01
11	There is an official training in schools to ensure the appropriate and effective use of the online systems and tools	3.67	1.10
12	The online assessment systems are effective	3.74	1.04
15	The classrooms are equipped with reliable high-speed internet and digital tools for learning	3.51	1.17

Table 3 Difference between participants on attitude

	Wilks' Lambda	MANOVA F	ANOVA F		
			Policy	Learning	Technology
Gender	1.00	1.99	0.80	3.21	1.22
Effect size		0.003	0.001	0.002	0.001
Emirate	0.97	2.90**	2.89**	4.64**	3.27**
Effect size		0.009	0.009	0.02	0.01
Grade level	0.98	14.48**	0.93	4.85**	0.26
Effect size		0.02	0.001	0.003	0.001

**$p < .001$

In the case of attitude towards learning, only students from Umm Al Quwain (M = 3.89, SD = 0.79) did not differ from those in the other Emirates (Abu Dhabi, M = 3.71, SD = 0.93; Ajman, M = 3.96, SD = 0.79; Dubai, M = 3.61, SD = 0.97; Fujairah, M = 3.88, SD = 0.81; Sharjah, M = 3.87, SD = 0.79; Ras Al Khaimah, M = 3.91, SD = 0.86). The attitudes of participants from Abu Dhabi differed from those of their Ras Al Khaimah and Ajman counterparts. Furthermore, while the participants from Sharjah differed only from their counterparts in Dubai, those from Ajman and Ras Al Khaimah

differed from their Abu Dhabi and Dubai counterparts. Meanwhile, participants from Dubai differed from their counterparts in all Emirates, except Abu Dhabi.

Regarding attitude towards technology, once again, participants from Umm Al Quwain (M = 3.76, SD = 0.82) did not differ from participants in the other Emirates (Abu Dhabi, M = 3.60, SD = 0.97; Ajman, M = 3.74, SD = 0.85; Dubai, M = 3.54, SD = 0.96; Fujairah, M = 3.79, SD = 0.86; Sharjah, M = 3.79, SD = 0.83; Ras Al Khaimah, M = 3.80, SD = 0.89). The participants from Ajman did not differ from the others as well. However, participants from Abu Dhabi differed from their Ras Al Khaimah counterparts. Additionally, the participants from Dubai differed from their Sharjah and Ras Al Khaimah counterparts. Furthermore, the participants in Ras Al Khaimah differed from those of Abu Dhabi and Dubai.

Differences were also noticed between the participants based on the effect of their grade level on the combined dependent variable (F (3, 1846) = 14.48, *Wilks' Lambda* = 0.98, $p = 0.001$, *partial eta squared* = 0.02). When considered individually, a difference was identified between participants only with regard to their attitude towards learning (F (1, 1848) = 4.86, $p = 0.02$, *partial eta squared* = 0.003). Furthermore, the participants in cycle three ($M = 3.91$, $SD = 0.88$) exhibited higher mean scores than their counterparts in cycle two ($M = 3.81$, $SD = 0.85$).

Path analysis

Figure 2 depicts the relationship between the three subscales—attitude towards learning and technology ($r = 1$), attitude towards policy and learning ($r = 0.95$) and attitude towards policy and technology ($r = 0.92$).

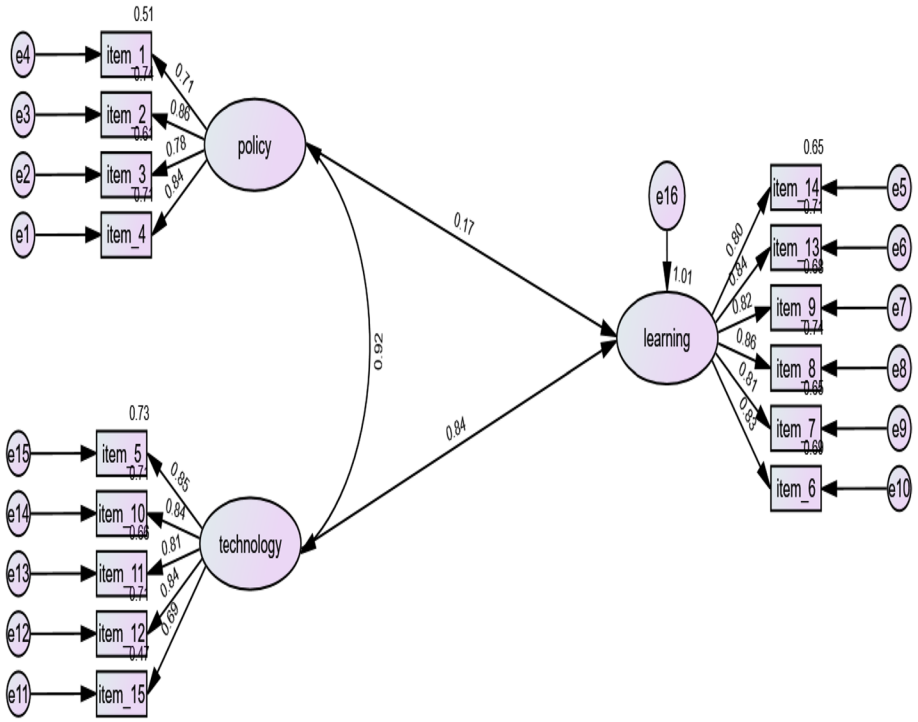

Fig. 2 Contribution of policy and technology in the variance in learning

SEM path analysis was employed to test the contribution of policy and technology to variations in attitude towards learning. The fit indices mentioned above were observed and found to be appropriate. The results showed that attitude towards policy ($b = 0.18$, $p = 0.001$) and technology ($b = 0.84$, $p = 0.001$) made significant contributions to the variance in the attitude towards learning (see Fig. 2).

Moderation effect of demographics

Moderation analysis was performed using Model 1 of Andrew Hayes' moderation method to estimate the influence of demographic variables on the relationship between the predictors (attitudes towards policy and technology) and the outcome variable (attitude towards learning) (see Table 4).

The results revealed that only the level of education could moderate the relationship between attitudes towards technology and learning (b = −0.06, 95% CI (−0.11, −0.02), t = −2.77, p = 0.005). At the individual level, both the level of education (b = 1.56, p = 0.002) and attitude towards technology (b = 1.13, p = 0.001) were observed to be significant predictors of attitude towards learning. Furthermore, in the case of the students

Table 4 Summary of the moderation effect of demographic variables

	Beta	S.E.	t	p	Confidence interval	
					Lower	Upper
Gender						
Policy × learning	−0.05	0.04	−1.45	0.15	−0.12	0.02
Technology × learning	0.01	0.02	0.54	0.58	−0.03	0.06
Emirate						
Policy × learning	−0.01	0.009	−1.24	0.21	−0.03	0.006
Technology × learning	−0.008	0.006	−1.44	0.15	−0.02	0.003
Educational level						
Policy × learning	−0.03	0.04	−0.92	0.36	−0.10	0.04
Technology × learning	−0.06	0.02	−2.77	0.005**	−0.11	−0.02

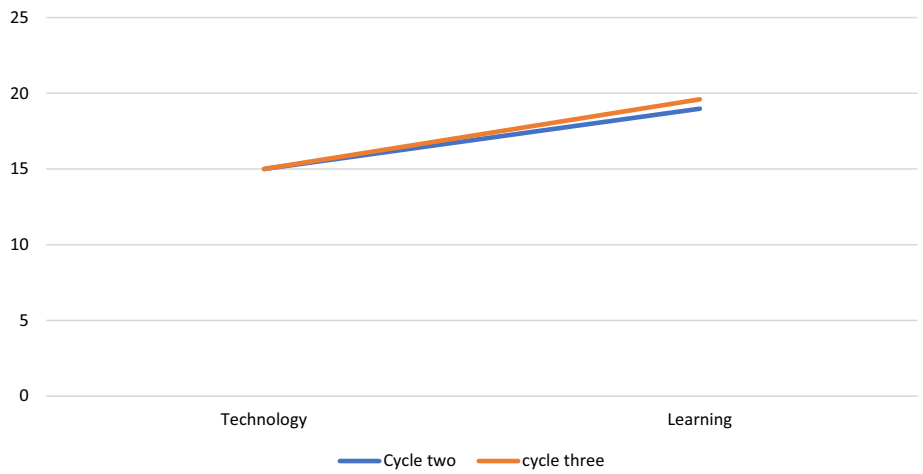

Fig. 3 Moderation effect of grade level on relation between attitude toward technology and learning

in cycle two, a significant difference was found between their attitudes towards learning and technology (b = 1.07, 95% CI [1.05, 1.11], t = 81.30, p = 0.001). Similarly, for students in cycle three, a significant difference was identified between the dependent and independent variables (b = 1.01, 95% CI [0.97, 1.05], t = 53.34, p = 0.001).

As shown in Fig. 3, it was observed that interactions among students often differed from each other. While the students belonging to cycles two and three did not differ regarding their attitude towards technology, the students of cycle three exhibited a more positive attitude towards learning than those of cycle two.

Discussion

This study investigated the attitudes of students towards the implementation of SLE in UAE schools by evaluating their feedback on the efforts to integrate SLE into their school education system, ultimately identifying an ambivalence in their attitudes towards SLE. This implies that the students who participated in this study were uncertain about the impact of SLE on their learning. Notably, this finding is inconsistent with those of previous studies conducted among university students in the UAE (Al-Emran et al., 2016; Galil, 2014; Islam et al., 2023) and similar contexts (Alsaffar et al., 2022; Ameen et al., 2018), which largely reported positive student attitudes towards using technology to support learning. The reason for this discrepancy may be attributed to the participants' lack of engagement with SLE before its implementation in their schools. In this context, it must be mentioned that SLE does not simply refer to the mere provision of technology—it includes tailoring instructions and devices to suit the unique needs and abilities of students (Cheung et al., 2021; Zhu et al., 2016). Therefore, as suggested by Ruipérez-Valiente et al. (2019), the implementation of SLE should be guided by appropriate technology and teaching pedagogy. In this context, it may be useful for policymakers to assess existing systems in schools to determine whether they cover or meet the required standards for the implementation of SLE.

Notably, the findings of this study supports Hypothesis I, as interrelationships were identified among the components of the study framework. A linear relationship between the three tenets (policy, technology and learning) was identified, meaning that an improvement or availability of one has the potential to impact the other. These findings are partly consistent with those of a previous UAE-based study by Al-Naqbi and Mustaffa (2021), which reported a significant relationship between smart technology and pedagogy. The results indicate that the participants of the current study realised that learning in SLE encompasses the institutionalization of a multiplicity of measures. Furthermore, these findings support Spector's (2014) proposed foundation for the implementation of SLE.

Previous studies have already suggested that countries or education systems considering the implementation of SLE should first deploy innovative technological tools that suit various students (Hwang & Fu, 2020). In addition, the implementation of SLE must be accompanied by teacher training in pedagogical strategies to equip teachers substantially to teach students with diverse abilities (Garcia-Tudelo et al., 2021). However, in the UAE and similar contexts, concerns have been raised about teachers' competence in teaching students with diverse needs and abilities in classrooms (Ahmad et al., 2021; Demir, 2017; Vasbieva et al., 2018). The integration of SLE into education systems can indeed facilitate student learning, but existing challenges in the education system must

be addressed so that all students can benefit from their participation in education. Therefore, it is strongly recommended that policymakers consider each of the tenets of Spector's theoretical foundation before implementing SLE.

The findings of this study also supports Hypothesis II. Specifically, it was observed that the attitude towards policy and technology contributed positively to the variance in the attitude towards learning. Similarly, in a previous UAE-based study, Galil (2014) reported positive changes in study performance in English when using SLE. Furthermore, studies have reported widespread use of technology among students (Al-Emran & Shaalan, 2015), which might also be the case for the participants of this study because they could effortlessly use various devices for their day-to-day activities, which led them to acquire tangible benefits from using SLE to study. The findings further suggest that SLE would be beneficial for the study participants if appropriate policies and technologies were implemented in the UAE. Fortunately, the UAE government has already taken significant steps in this direction with the development of an SLE policy and continuous investments in learning technology (The Prime Minister's Office in the UAE Ministry of Cabinet Affairs, 2015). However, while these government initiatives are commendable, there is still room for further improvement. For example, the mean scores indicated uncertainty among students about their attitudes towards the implementation of SLE. To address this issue, the UAE government may consider formulating educational reforms based on the trends reported in this study. For example, policymakers may consider stakeholder engagement in discussing the contents of the policy, providing the technology needed by teachers and students and offering substantial training to teachers for the implementation of SLE.

Hypothesis III is partially supported by the findings, with the identification of grade level as having a moderating influence on the relationship between the independent and outcome variables. The calculation of MANOVA and the interaction effect showed a difference between the students with regard to their attitudes towards learning. Specifically, cycle three students expressed a more positive attitude towards learning than cycle two students. Notably, previous studies have reported mixed findings about attitudes towards SLE among students at different levels of education (Al-Emran & Shaalan, 2015; Al-Emran et al., 2016; Almekhlafi & Shaban, 2021). In the current study, the difference between participants may be attributed to the maturity of the students, considering that those in cycle three were likely to be more mature than their counterparts in cycle two. In this context, it must be mentioned that students in cycle three were closer to or had already reached adolescence, which implies that they were in a better position to recount the benefits of an initiative such as SLE and explain the impact of SLE on their learning experiences. However, students from both grades demonstrated ambivalence regarding their attitude towards the implementation of SLE, emphasising the need for concerted efforts to improve systems for SLE implementation and practise. This further calls for more engagement with students at different levels of education to understand their needs and the challenges they face in using SLE.

Notably, a difference was observed between the students based on the location of their schools. However, this difference was not linear but was rather convoluted. In a similar vein, a previous comparative study identified differences between Omani and UAE university students regarding their attitudes towards M-learning (Al-Emran et al., 2016).

Moreover, although the UAE has a federal SLE policy (United Arab Emirates Government Portal, 2023), the various Emirates each have their own supervisory authority. For instance, public schools in Abu Dhabi are supervised by the Emirate School Establishment, while those in Dubai and the other Emirates are managed by the Ministry of Education. Since these agencies have different affiliate offices in their respective jurisdictions that manage and supervise the implementation of policies in schools, it is unclear how each emirate implements SLE. However, exploring the ways in which SLEs are reflected in educational policy was beyond the scope of this study. Future studies may delve into this aspect and investigate the implementation of SLEs in different Emirates and their impact on student learning outcomes.

Study limitations

The current study is not without its limitations and, therefore, caution is necessary in interpreting its findings. First, since the data were collected through schools, there is a possibility of response bias. Since the schools sent the instrument to potential students who self-reported their attitudes towards SLE, one must consider the likelihood of the students responding in a way that the school wanted or in a manner more suitable for social acceptability. Nonetheless, an information statement was available to each potential participant assuring that their responses would remain confidential. Second, it was beyond the scope of this study to verify whether the students themselves had completed the questionnaire. However, since the invitation sent to the students clearly spelt out the inclusion criteria, there was high confidence that the students had filled out the survey themselves. Third, the responses reflected evaluations conducted only by students, as it was beyond the scope of this study to obtain in-depth information from the participants. Future studies may consider using qualitative methods to investigate students' in-depth student experiences regarding the implementation of SLE in the UAE or in a similar context.

Conclusion and practical implications of the findings

This study presents a national assessment of the attitudes of students towards the implementation of SLE. In particular, secondary school students from across the country were recruited to share their perspectives. The theoretical support for this study was drawn from a newly developed instrument to assess the attitudes of students towards SLE. Notably, the results of this study supported both Hypotheses I and II and offered partial support for Hypothesis III. The results identified interdependency among the three tenets, based on the theoretical framework proposed by Spector (2014), that were assessed in this study—attitude towards policy, attitude towards learning and attitude towards technology. Furthermore, this study hypothesised the relationship between the operationalised independent variables (attitude towards technology and policy) and the dependent variable (attitude towards learning). It was concluded that the grade of study actively moderated the relationship between the dependent and independent variables. Overall, it was observed that the students were unsure about their attitudes towards the implementation of SLE—a finding that lends support to the need for making concerted efforts to promote SLE policies and its implementation in schools.

The study findings may have valuable implications for policymaking. For instance, policymakers may consider accounting for the three dependents identified in this study in future policy reforms, which could be achieved through stakeholder engagement in defining the scope and resources needed for the implementation of SLE. Additionally, educational campaigns could be organised to create awareness about SLE among students and to promote its acceptance among its beneficiaries. In particular, this awareness should be directed towards educating students about technology and the teaching approaches used to promote their learning. Moreover, educating students about the three tenets can help improve their attitudes towards SLE. This study further highlights that policymakers should engage with students to understand their needs and challenges as well as to offer appropriate support to improve their learning. Notably, achieving this would require policymakers to gather specific information pertaining to the geographical location of schools and the grade level of students, which in turn would help them access basic information about SLE policies and identify the key areas of improvement for optimising its practise in schools.

Abbreviations

CFI	Comparative fit index
ICT	Information And communication Technology
MANOVA	Multivariate analysis of variance
MOE	Ministry of Education
RMSEA	Root mean square error of approximation
SASLS	Students attitude towards smart learning environment
SLE	Smart learning environments
SRMRM	Standardised root mean square residual
TLI	Tucker–Lewis Index
UAE	United Arab Emirates
VC	Virtual classroom

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Author contributions
ME, MPO, AS, CD, AJ and AM were involved in conceptualization, methodology, data analyses, writing of the draft and review of the manuscript. ME, CD, AJ and AM were involved the investigation and data curation. All authors were involved in the writing of the manuscript, including critical review and editing. All authors approved the final version for publication.

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Declarations

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