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Impact of digitised ‘teaching-learning’ virtual platforms on tertiary students’ learning objectives and teaching outcomes

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ABSTRACT

This study explores and understands the impact of remote teaching using digitised teaching-learning virtual platforms on students’ learning objectives and outcomes in Ghanaian Universities. Using a self-administered questionnaire, quantitative data from four hundred and four graduate students whose courses were delivered online due to the COVID-19 pandemic were gathered. Data were analysed using a systemic analytical approach. Confirmatory factor analysis was conducted first, followed by an analysis of moment structures for multiple levels of variables using structural equation modelling. It was found that students’ trust in the quality of information they received online, their interactions with instructors, and their interactions with virtual platforms positively affected their trust in the usability of digitised ‘teaching-learning’ virtual platforms; this had a positive impact on their attainment of learning objectives. In conclusion, students’ perceptions of the usability of virtual platforms as classrooms for teaching and learning are influenced by a psychological dynamic between the quality of information they receive from their instructors and the quality of their interactions with instructors and the virtual platforms. The findings offer a good pedagogic understanding of the dynamics of virtual teaching-learning design practices, which may be applied to effectively design virtual classrooms and assignments to improve student learning.

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KEYWORDS

Online teaching-learning; virtual platforms; learning objectives; teaching outcomes; tertiary students

Relevance to human factors/ergonomics theory

This study was focused on understanding the normatively prescribed and subjectively accepted impact of digitised ‘teaching-learning’ virtual platforms on tertiary students’ learning objectives and teaching outcomes. The learning contributes to human factors/ergonomics theory by providing an added theoretical and practical pedagogic knowledge to educational instructors and administrators on how to model efficient and effective digitised human-tech-nology interactive systems for virtual teaching and learning.

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Introduction

The pace at which information technology has advanced over the past two decades and the impact it has had and continues to have on the socioeconomic development of most countries is a clear manifestation of the increasing positive impact of the global technological revolution that has been trending over the past two decades (Sanda 2020). As the COVID-19 pandemic spread, academic institutions were forced to identify which components of their educational models could be substituted, supplemented, and/or complemented by digital technologies. According to Govindarajan and Srivastava (2020), lectures that require little personalisation or human interaction can be recorded as multimedia presentations that students can view at their own convenience. Technology platforms can deliver the content to very large audiences at a low cost without sacrificing one of the key advantages of the in-person classroom, the social experience, as there is hardly any in these basic-level courses (Govindarajan and Srivastava 2020). There is also the argument that by freeing resources from courses that can be commoditised, universities will have more resources to commit to research-based teaching, personalised problem-solving, and mentorship (Govindarajan and Srivastava 2020). Furthermore, students are deemed to have more resources at their disposal, since they would be able to take commoditised courses online at their convenience and not have to live on campuses (Govindarajan and Srivastava 2020). In this regard, the use of effective information technology in remote teaching and learning is now considered a critical factor for rapid economic growth, especially during this period of COVID-19 pandemic.

The criticality of the application of information technology in Ghana is even more evident in the usage of virtual platforms as instructional media for teaching-learning dynamics across all educational levels in the country. In line with this, most educational institutions in Ghana, by virtue of the forced closure of their institutions brought on by the COVID-19 pandemic, have developed a comprehensive integrated information technology-led system, strategies, and plans to enhance continuity in their teaching and learning activities. Virtual interactive platforms seek to address specific educational problems, including real-time visualisation of teaching by lecturers and learning by students. Additionally, it seeks to provide adequate checks for the tasks given to students and the administration of examinations. The adoption of this technological system by educational institutions is informed by the notion that the functionalities of the systems' digitised platforms have demonstrated viability in their application in the interactive social media environment and therefore will also work in the educational social space. However, as this is the first time that such digitised virtual systems have been introduced in most Ghanaian tertiary institutions, it is imperative that the impact of such digitised teaching-learning virtual platforms on tertiary students' learning objectives and teaching outcomes is explored. In this respect, this research seeks to answer the following questions: (i) What effects do digitised teaching-learning virtual platforms used for remote teaching have on tertiary students' learning objectives? (ii) What effects do digitised teaching-learning virtual platforms used for remote teaching have on tertiary students' learning outcomes?

In a face-to-face teaching-learning environment, a lecturer can usually sense whether students are absorbing what is being taught in real time and can adjust the pace of teaching accordingly. In a similar setting, a student can typically tell whether he/she is delaying the class as a whole by asking too many questions. The question is whether intermediary

technologies that serve as interactive interfaces are effective enough to accommodate real-world environment features in a virtual teaching-learning environment in which the sensibilities offered by the real-world environment are missing. It raises the question of what else needs to be developed to enhance the quality of learning by students in a virtual environment. This is why it is important to get students to share their experiences and perceptions of the quality of the knowledge they acquired in a remote setting in terms of their learning objectives and anticipated teaching outcomes. Thus, it is imperative to explore the prevailing remote teaching-learning experiment, whereby students, lecturers, and university administrators are expected to keep track of which classes benefit from being taught remotely and which ones are not doing so well. In this regard, they are all expected to maintain chat rooms where anonymised discussions about technology issues, course design, course delivery, and evaluation methods can take place. These data points, if appropriately captured, can help inform future decisions on (i) when and why some courses should be taught remotely, (ii) which courses should be taught in-person on campus, and (iii) which courses should be taught in-person on campus with technology added to or supplementing them.

Since it is now clear that the daily schedules of lecturers and students alike have transformed into a series of virtual meetings, the impact of hardware and software issues on the remote teaching-learning dynamic interaction and the consequences it has on student learning should be properly understood. Although it is evident that tested digital technologies, such as mobile, cloud, and artificial intelligence applications, are extensively deployed, we also know that much more needs to be done to enhance the viability of the virtual teaching-learning arrangement. On the hardware side, the issue of bandwidth capacity and digital inequalities in the network stability of various teaching-learning interfaces used individually by lecturers and students, as well as its consequences on the quality of learning, needs to be addressed. The required setting for remote teaching has exacerbated the digital divide, with some students having access to the latest laptops, better bandwidths, more stable internet connections, and more sophisticated audio-visual gadgets in comparison to others, further reinforcing the divide in the quality of virtual knowledge acquisition by various students. This is in contrast to the in-person teaching-learning setting, where students in the same class receive the same delivery. Therefore, from the perspective of ergonomics, this study focused on challenges related to virtual work and technology design that may be significant for both researchers and practitioners. This study was therefore centred on the concept of ergonomics of virtual organisations that are built within the precinct of information technology; thus, the topic of trust amongst students interacting with a technology was deemed to be of importance in organisational and human factors studies. Such studies are deemed as being largely disjointed in how they discuss and treat the role of trust in this contemporary information age; therefore, bridging the gap between organisational and human factors in studies of this nature is of critical importance in the context of ethical and successful design, operation, and management of interactive virtual systems, as well as the organisation that surrounds them. This study aimed to explore and understand the impact of digitised teaching-learning virtual platforms used for remote teaching on the learning objectives and learning outcomes of students in Ghanaian tertiary institutions. Answers to the following questions were sought: (i) What effects do digitised teaching-learning virtual platforms have on tertiary students' learning objectives? (ii) What effects do digitised teaching-learning virtual platforms have on tertiary students' teaching outcomes?

Literature review

The digitisation of organisational systems has now gained currency to the extent that many organisations now see the design of future organisational life as being centred on complete automation. In this vein, information technology integration into organisational systems is now widely recognised as a crucial component of organisational design (Sanda 2020). Thus, the introduction of information technology in organisational systems can be viewed as very important (Walton 1989; Sanda 2020). According to Sanda (2020), this can be attributed to its recognition as a key integrator of organisational goals and other organisational subsystems at various levels. In a similar vein, extant literature on the implementation of information technology abounds with much focus on understanding the internal dynamics associated with the implementation process (Sanda 2020), of which trust is a key prerequisite. Thus, the majority of researchers who study information technology implementation view the process as being intricately intertwined with organisational design and culture (Globerson and Maggard 1991; Hansen 1995; Sanda 2020). Following the completion of the implementation objectives, it is crucial in this context to establish alignment between information technology development and organisational goals (Hansen 1995; Sanda 2020). Therefore, it is important to investigate how the introduction and implementation of a system are perceived (Sanda 2020) and its level of psychometric intelligence understood. This is deemed to be of relative importance because the psychometric intelligence of systems, as argued by Elg (2005), is weakly correlated with control performance in micro-worlds, such as those pertaining to virtual teaching and learning environments. According to Elg (2005), previous attempts to explain these low correlations have focused on the reliability problems of micro-worlds and/or the need for skills and capabilities not captured in static problem-solving tests.

According to Haines and Petit (1997) and Sanda (2020), user satisfaction is based on attitudes and beliefs, whereas system usage is based on the perceived behaviour of users. As such, combining user satisfaction and system usage will provide a more accurate picture of users' acceptance of technology-based systems than when either measure is applied in isolation (Haines and Petit 1997; Sanda 2020). In this respect, the acceptance or otherwise of a technology-based system is measured by system usage and user satisfaction (Haines and Petit 1997; Sanda 2020). It has been established by Govindarajan and Srivastava (2020) that not all faculty members are at ease using virtual classrooms and that there is a digital divide between faculty members who have never used even the most basic audio-visual equipment and have relied on blackboards and flipcharts and younger faculty members who are knowledgeable about and adept at using newer technology. According to Govindarajan and Srivastava (2020), students enrolling in online classes discover that many instructors lack the necessary training to design multimedia presentations with elaborate notations and graphics. As such, colleges and universities should take this opportunity to assess what kind of training is needed to deliver a smooth learning experience (Govindarajan and Srivastava 2020). Furthermore, students face several issues when taking online courses (Govindarajan and Srivastava 2020). These issues, according to Govindarajan and Srivastava (2020), have led to situations where students are required to adhere to their universities' calendars, pushing them to complete their courses (Govindarajan and Srivastava 2020) despite the consequences on the quality of learning that are involved. Adding to this consequence is an argument that an online setting makes students feel as though they do not belong to a peer group or a college cohort, which is not the case with an in-person setting, where competition is ingrained

and motivates everyone to succeed. Since students multitask by checking emails, chatting with friends, and surfing the Web while attending online lectures (Govindarajan and Srivastava 2020), it is assumed that anything they do online will suffer from their short attention span. Therefore, this brings to the fore the issue of trust in the virtual teaching-learning environment in relation to what is being taught, as well as its alignment with students' learning objectives and expected teaching outcomes. According to Grudzewski et al. (2008), trust involves much more than simply relying on another party. According to Grudzewski et al. (2008), what makes this true is that trust might originate from notably good will, internalised interest, or the force of norms. Moreover, it may stem from reasonable activities taken by certain groups or individuals, as well as from the presence of people in the proximate environment or those far away (Grudzewski et al. 2008).

Two theoretical perspectives on trust are elucidated. While the first posits that every human being is open and prepared to trust by accepting another person, the second directly mirrors social and economic life, in which trust is recognised together with certain aims (Grudzewski et al. 2008). These two perspectives are accompanied by the ethical and practical aspects of trust. According to Grudzewski et al. (2008), the ethical component originates from the fact that when a person decides to trust someone or exposes himself/herself to risk, that person is given something deemed to be very valuable. Reciprocation, loyalty, and honesty are expected from a person (Grudzewski et al. 2008). According to Grudzewski et al. (2008), trust should not just be apprehended in the categories of mutuality and claims because trust can be obtained from numerous potential transactions. The practical component of trust means that its motive is 'commercial' transaction (Hardin 1991). According to Grudzewski et al. (2008), this transaction is aimed at profit maximisation, and trust is seen as helpful in accomplishing such a goal. Therefore, using Elg's (2005) argument that metacognitive factors are hypothesised to influence the efficacy of problem-solving capability in managing a micro-world control task, the following hypotheses (H) are proposed to guide this study.

- H1: Students' trust in the usability of digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives.
- H2: Students' trust in the interactive nature of digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives.
- H3: Students' trust in the quality of online information that instructors provide on digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives.
- H4: Students' trust in their interactions with instructors on digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives.

The postulations above are encapsulated in the conceptual framework (see [Figure 1](#)) tested in this study.

Arguing from the perspectives of Shortland, Alison, and Barrett-Pink (2018), wider theoretical contributions that focus on the recognition of prime models for effective decision-making in an activity should be used to enable the sequential process of situation assessment, plan formulation, plan execution, and team learning. Such a decision-making process, entailing a linear process of identifying, evaluating, and choosing the best course of action, stands to provide an avenue for knowledge generation in an

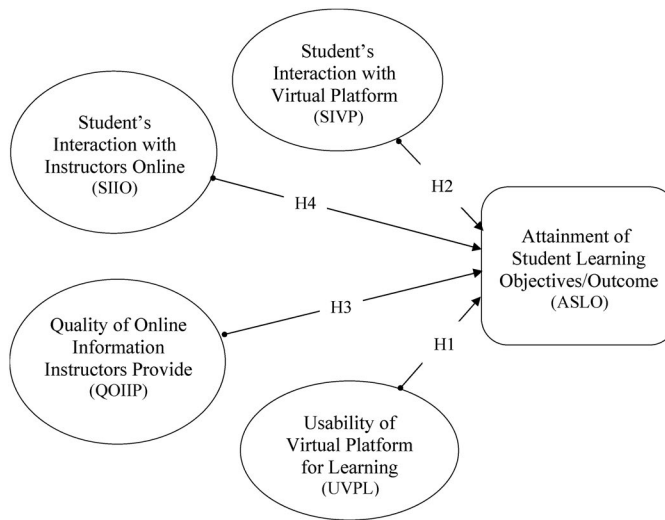


Figure 1. Conceptual framework for the study.

activity. In this study, therefore, the conceptual framework (Figure 1) above can help elucidate the process of knowledge generation and the impact of digitised ‘teaching-learning’ virtual platforms on tertiary students’ learning objectives and teaching outcomes. This is because work practices, as argued by Nathanael and Marmaras (2008), are understood as stable, historically developed, and partially unacknowledged arrays of activity that form the cornerstone of successful action in a particular work setting (Nathanael and Marmaras 2008).

Methodology

Nathanael and Marmaras (2008) have argued that work practices, from a methodological perspective, correspond to a level of analysis that is more macroscopic than the level of individually situated activity. According to Nathanael and Marmaras (2008), the practice level of analysis explicitly considers both development in time and the collective aspect. Thus, practices can be seen as evolving entities that emerge through repetition, engaged situational distinctions, and subsequent descriptions (Nathanael and Marmaras 2008). Teaching and learning, as a practice, is a systemic activity whose study can be facilitated by employing the Systemic-Structural Activity Theory to develop practical approaches and methods in the study of human work (Bedny and Karwowski 2006, 2007; Sanda et al. 2014). The most important of these approaches, according to Bedny and Karwowski (2006, 2007), are the morphological analyses of activity, whose basic concept is action, and the functional analyses of activity, whose major concepts, as a self-regulating system, are centred on the functional mechanism or function block (Bedny and Karwowski 2006, 2007).

Therefore, in this study, functional analyses were guided by the conceptual framework in which the interaction between the latent variables and the endogenous variable was conducted. The latent variables in this context are factors that cannot be directly observed but whose characteristics can be statistically measured. Similarly, the endogenous variable is a factor that cannot be directly observed but whose characteristics can be statistically predicted

by the latent variables. The latent variables include the following: Students' Interaction with Instructors Online (SIIO), Quality of Online Information Instructors Provide (QOIIP), Students' Interaction With Virtual Platform (SIVP), and Usability of Virtual Platform for Learning (UVPL). The endogenous variable is 'Attainment of Student Learning Objectives/ Outcome (ASLO)'. Considering the orientation of the variables, the study participants' perceptions relative to the applicability of the respective items entailed in the respective variables are taken into consideration. In this regard, the quantified subjective opinions of the study participants were taken into consideration. The interrelatedness and interactive influence (predictive) of the latent variables with the endogenous variable are captured using a systemic analytical approach (Bedny and Karwowski 2007; Sanda et al. 2014).

Data collection

Quantitative data were collected, using a self-administered questionnaire, from four hundred and four (404) graduate students at the University of Ghana Business School whose courses were delivered virtually owing to the COVID-19 pandemic. The questionnaire included a synopsis of the research purpose and objectives. The measurement scales, which were developed after an extensive literature review and whose corresponding items served as predictive factors, included the following: (i) students' interaction with instructors online (SIIO), which entailed 7 items; (ii) quality of online information instructors provide (QOIIP), which entailed 5 items; (iii) students' interaction with virtual platform (SIVP), which entailed 6 items; (iv) usability of virtual platform for learning (UVPL), which entailed 8 items; and (v) attainment of student learning objectives/outcome (ASLO), which entailed 13 items. For all items, the respondents rated their perceptual levels on a five-point Likert scale. As scales were developed from the extant literature, their reliabilities were determined as analytical outcomes pursuant to further analysis.

Data analysis

A stepwise approach was used in analysing the data. The collated data were first descriptively analysed to establish the reliability of the various scales. Underlined by the assumption that the respective scales were valid measures, confirmatory factor analysis was conducted to confirm whether all the items in each scale loaded significantly. In the factor extraction, items were retained if they loaded > 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020; Sanda 2020) on a factor and were considered to be contributing to factor strength. The Kaiser-Meyer-Olkin value was checked whether it exceeded the recommended 0.6 value (Kaiser 1974; Forsell, Tower, and Polman 2020; Sanda 2020) and Bartlett's Test of Sphericity (Bartlett 1950; Forsell, Tower, and Polman 2020; Sanda 2020). Second, using the determined factors in the scales, the data were analysed inferentially using the structural equation modelling (SEM) approach with the analysis of moment structures (AMOS) as an analytical technique (Sanda and Kuada 2016; Sanda 2020). This procedure has the advantage of maximising the validity of estimates (DiStefano, Zhu, and Mindrila 2009). Thus, SEM is 'a melding of factor analysis and path analysis into one comprehensive statistical methodology' (Kaplan 2008, 3). The AMOS Graphics software is a highly integrated analytical tool that allows for the loading of the complete framework and conduction of complete analysis of the conceptual model, including path analysis.

The AMOS Graphics enables an analysis of multiple levels of variables using a range of in-built statistical techniques (Sanda and Kuada 2016; Sanda 2020). In this analysis, path analysis was conducted to test the fit between the latent variable components and the endogenous variable component in the conceptualised model (see Figure 1). In the path analysis, the path coefficients (i.e. model fit estimates) for the relatedness of all the latent variables (i.e. SIIO, QOIP, SIVP, and UVPL) with the endogenous variable (i.e. ASLO) were determined and the model fit of their relationships tested. The AMOS Graphics statistical software was used as the analytical tool. In the SEM analysis, the respective variables in the proposed model (Figure 1), along with their respective factors, were loaded into the AMOS software and their model fitness was determined (Sanda and Kuada 2016; Sanda 2020). The unit of analysis was an individual. The model fit, in terms of the association between the different latent variables (as model components) and their respective interrelatedness with the endogenous variable, was interpreted using Schumacker and Lomax (2004) path coefficient benchmark value of 0.7 or higher. The criteria for model acceptance and fit were the Chi Square (CMIN) and Comparative Fit Index (CFI). For CMIN, a probability value below 0.05 implies model acceptance. CFI values close to 1.0 indicates an exceptionally good model fit.

Results and discussion

All of the respondents held bachelor's degrees, had four years of university education experience, and were enrolled at the University of Ghana Business School to pursue a master's degree. The programme distribution of the study participants showed that 224 students (55.44%) were pursuing a Master of Business Administration degree programme, while 180 students (44.56%) were pursuing a Master of Arts in Management and Administration programme. The gender distribution of the 404 study participants showed that 110 (27.2%) were male and 294 (72.8%) were female. Although the majority of the respondents were female, which signifies feminine influences on the perspectives shared, such an influence is deemed to have no bearing on the outcome of the analysis because all of the respondents are graduate students participating in the same virtual learning environment. Thus, gender was controlled for in the subsequent analysis.

Confirmatory factor analysis

Confirmatory factor analysis (CFA) was conducted to identify items (i.e. factors) in the measured scales that had a predictive relationship with the respective latent variables and

Table 1. KMO measures of sampling adequacy and Bartlett's test result for the model components.

Model components	KMO values	Bartlett's test of sphericity		
		χ^2	df	Sig.
Student's interaction with instructors online (SIIO)	0.78	644.29	28	0.00
Quality of online information instructors provide (QOIP)	0.83	730.58	15	0.00
Student's interaction with virtual platform (SIVP)	0.81	794.69	21	0.00
Usability of virtual platform for learning (UVPL)	0.85	1482.00	36	0.00
Attainment of student learning objectives/outcome (ASLO)	0.90	2228.00	91	0.00

the endogenous variable. The results obtained in terms of the Kaiser-Meyer-Olkin (KMO) and Bartlett's test statistics, highlighting the chi square (χ), degree of freedom (df), and level of significance (p) values, are shown in Table 1.

As shown in Table 1, the estimated Kaiser-Meyer-Olkin (KMO) value for all the tested latent variables and the endogenous variable ranged between 0.78 and 0.90, thus exceeding the recommended 0.6 value (Kaiser 1974; Forsell, Tower, and Polman 2020); this indicates that the correlation patterns of their measured items are good. Moreover, the estimated chi-square (χ^2) values from the Bartlett's test for all the tested variables were highly significant ($p < 0.00$). Thus, the KMO and the Bartlett's tests showed that the values for all the tested variables exceeded the recommended 0.6 value (Kaiser 1974; Forsell, Tower, and Polman 2020), which established that it is appropriate to factor analyse all the latent variables and the endogenous variable tested. Thus, confirmatory factor analysis was performed to identify the tested scales perceived by the study participants as determinant factors of the unobserved latent variables (i.e. SIO, QOIP, SIVP, and UVPL) and the unobserved endogenous variable (i.e. ASLO).

CFA for usability of virtual platform for learning

The item codes, as well as the mean (M), standard deviation (SD), and factor loadings/regression (r) estimates for the latent variable UVPL (i.e. usability of virtual platform for learning) are shown in Table 2.

From Table 2, it can be seen that 8 out of the 9 items in the UVPL scale showed factor strength with factor loadings greater than 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020). The exception was the item QC23, which had a factor loading ($r = 0.39$) below the recommended benchmark of 0.5. Thus, the item QC23 (i.e. overall, I view usability of the online teaching-learning mechanism as highly effective) was deemed to have no significant influence on the students' perception of UVPL (i.e. usability of virtual platform for learning).

Table 2. Mean, standard deviation and factor loadings estimates for UVPL.

Items in UVPL Scale	Code	M	SD	r
It was easy for me to learn on the online teaching-learning platform.	QC16	3.73	1.02	0.79*
My interaction with the online teaching-learning platform was comfortable.	QC17	3.84	0.94	0.82*
I find the online teaching-learning platform easy to navigate.	QC18	3.99	0.83	0.77*
I find the online teaching-learning platform easy to use.	QC19	4.13	0.77	0.78*
The online teaching-learning platform has an attractive appearance which enhanced my learning capability.	QC20	3.50	0.95	0.77*
The online teaching-learning platform has a fast-browsing speed which enhances my learning.	QC21	3.03	1.08	0.69*
The use of the online teaching-learning platform has resulted in me developing an added technological competence.	QC22	4.41	2.63	0.94*
The use of the online teaching-learning platform was a positive experience for me.	QC23	4.13	0.81	0.68*
Overall, I view the usability of the online teaching-learning mechanism as highly effective.	QC23	3.90	2.74	0.39

*Significant factor loadings.

CFA for quality of online information instructors provide

The item codes, as well as the mean (M), standard deviation (SD), and factor loadings/regression (r) estimates for the latent variable QOIIIP (i.e., quality of online information instructors provide) are shown in Table 3.

From Table 3, it is observed that 5 out of the 6 items in the QOIIIP scale showed factor strength with factor loadings greater than 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020; Sanda 2020). The exception was the item Q28, which had a factor loading ($r=0.36$) below the recommended benchmark of 0.5. Thus, the item Q28 (i.e. the online courses entailed the right level of knowledge I expected to acquire) was deemed to have no significant influence on the students' perception of QOIIIP (i.e. quality of online information instructors provide).

CFA for students' interaction with virtual platform

The item codes, as well as the mean (M), standard deviation (SD), and factor loadings/regression (r) estimates for the latent variable SIVP (i.e. students' interaction with virtual platform) are shown in Table 4.

From Table 4, it is observed that 6 out of the 7 items in the SIVP scale showed factor strength with factor loadings greater than 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020). The exception was the item IP37, which had a factor loading ($r=0.37$) below the recommended benchmark of 0.5. Thus, the item IP37 (i.e. overall, the interaction

Table 3. Mean, standard deviation and factor loadings estimates for QOIIIP.

Items in QOIIIP Scale	Code	M	SD	r
The online courses provided information that aligned with my learning objectives.	Q25	4.10	0.71	0.77*
The online courses provided information that are relevant and enough for me to master what were taught.	Q26	4.00	0.80	0.81*
The online course deliveries were easy to understand.	Q27	3.87	0.86	0.78*
The online courses entailed the right level of knowledge I expected to acquire.	Q28	4.00	2.15	0.36
The online courses materials provided me were appropriately formatted.	Q29	4.01	0.73	0.66*
Overall, I view the quality of information provided by the online courses as good.	Q30	4.15	0.67	0.79*

*Significant factor loadings.

Table 4. Mean, standard deviation and factor loadings estimates for SIVP.

Items in SIVP Scale	Code	M	SD	r
I view the reputation of the online teaching-learning delivery platform as good.	IP31	3.98	0.72	0.58*
The online teaching-learning platform made me feel connected to my colleagues.	IP32	2.87	1.10	0.79*
The online teaching-learning platform created in me a sense of personalization.	IP33	3.76	0.84	0.56*
The online teaching-learning platform conveyed in me a sense of community.	IP34	3.26	0.98	0.82*
The online teaching-learning platform made it easy for me to communicate my needs with my lecturers.	IP35	3.29	1.05	0.80*
The contents of the online courses were easily followed on the teaching-learning platform.	IP36	3.93	0.76	0.68*
Overall, the interaction provided by the online teaching-learning platform was effective.	IP37	3.99	2.70	0.37

*Significant factor loadings.

provided by the online teaching-learning platform was effective) was deemed to have no significant influence on the students' perception of SIVP (i.e. students' interaction with virtual platform).

CFA for students' interaction with instructors online

The item codes, as well as the mean (M), standard deviation (SD), and factor loadings/regression (r) estimates for the latent variable SIIO (i.e. students' interaction with instructors online) are shown in Table 5.

From Table 5, it can be seen that 7 of the 8 items in the SIIO scale showed factor strength with factor loadings greater than 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020). The exception was the item IL40, which had a factor loading ($r = 0.44$) below the recommended benchmark of 0.5. Thus, the item IL40 (i.e. I was able to attract the attention of lecturers to ask questions during teaching on the online teaching-learning platform) was deemed to have no significant influence on the students' perception of SIIO (i.e. students' interaction with instructors online).

CFA for attainment of student learning objectives/outcome

The item codes, as well as the mean (M), standard deviation (SD), and factor loadings/regression (r) estimates for the latent variable ASLO (i.e. attainment of student learning objectives/outcome) are shown in Table 6.

From Table 6, it can be seen that 12 out of the 13 items in the ASLO scale showed factor strength with factor loadings greater than 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020; Sanda 2020). The exception was the item BL13, which had a factor loading ($r = 0.37$) below the recommended benchmark of 0.5. Thus, the item BL13 (i.e. I think I have learned more in the online course delivery than in the face-to-face course delivery) was deemed to have no significant influence on the students' perception of ASLO (i.e. attainment of student learning objectives/outcome).

Table 5. Mean, standard deviation and factor loadings estimates for SIIO.

Items in SIIO Scale	Code	M	SD	r
It was easy for me to interact with lecturers on the online teaching-learning platform.	IL38	3.70	0.96	0.80*
The expertise of lecturers was visible to me on the online teaching-learning platform.	IL39.	4.06	0.78	0.74*
I was able to attract the attention of lecturers to ask questions during teaching on the online teaching-learning platform.	IL40	3.91	1.719	0.44
I received support and counsel from my lecturers to help enhance my learning ability on the online teaching-learning platform.	IL41	3.52	0.97	0.76*
The online teaching-learning platform resulted in me having a low personal contact with my lecturers.	IL42	3.55	1.14	0.70*
The online teaching-learning platform made it difficult for me to share my opinions with my lecturers.	IL43	2.82	1.15	0.74*
The online teaching-learning lecturers made it difficult for lecturers to take questions from students.	IL44	2.46	1.13	0.64*
Overall, the interaction between me and my lecturers during the online teaching-learning process was effective.	IL45	3.85	0.89	0.75*

*Significant factor loadings.

Structural component analysis

The AMOS-generated structural model (standardised path diagram) showing the standardised factor loadings/regression weights (r) for the association between the four latent variables (i.e. UVPL, QOIP, SIVP, and SIIO) and their respective interrelatedness with the endogenous variable (ASLO) is shown in Figure 2.

Table 6. Mean, standard deviation and factor loadings estimates for ASLO.

Items in ASLO Scale	Code	M	SD	r
I find online learning remarkably interesting.	BL2	4.00	0.90	0.84*
I find online learning very enjoyable.	BL3	3.85	0.91	0.85*
I find online learning as fun.	BL4	3.54	0.97	0.79*
Taking all my courses online is very convenient.	BL5	4.02	1.05	0.56*
Taking online courses has increased my productivity.	BL6	3.80	0.97	0.70*
The online learning is compatible with the way I like to learn.	BL7	3.50	1.05	0.73*
Taking my courses online fits well with my lifestyle.	BL8	3.78	1.10	0.65*
Taking my courses online has made me become less confident.	BL9	2.31	1.12	0.74*
I have the skill to use the online learning platform.	BL10	4.35	0.66	0.68*
I have the resources for using the online learning platform.	BL11	4.14	0.90	0.85*
I prefer online courses delivery than the face-to-face delivery.	BL12	3.18	1.27	0.72*
I think I have learnt more in the online courses' delivery than in the face-to face delivery.	BL13	3.15	2.82	0.37
Using online learning is entirely within my control.	BL14	3.67	1.02	0.55*
The online courses learning requires more study time than the face-to-face option.	BL15	3.73	1.07	0.76*

*Significant factor loadings.

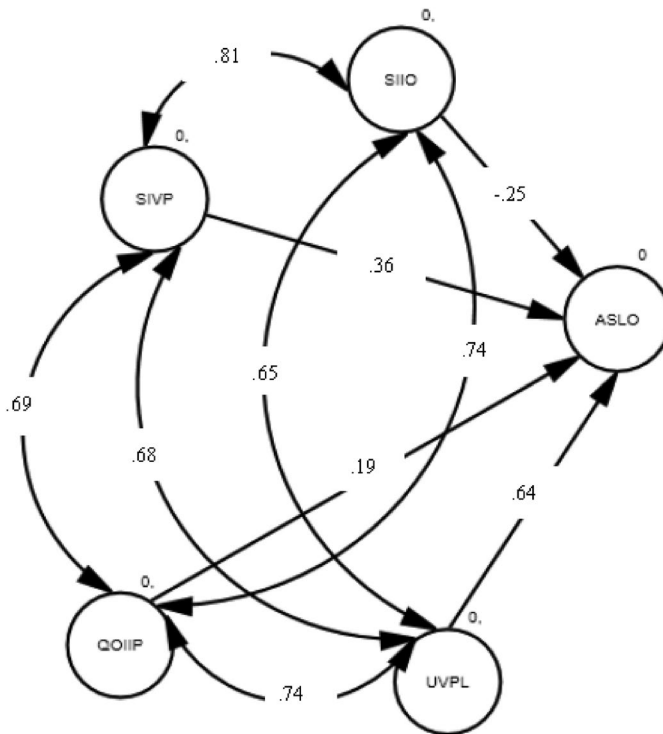


Figure 2. AMOS graphics generated structural regression model showing standardized path and correlation coefficients for the observed and latent variables.

The goodness-of-fit statistics for the structural model (Figure 2) showed that the minimum was achieved, and the overall fit of the default model appeared quite good. This is because the estimated χ^2 of 2110.32 (df = 692) has probability level of 0.00, which is smaller than 0.05 used by the convention. Thus, the null hypothesis that the model fits the data was accepted. In addition, the estimate for the Comparative Fit Index (CFI) of 0.81 showed that the default model is not saturated, indicating an acceptance of the null hypothesis of a good fit for the tested model. The path coefficient estimates that determine the relatedness of the four latent variables (i.e. QOIP, SIVP, SIIO, and UVPL) to the endogenous variable (i.e. ASLO) in the structural model are shown in Table 7.

It is observed from Figure 2 and Table 7 that only the interrelatedness of the unobserved latent variable UVPL (i.e. usability of virtual platform for learning) with the endogenous variable ASLO (i.e. attainment of student learning objectives/outcome) in the structural model was significant ($r > 0.5$). The interrelatedness of the unobserved latent variables QOIP (i.e. quality of online information instructors provide), SIVP (i.e. students' interaction with virtual platform), and SIIO (i.e. students' interaction with instructors online) with the endogenous variable ASLO (i.e. attainment of student learning objectives/outcome) in the structural model was not significant because their factor loadings ranged between 0.19 and 0.26, which is below the benchmark value of 0.50 (Tabachnick and Fidell 2007; Forsell, Tower, and Polman 2020; Sanda 2020).

Relating the above findings to the hypotheses that informed the framing of the tested conceptual model (see Figure 1), only H1 hypothesis, that is 'trust of students in the usability of digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives in Ghanaian tertiary institutions' holds. Conversely, H2 hypothesis that is 'trust of students in the interactiveness of digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives in Ghanaian tertiary institutions' did not hold. Similarly, H3 hypothesis, that is 'trust of students in the quality of online information instructors provide on digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives in Ghanaian tertiary institutions' did not hold. In addition, H4 hypothesis, that is 'trust of students in their interactions with instructors on digitised 'teaching-learning' virtual platforms will positively affect the attainment of their learning objectives in Ghanaian tertiary institutions' did not hold. Although the interrelatedness of the unobserved latent variables QOIP (i.e. quality of online information instructors provide), SIVP (i.e. students' interaction with virtual platform), and SIIO (i.e. students' interaction with instructors online) with the endogenous variable ASLO (i.e. attainment of student learning objectives/outcome) in the conceptual model were found to be insignificant, correlation analysis showed that they associate with each other, including the latent variable UVPL (i.e. usability of virtual platform for learning), which was interrelated with the endogenous variable ASLO. The standardised correlation weights (α) for the associations between the respective unobserved endogenous variables are shown in

Table 7. Path coefficient estimates of the relatedness of latent variables to the exogenous variable in the structural model.

Exogenous Variable	Latent Variables	Coefficient
		<i>r</i>
ASLO	QOIP	0.19
ASLO	SIVP	0.36
ASLO	SIIO	-0.26
ASLO	UVPL	0.64

Table 8. By convention, the α values should be 0.7 or higher (Schumacker and Lomax 2004; Sanda 2020) for each association to be considered robust and of very high significant interpretive value.

It is highlighted in Table 8 that the standardised correlation weights (α) for two associations between the unobserved latent variables are below the threshold value of 0.7; these are the associations between SIIO (i.e. students’ interaction with instructors online) and UVPL (i.e. usability of virtual platform for learning), as well as between SIVP (i.e. students’ interaction with virtual platform) and UVPL (i.e. usability of virtual platform for learning). This finding shows that although the three unobserved latent variables QOIP (i.e. quality of online information instructors provide), SIVP (i.e. students’ interaction with virtual platform), and SIIO (i.e. students’ interaction with instructors online) do not directly interrelate with the endogenous variable ASLO (i.e. attainment of student learning objectives/outcome) as established apriory, they indirectly exert influence through their dynamic associations with each other and through QOIP’s association with the only latent variable UVPL, which is interrelated with the endogenous variable ASLO. Thus, by revisiting and transposing the findings above in the conceptual framework (see

Table 8. Standardized correlation estimates for associations between the unobserved exogenous variables.

Unobserved Variables	Unobserved Variables	α
QOIP	SIVP	0.70
SIVP	SIIO	0.88
UVPL	QOIP	0.74
QOIP	SIIO	0.74
UVPL	SIIO	0.65
UVPL	SIVP	0.68

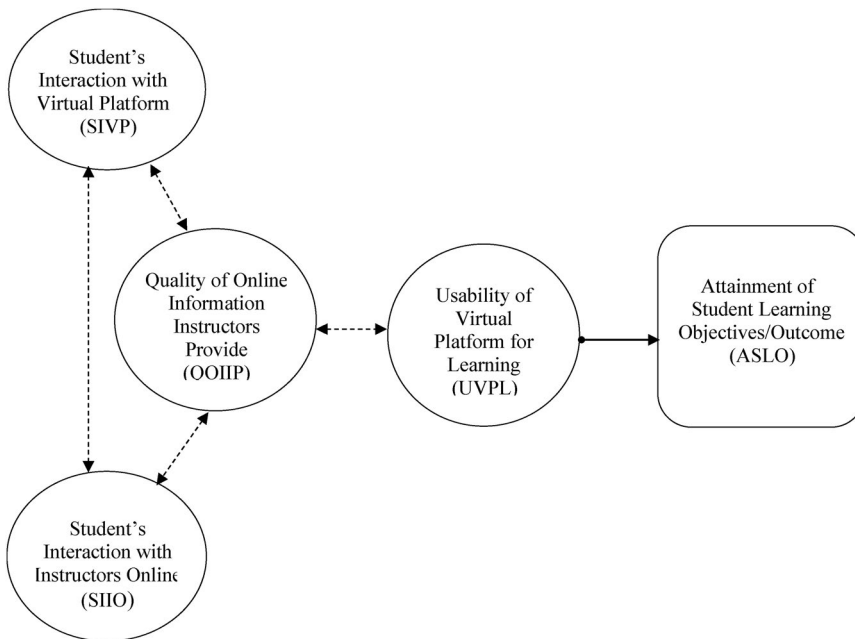


Figure 3. Empirical model for the interactive dynamics of the unobserved exogenous variables and the endogenous variable.

Figure 1), an empirical model showing the dynamic associations between the latent variables QOIP, SIVP, and SIIO, as well as the association between QOIP and UVPL, leading to UVPL's interrelatedness with the endogenous variable ASLO, is obtained (Figure 3).

It is thus inferred from the empirical model that there is a psychological dynamic that exists between the quality of information that instructors provide, students' interaction with their instructors during online teaching, and students' interaction with the virtual platforms themselves; this has consequences on students' perceptions of the usability of virtual platforms as classrooms for teaching and learning. The existence of the psychological dynamic is theorised from the perspective of trust in human-technology system design as follows: 'The trust that students have on digitised 'teaching-learning' virtual platforms will increase when they are provided with quality information and have enhanced interactive experiences with the platforms and their instructors. This will culminate in students developing increased trust in the usability of virtual platforms due to the loyalty and honesty associated with the excitement they derive from their user experiences, which help in the attainment of their learning objectives'. This theorisation is deemed to be of pedagogical significance, since its incorporation in designing virtual classrooms may result in virtual teaching and learning systems that enhance students' attainment of their learning objectives and outcomes. In other words, the empirical model may be useful in shedding light on the co-adaptation process between students' cognition, virtual classroom pedagogy, educational institutions, and technology (i.e. the development of efficient virtual teaching-learning practices) that follow technological or organisational changes.

Conclusion

This study sheds light on the impact of digitised 'teaching-learning' virtual platforms on tertiary students' learning objectives and teaching outcomes. The insights offer perspectives that might enable educators to be in tandem with the pace at which information technology has advanced over the past years and the effects it has had, and is continuing to have, particularly in the COVID-19 pandemic era, on the digitisation of teaching and learning and the replacement of in-person classrooms with virtual online platforms. Based on the findings of this study, the author concludes that in the provision of knowledge to students in a virtual platform systemic environment, students' perceptions of how useful these virtual platforms are as classrooms for teaching and learning are influenced by a psychological dynamic between the quality of information they receive from their instructors and the quality of their interactions with their instructors during online teaching as well as with the virtual platforms themselves. Additionally, it is concluded that such psychological dynamic that informs the students' perceptions of the usability of virtual platforms has consequences on the degree to which they measure the attainment of their learning objectives and outcomes.

Implications

The study findings give educators and educational administrators a clear understanding of the dynamics of virtual teaching-learning design practices that they may apply to the effective design of virtual teaching and learning tasks for improved student learning outcomes.

The learning will offer crucial pedagogic insights and will guide the design of future interactive digitised virtual systems for teaching and learning that are both efficient and effective. Additionally, it will lead to the initiation of a knowledge-based platform within academic institutions for practical and theoretical learning on how to model efficient and effective human-technology interactive digital systems.

Disclosure statement

No potential conflict of interest was reported by the authors.

Notes on contributor

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