Aug 26th, 12:00 AM - Aug 27th, 12:00 AM

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Abstract
Digitization of learning activities has introduced some notable improvements as well as some significant knowledge retention impairments. Extant theories of knowledge retention are dominated by instrumental and cognitive approaches. Relatively less attention has been paid to the smartphone appropriation which includes instrumental and cognitive approaches but transcends them. This research adopts the smartphone appropriation approach to model antecedents of knowledge retention in the context of technology-mediated learning. It synthesizes user-invited actions based on technology design, knowledge retention, looping, and unlearning. The data analysis and model testing primarily confirm smartphone appropriation in knowledge retention. Complexity of technology usage in itself does not cause an increase in cognitive load. Cognitive load increases because of the combination of smartphone appropriation and extraneous cognitive load. The proposed appropriation model of knowledge retention complements the extant ones. The theoretical contributions are discussed with their research and practical implications.

Keywords: appropriation, knowledge retention, technology-mediation, memory schemas, grafting

Introduction

In recent times, smartphone appropriation in the educational sector is on the increase especially because students are able to use mobile computers on-the-move to overcome and even leverage space and time barriers (Wiredu, 2014). This research seeks to model the relationship between smartphone appropriation and knowledge retention among students in their technology-mediated learning activities.

So far, the dynamics of knowledge retention have been encapsulated by two main approaches: instrumental and cognitive.

The instrumental approach overly focuses on the automation of learning processes and usage of novel digital technologies as antecedents to successful learning. Some notable knowledge retention theories in this research stream are replacement, amplification, and transformation (RAT) (Hughes, et al., 2005; Hughes, et al., 2006), substitution, augmentation, modification, and redefinition (SAMR) (Puentedura, 2010), and connectivism (Siemens, 2005). The cognitive approach predominantly focuses on the intense neural connections of memory schemas as antecedents to the successful learning process. Its notable theories include cognitive load (Chandler and Sweller, 1991), trial-and-error (Thorndike, 1988), and traditional blended learning (Behaviorism, Constructivism, and Cognitivism) (Ertmer & Newby, 1993).

While insights from both approaches are helpful, explanations stemming from them are quite simplistic and incomplete.

In the instrumental approach, smartphone appropriation is informed by automation and at the same time assumes a definite improvement in the outcomes of learning. For instance, the RAT model assesses technology integration in successful learning activities in three phases. Firstly, as a replacement of established learning processes to the same end. Secondly, as facilitating the increase in effectiveness, efficiency, and productivity. Finally, as reinventing learning in new and original ways. Technology in these phases assumes a solutional role. This flow of thought is quite incongruent with the assumptions and outcomes of technology mediation in activities. This is because when technologies play a solutional role, positive or negative outcomes are not definite (Carr, 2003).

Similarly, the SAMR model calls for deeper integration of technology in all phases of the students' learning process – downplaying the role of the human characteristics in the modulation of the technology. This call presupposes a designers' praxis that intends positive outcomes only upon usage. However, this is not always the case. Technologies, as noticed by their 'platform' architectures, are customizable by users to take advantage of a continuum of praxis (Rahaman, 2017).

Similarly, connectivism combines technology and networks to proffer an understanding of knowledge retention in a digital age, acknowledging learning as a less individualistic activity. Knowledge is relative to multiple information sources, and technology acts as an interconnecting instrument. Thus, connectivism does not provide adequate insights about the learner's appropriation of the technology. The tools we adapt to learning activities rewire (define and shape) our minds (Siemens, 2005). As such, theories that acknowledge technology in learning activities must necessarily explain the effect of the learner-technology relationship.

In the cognitive approach, the antecedents of knowledge retention are primarily based on the presentation of information to be learned as well as the learner's efforts. For instance, the cognitive load theory (CLT) assumes knowledge retention to be improved following the reduction in cognitive load. This reduction, according to the CLT is made possible when information to be learned is structured in a format to lessen intrinsic and extraneous cognitive loads. However, it does not account for technology mediation and appropriation, leaving it in a passive or potential state.

Similarly, the trial-and-error theory assumes a highly motivated learner faced with a new and difficult problem, meandering across alternatives to arrive at an optimum solution. The theory indicates the retention of knowledge in the process. As the learner tries to find solutions, errors occur. The learner conflates the solutions and errors into a knowledge base and retains them to shape subsequent efforts. Like the CLT, the trial-and-error theory does not address technology mediation and appropriation issues. Thus, it does not account for the underlying social environment. The traditional blended learning theories (behaviorism, constructivism, and cognitivism) assume that a learner's effort is the only antecedent to knowledge retention. They promote the view of learning as occurring internally – only inside of a learner. Their explanations are limited as they fail to address learning that occurs outside of a learner. Knowledge acquisition in recent times does not follow a linear fashion as technology performs or supports some cognitive operations previously carried out by learners (Siemens, 2005).

The limitations of both approaches suggest the need to combine them synergistically to yield complementary knowledge of the interrelations between technology and cognition. These interrelations are captured by the proposed smartphone appropriation approach. Smartphone appropriation is neither solely instrumental nor solely cognitive; rather, it combines instrumentation and cognition to enable the study of their interrelations. Thus, this approach explains and predicts the relationship between technology convergence, proximity, connectivity, and modernity on the one hand, and connections in memory schemas on the other as antecedent to knowledge retention.

This paper identifies the specific determinants of knowledge retention among students who use and appropriate smartphone technology for learning. It deductively analyzes the factors that explain and predict students' reflective ability during technology-mediated learning. The hypotheses formulated tentatively explain and predict how and why the appropriation approach constitutes a complementary understanding of technology-mediated knowledge retention. Their tests confirm knowledge retention effects following the students' appropriation of smartphone technology.

The rest of the paper is organized as follows. First, a critical synthesis of the available literature and issues relating to knowledge retention in the context of smartphone appropriation is presented (Section 2). This is followed in Section 3 by a deductive analysis leading to the formulation of hypotheses and development of the conceptual model. Section 4 presents the methodology for this study. Sections 5 and 6 provide the results of data and hypotheses testing. The concluding section proffers some implications of the findings to researchers and practitioners.

Literature

This section presents a critical synthesis of the available literature and issues about smartphone appropriation and knowledge retention in building a coherent argument for undertaking this research. Smartphone appropriation includes its proximity, convergence, connectivity, mobility, and modernity. Knowledge retention includes a learner's cognitive ability as a precursor, looping as the stagnation of trained memory schemas in relative periods, and reflective ability.

Smartphone Appropriation

Even in the face of its unambiguous advantages, smartphone appropriation has been extensively linked to several negated consequences such as reduced attentional capabilities and distorted cognitions (Bianchi and Phillips, 2005; Billieux, 2012). The linkage is underpinned by the smartphone's change of status from an instrument supporting social exchanges to indubitably interfering with them (Nickerson et al., 2008). This interference is noticed in this study by problematizing smartphone's proximity, convergence, connectivity, and modernity.

The smartphone was birthed following the convergence of technological innovations in the communications and mobile computing industry (Conley & Christopher, 2010; Aker & Mbiti, 2010; Sarwar & Soomro, 2013). It relates with the user by a function of distance (Goldman, et al., 1998; Hashemi, et al., 2011) or proximity (Coren & Girgus, 1980; Boschma, 2005; Aguiléra et al., 2012; Cunningham & Werker, 2012). Elating the notion of proximity in smartphone appropriation is the concept of the multi-sided platform which dynamically supports the interplay between "distinct but interdependent groups of users" (Koh & Fichman, 2014, p. 977); see also Spagnoletti et al., (2015). Each user group is in essence a smartphone and an individual tightly coupled to the extent that the latter's representation by proxies of the former goes unnoticed (Oerlemans & Meeus, 2005). Whereas this tight coupling may be directly problematic in the face of issues such as addiction (Shambare, Rugimbana, & Zhowa, 2012), our attention is drawn towards the complex coordination processes between the users. The problematic perspective to this coordination is noticed by the erosion of structure between users in an inverse relationship with complexity (Oerlemans & Meeus, 2005). Structure indicates the formal protocols between users in a relationship. With the pervasiveness of smartphones, coordination among users is further complicated and as such, there is the impossibility to cooperate within specified structures – a rather important condition for knowledge retention.

Coordination among smartphone users is fueled by the trendy convergence of complementary technologies (Kallinikos, 2012). Convergence has had hardware and software technologies distinctively and cooperatively approaching unity (Lyytinen & Yoo, 2002; Bores, Saurina, & Torres, 2003; Calvo, 2019). This unity implies the seamless flow of data across the various software applications installed. Though this capability may seem advantageous, the problem arises with the smartphone technology performing cognitive operations previously carried out by users (Siemens, 2005).

Related to convergence is connectivity among subjects from remote sources and locations (Markus and Silver, 2008; Martin and Rizvi, 2014). Connectivity has introduced new forms of practices such as the replacement of face-to-face meetings with smartphone-based virtual forms (Dery et al., 2014). While such a technology-mediated practice may be fueled by some revelatory individual and collective benefits, there have been some flipside concerns with 'always-on' and information overload (Choi, 2016; Gao et al., 2018). For example, individuals may no longer able to disconnect from work as the challenge to achieve a state of connectivity while maintaining work efficiency and personal wellbeing increases (MacCormick et al., 2012). When this occurs, smartphone appropriation becomes excessive and uncontrollable, presenting a disservice to the user's mind as it has to deal with the overload.

On smartphone modernity, it is "a runaway engine of enormous power which … we can drive to some extent but which also threatens to rush out of our control …. The juggernaut crushes those who resist it, and while it sometimes seems to have a steady path, there are times when it veers away erratically in directions we cannot foresee ..." (Giddens, 1990a: 139). Modernity calls for the appropriation of smartphones as tokens of exchange media. During their use for exchange, people experience increased individualization and disconnection from traditional social structures (Beck, 1992; Jiang et al., 2018).

Knowledge Retention

"Forgetting is ubiquitous as the human memory is imperfect" (Qureshi et al., 2017: 126). Schemas or representations residing in human memory fade with time regardless of their nature, age, or background of the learner (Lindsey, Stroyer, Pashler, & Mozer, 2014; Kumar, 2017). However, a periodic review of these schemas is a requirement for a relatively long-term remembrance (Granito and Chernobilsky, 2012; Lindsey et al., 2014). Knowledge, according to the Schema Theory (Bern, 1983; Thornton, 2003) is systematized into units. This calls for assimilation by a function of size (Vitulic & Prosen, 2012). Tse *et al*. (2007) notice that this size is independent of every learner and is implicated by knowledge previously assimilated. This is where the concept of *grafting* comes in. A more informed learner would be able to assimilate new concepts or ideas easier and faster considering the availability of more memory interfaces for which new knowledge could be grafted (King, et al., 2019). In the heart of knowledge retention is an understanding of how knowledge is retained after grafting. In this study, how knowledge is retained is understood with the concept of a basic set-reset (SR) flip flop in replacement of anatomical approaches. The central hypothesis is that the mind has mental representations analogous to computer data structures. The introduction of flip flops to represent anatomical approaches to knowledge retention was adapted from Wolter Pieters' adoption of Niklas Laumann's system-theoretic notion of causal insulation to explain information security. We assign the term 'looping to the dynamics regarding how knowledge is retained in the mind.

Hypotheses Development

Cognitive Load Theory

CLT assumes a limited working memory and a virtually long-term memory (Chandler & Sweller, 1991). Working memory is limited and as we learn, it becomes overloaded which reduces the amount of information we can move to our long-term memory schemas. These schemas are mental structures that organize knowledge by how it is used. Cognitive load is placed on the very finite working memory and heavy load on this memory can have negative effects on task completion and retention. There are three types of cognitive load: intrinsic, extraneous, and germane.

The intrinsic is related to the complexity of the information the learner is paying attention to and processing. This is determined by the number of novel elements and the level of interactivity between the elements – given that working memory is limited to somewhere between 3-7 novel elements interacting at a time (Merrienboer & Sweller, 2005). The more elements a learner holds in long-term memory schemas, the easier the learning task will be because working memory is only limited when dealing with novel information.

The extraneous is essentially the load on the working memory that is completely unrelated to the learning task and can be considered as any distraction to the learning process. This load can be imposed by the poor design of information material. Extraneous load is anything included that does not directly contribute to the learning goal.

The germane is the mental processing effort of creating connections between existing knowledge and/or novel information. The germane load is the mental capacity that is directed at integrating the new information learned with existing knowledge. This load can be understood as an effort that contributes to the construction of schemas. A reduction in extraneous cognitive load (reducing unnecessary information not directly related to the learning process) and a reduction in intrinsic cognitive load (splitting the task and using informal previous knowledge) will result in more space or an increase in germane cognitive load.

The mental load is the aspect of cognitive load that originates from the interaction between task (intrinsic and extraneous) and subject (germane) characteristics. Related to mental load is mental effort which refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task. Performance, also an aspect of cognitive load, can be defined in terms of the learner's achievements, such as the number of correct test items, a number of errors, and time on task (Paas, Tuovinen, Tabbers, & Gerven, 2003). In sum, CLT argues that there are many ways to utilize long-term memory storage and many ways to reduce cognitive load. This allows more space in working memory so learners can process more information and as a result, ease learning and increase performance.

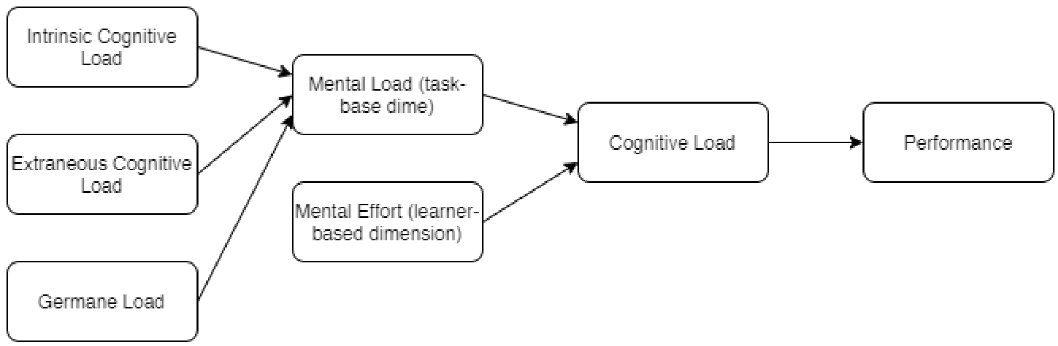

Figure 1 The Cognitive Load Theory. Source: Chandler and Sweller (1991)

Discussion and Hypotheses

Smartphone Appropriation & Mental Load

The dimensions of problematic smartphone appropriation point to several negated tendencies among individuals (Billieux, 2012). The CLT reasons this occurrence as a reduction in the germane load and an increase in the intrinsic and extraneous loads. Now, in a quest to improve the gratification and service the smartphone provides, updates and novel elements are constantly pushed to users. Even though the frequency of these updates is fairly low, the effects cannot be disregarded. The CLT assumes a working memory that is limited to somewhat three (3) to seven (7) novel elements interacting at the same time. There is no doubt that the novel elements a smartphone user is constantly exposed to surpass the limits assumed by the CLT – increasing the complexity the working memory has to deal with. These novel elements could be the application interfaces and variegated data churned following the platform participation of the smartphone device. Lest we forget, these novel elements should be also envisioned with regards to relational simultaneity and element interactivity. The CLT indicates this phenomenon as an increase in intrinsic cognitive load. We could hypothesize that:

H1: Smartphone appropriation increases intrinsic cognitive load.

With the novel elements mostly not directly related to the task undertaken by the smartphone user, there is a consumption of working memory needed for relevant tasks. Working memory required to deal with tasks in focus is apportioned to firstly deal with the grasping of novel technology features and any other characteristics posing a distraction to the processes of the working memory. The distraction posed could also include the tenets of modernity specifically the disembedded social systems and reflexive modern society. The CLT conceptualizes these distractions as an extraneous cognitive load. In this domain, the hypothesis below could be proposed:

H2: Smartphone appropriation increases extraneous load.

Still focusing on the presence of greater intrinsic and extraneous loads following smartphone appropriation, a significant reduction in germane load is noticed since there is less creation of connections between new information and existing information. First of all, the rate of exposure to novel elements is high and hence the 'reverberation' of these elements in the working memory is inconsistent to save in long-term memory. Since knowledge retention is enhanced with connections between novel information and existing schemas, the germane load is decreased in the event of 'less' long-term memory. Thus, we could hypothesize that:

H3: Smartphone appropriation decreases germane load.

Further inching on the relationship established aforehand about the intrinsic, extraneous, and germane cognitive loads, the CLT collectively conceptualizes them as mental load. The literature review presented insights about the potentially unlimited space in long term memory and the finite amount of space in working memory. In actuality, learning is made possible following the consolidation and reconsolidation of schemas from working memory to long term memory. But this presupposes that schema should primarily be available in working memory. The CLT highlights the inability of a learner to make available schemas in working memory as a result of an increased intrinsic, extraneous, and a decreased germane load. In furtherance, the CLT assumes a posture to argue out the definacy of a decreased germane load following increased instances of intrinsic and extraneous cognitive loads. Also, increased intrinsic cognitive loads qualify as extraneous loads. To exemplify this reasoning, consider the sentences below:

- GIMPA lecturers are deeply thoughtful.
- GIMPA lecturers are the arrant embodiment of intellectual depth.

The two sentences presented above may carry the same meaning. The first sentence however relatively qualifies as an epitome of providing a reduced intrinsic cognitive load as compared to the second one. Inasmuch as both sentences carry the same meaning, the presentation of sentence two (2) goes ahead of providing an increased intrinsic cognitive load to providing an extraneous cognitive load. Simply, the presentation of sentence two (2) exposes conditions 'unrelated' to the understanding of the sentence and could be considered as a distraction to the understanding process. Thus, an increased intrinsic cognitive load could gravitate towards an increased extraneous cognitive load and could be relatively associated with mental load. Collectively, the following hypotheses could be proposed:

H4: Intrinsic cognitive load is positively associated with mental load.

H5: Extraneous cognitive load increases mental load.

H6: Germane load decreases mental load.

Having established the conditions with which an increase in mental load is inevitable, The CLT generally emphasizes the relatively low mental load to achieve higher cognitive ability. In other words, the CLT considers the possession of a higher knowledge retention ability as a reflection of a lower mental load. Since the smartphone is the center of attraction in this study, we could propose the hypothesis:

H7: Mental load decreases knowledge retention.

Grafting

As established in the previous section, smartphone appropriation increases mental load. The CLT notes mental load as an aspect of cognitive load that originates from the interaction between task (intrinsic and extraneous) and subject (germane) characteristics. The other aspect of cognitive load is considered by the CLT as mental effort. Now, the literature review revealed the unreality of knowledge assimilation in a mind's original pristine state – tabula rasa. Leaning on the concepts presented about the preservation of knowledge in the brain, immediately ingested schemas (knowledge stock) required the presence of a congruent permanent schema (knowledge scion) to be able to 'stick' before reverberation. The latter and former conceptions were in the literature review assigned to the terms looping and grafting respectively. The ability to graft, though dependent on the number of schemas present in the student's mind is still independent of every student. The CLT indicates this ability as mental effort. In the presence of a high mental load introduced by the smartphone appropriation, the mental effort of the student is required to accommodate or counterbalance the cognitive load. In an attempt to further justify this reasoning, we would hop on the *law of requisite variety* where variety should absorb variety. With the introduction of variety in mental load, a notable variety of mental resources is required. The CLT notices this variety of mental resources as mental effort. In this regard, this study posits the following hypotheses:

H8: Mental load is positively associated with cognitive load.

H9: Mental effort decreases cognitive load.

With the increase in cognitive load, there is bound to be some knowledge retention effects. The CLT reasons these effects as evident in terms of the students learning achievements such as the number of correct test items, number of errors, time on tasks, and ability to produce praxical evidence. On this basis, we could hypothesize that:

H10: Cognitive load is positively associated with knowledge retention effects.

Conceptual Model

Depicted below is the conceptual model of this study – illustrating the relationships between the constructs forming the proposed hypotheses.

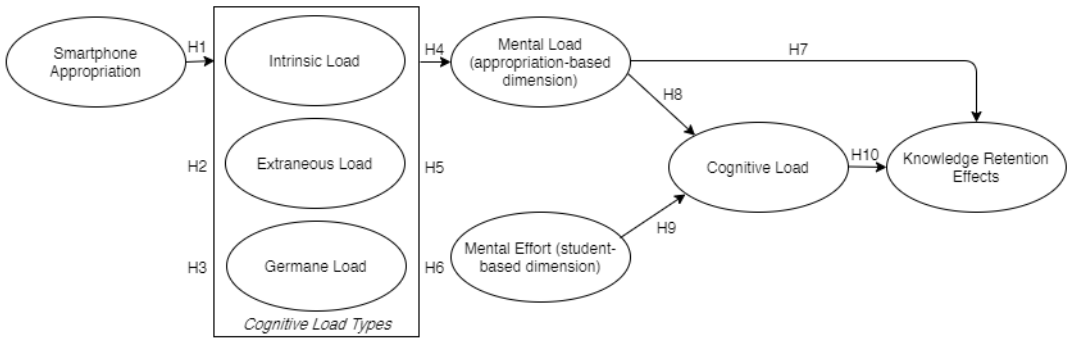

Figure 2 Conceptual Model

Method

Population, Sample, and Data Collection

This study considered a population of 1231 comprising all students under age 24 (as of March 2, 2020) from the various schools and sessions in the Ghana Institute of Management and Public Administration (GIMPA). This age range was necessitated as extant literature has found smartphone appropriation to be problematic among adolescents and young adults (Billieux, 2012). The population was restricted to students who double as Ghanaians ultimately because of their distinctiveness in socio-cultural practices, assumptions, and their definition of 'modernity'. Burdened with the task of ensuring our population was fairly aligned with our problem and objectives, we deliberately excluded certain students who doubled as faculty members or employees. This we believed could reduce some sort of bias in the process of finding a representative sample for our population and the data collection process at large.

To calculate the sample size for the study, we adopted Krejcie and Morgan's (1970) formula due to the simplicity and reliability in determining sample sizes. At a 95% confidence level with a degree of freedom one (1); Chi-square (χ^2) = 3.841 and margin of error (e) = 0.05. With the current population of 1231, the sample size = 242 students and the sample interval = 5. Now, we targeted the calculated sample by conducting an online survey in line with the difficulties posed by the coronavirus pandemic.

Measures

Just like the collection of any other commodity, the instrument used in data collection determines the quantity, type, nature, and/or kind of information gathered. In this regard, we adopted the use of a 7-point response set or Likert-type scale. These response sets ranged from 1 (strongly disagree) to 7 (strongly agree). There were no allocations made for respondents to present any other information. In other words, the questionnaire consists only of closed-ended questions. Even though these robust methods may still generate errors in measurement as the issue of 'response sets' holds regardless of the response set, we could, however, do less to offset this predicament. We hope our analysis with Structured Equation Models (SEMs) may correct such measurement errors. Now, ahead of developing our data collection instrument, the table below defines each of the constructs and presents the respective observable indicators used in the measurement.

Method

In this study, we adopted a covariance-based analysis, Structural Equation Modelling (SEM) using the R and R studio environment. The main reason is the suitability for modeling causal systems or 'systems' of relationships and also its appropriateness in instances where the research is concerned with indirect or mediated effects between variables. We firstly established a satisfactory measurement model for the latent constructs in our conceptual model using Confirmatory Factor Analysis (CFA). We bear cognizance to the fact that all measurements are made with some error – whether random or systematic. Now, CFA ensures the presentation of good measures for our variables by trying to decompose the error value from the measured variable. This process is aided by the presence of multiple indicators for each latent construct – canceling out the error variables and exposing the true score of the latent construct (Fornell & Larcker, 1981). Following the establishment of a good measurement model, we specified the relationship between the latent constructs by fitting regression paths. We then tested hypotheses and assessed model fit using Kline (2005) cut-off criteria.

Results

Overview of Respondents

Our online survey method garnered data from 362 respondents. 68.5% of the respondents representing 248 were aged 18-24; in line with our population and sample. We focused on the first 242 responses comprising 58.3% male and 41.7% female. To get more insights, we asked respondents about their level of education. In response, 207 representing 85.5% replied they were pursuing undergraduate degrees, 32 representing 13.2% and 3 representing 1.2% replied they were pursuing Diploma and Post Graduate Diploma respectively. Also, 85.5% (207) of respondents indicated they were unemployed and currently enjoying the care of parents and guardians whereas 14.5% (35) were employed. We finally asked respondents to indicate how long they have used the smartphone. In response, 59.1% indicated they had used the smartphone below six (6) years, 31% had used the smartphone above 6 years, 7.9% - below 3 years, and 1.7% - below a year.

Measurement Model Assessment

To ensure we have established a satisfactory measurement model for the latent constructs in our conceptual model, we performed a Confirmatory Factor Analysis (CFA) using R and R Studio. Table 2 below illustrates the results. First, the factor loadings of the measured variables were larger than 0.50 and Cronbach's alphas of the constructs all reached a level of significance. Thus, the constructs in this study met the minimum reliability requirement. The CFA found the model to provide a good fit (GFI=0.909, NFI=0.950, RMSEA=0.012, SRMR=0.026, TLI=0.998, CFI=0.997) with the dataset in accordance to recommended cut-off criteria (Kline, 2005). The criteria also indicate that Average Variance Extracted (AVE) and Composite Reliability (CR) values greater than 0.5 and 0.9 respectively are more accepted. As shown in Table 2 below, the AVE and CR values for all the latent constructs are greater than 0.5 and 0.9 respectively. Also, the squared root of AVE (bolded in Table 3 below) is larger than the inter-construct correlation values both row-wise and column-wise – in accordance to the Fornell and Larcker (1981) criterion.

Table 1 Measurement Model Statistics

Indicators	Factor Loadings	Cronbach's α	Squared Loadings	AVE	Errors	Σ Squared Loadings	Sum of Errors	CR
SA1	0.90	0.79	0.81	0.77	0.191	6.92	0.692	0.91
SA2	0.88		0.78		0.223			
SA3	0.85		0.72		0.278			
ICL1	0.95	0.91	0.89	0.84	0.106	3.36	0.321	0.91
ICL2	0.89		0.78		0.215			
ECL1	0.88	0.92	0.78	0.79	0.222	7.15	0.617	0.92
ECL2	0.90		0.80		0.197			
ECL3	0.90		0.80		0.198			
GCL1	0.91	0.90	0.82	0.82	0.18	3.30	0.352	0.90
GCL2	0.91		0.83		0.172			
ML1	0.92	0.72	0.85	0.79	0.146	7.14	0.618	0.92
ML2	0.87		0.76		0.24			
ML3	0.88		0.77		0.232			
ME1	0.93	0.70	0.86	0.78	0.143	28.17	1.303	0.96
ME2	0.88		0.78		0.223			
ME3	0.86		0.74		0.259			
ME4	0.88		0.77		0.228			
ME5	0.87		0.75		0.252			
ME6	0.90		0.80		0.198			
CL1	0.91	0.70	0.83	0.82	0.174	13.13	0.716	0.95
CL2	0.91		0.82		0.179			

CL3	0.91		0.84		0.164			
CL4	0.90		0.80		0.199			
KRE1	0.84	0.71	0.71	0.77	0.294	6.95	0.679	0.91
KRE2	0.87		0.76		0.245			
KRE3	0.93		0.86		0.14			

Table 2 Discriminant Validity Table in accordance to Fornell & Larcker (1981) Criterion

	SA	ICL	ECL	GCL	ML	ME	CL	KRE
SA	**0.877**							
ICL	0.588	**0.916**						
ECL	0.686	0.528	**0.891**					
GCL	0.719	0.507	0.558	**0.908**				
ML	0.731	0.753	0.730	0.685	**0.891**			
ME	0.305	0.447	0.276	0.423	0.539	**0.885**		
CL	0.325	0.478	0.459	0.462	0.663	0.791	**0.906**	
KRE	0.503	0.443	0.494	0.524	0.644	0.564	0.687	**0.879**

Structural Paths and Hypotheses Tests

After performing the Confirmatory Factor Analysis (CFA) to establish a satisfactory measurement model, we performed a structural equation analysis to ascertain the relationships between the latent constructs with regards to variance and covariance. Table 4 below illustrates the results. The analysis found the model to provide a good fit (GFI=0.878, NFI=0.932, RMSEA=0.034, SRMR=0.080, TLI=0.998, CFI=0.984) with the dataset in accordance to the recommended cut-off criteria (Kline, 2005). Table 4 below presents the standardized path coefficients (beta weights) as a representation of correlation or significance in the hypothesis similar to the p-value (Yu & Jieun, 2019). Generally, a beta weight greater than 0.8 represents a large significance or influence whereas between 0.5 and 0.8 represents a moderate significance or influence. Negative beta weights are not significant.

Table 3 Results of Hypotheses Testing

H	Relationship between constructs	Beta Weights (β)	Result
H1	Smartphone Appropriation (SA) → Intrinsic Cognitive Load (ICL)	-0.229	Rejected
H2	Smartphone Appropriation (SA) → Extraneous Cognitive Load (ECL)	0.684	Accepted
H3	Smartphone Appropriation (SA) → Germane Cognitive Load (GCL)	0.728	Accepted
H4	Intrinsic Cognitive Load (ICL) → Mental Load (ML)	-0.126	Rejected
H5	Extraneous Cognitive Load (ECL) → Mental Load (ML)	0.513	Accepted
H6	Germane Cognitive Load (GCL) → Mental Load (ML)	0.407	Accepted
H7	Mental Load (ML) → Knowledge Retention Effects (KRE)	0.356	Accepted
H8	Mental Load (ML) → Cognitive Load (CL)	0.349	Accepted
H9	Mental Effort (ME) → Cognitive Load (CL)	0.661	Accepted
H10	Cognitive Load (CL) → Knowledge Retention Effects (KRE)	0.465	Accepted

Discussion

Per the results, smartphone appropriation may not increase intrinsic cognitive load. Smartphone appropriation and intrinsic cognitive load had a negative standardized beta (β) regression weight between them. This could be interpreted as: an increase in smartphone appropriation seemingly leads to a lower intrinsic cognitive load. This result interestingly makes less theoretical sense but some practical sense. Theoretically, complexity is considered as the more novel elements the working memory has to deal with. Smartphone appropriation is not spared in this domain. The churning of variegated data and novel application interfaces and 'pop-ups' is all encapsulated in intrinsic cognitive load. Thus, more appropriation of the smartphone device should increase the intrinsic cognitive load. However, with regards to practicality, the more a person uses a smartphone, the more used they are to the device. They may need time to get used to the novel features and data. This time needed would be shortened by the constant appropriation of the smartphone. Implying, further usage may not necessarily require the need to accommodate novel elements in the working memory – as there may be no novel elements. In that domain, the hypothesis; an increase in smartphone appropriation leads to a lower intrinsic cognitive load may hold true. Since this study upholds the theoretical rendition, we accept the rejected hypothesis. Also, the hypothesis 'intrinsic cognitive load is positively associated with mental load' was rejected. This hypothesis, though institutionalized by the Cognitive Load Theory (CLT) was rejected by our data. This could immediately imply that, in non-smartphone learning activities, intrinsic cognitive load is in positive association with mental load. Thus, with the smartphone appropriation in itself not increasing intrinsic cognitive load, as intrinsic cognitive load decreases, mental load increases. In a nutshell, smartphone appropriation has a positive influence on mental load.

Secondly, a keen look at the accepted hypotheses. Per the results, hypotheses (H2; H3; H5; H6; H7; H8; H9; H10) were accepted. Thus, about the dataset, the hypotheses formulated held. The hypotheses H7 and H8, however, had a relatively lower beta (β) weight of 0.356 and 0.349 respectively. Statistically, we may call for lower influence between the constructs in these hypotheses. However, it may not be the case in reality. For instance, a 10% reduction of risk following the protection granted by aspirin against cardiovascular disease may be seen as small. However, it is extremely important. Thus, in reality, the effect of mental load on knowledge retention as hypothesized in H8 may be significant.

Finally, our model exhibits moderate and substantial explanatory power in addressing the actual relationship between smartphone use and knowledge retention in successful learning activities. This inference is necessitated solely on a statistical basis. The r^2 values were 0.835 for smartphone appropriation, 0.053 for intrinsic cognitive load, 0.467 for extraneous cognitive load, 0.530 for germane cognitive load, 0.690 for mental load, 0.671 for cognitive load, and 0.512 for knowledge retention effects. Per Chin (1998), only r^2 values below 0.15 exhibit weak power with regards to explanation.

Conclusions

The model developed in this study added and subtracted factors or constructs from the Cognitive Load Theory (CLT) and Affordance Theory in Information System Discipline (ATISD). Though these additions and deletions in the simplistic sense suffice or qualify to be presented as theoretical contributions, we intend to focus on the epistemological ramifications. That is to say, how the changes made to the theories affected the accepted understanding of relationships between the constructs. Firstly, CLT. In smartphone appropriation in the learning activity domain, intrinsic cognitive load is not positively associated with the mental load. Also, excessive intrinsic cognitive load could result in extraneous cognitive load. Performance effects, as proffered by the CLT was particularly explicated as knowledge retention effects in this study. These contributions indicate that the CLT in its pristine state may not be able to better explain smartphone appropriation in successful learning activities.

Secondly, ATISD. Smartphone appropriation, as understood in this study subsumes affordances existent. Users appropriate the smartphone device on recognition of the affordance existent – from other entities as affordance recognition is mostly independent of the observer (Gibson, 1979). This is to say, Affordance Perception and Affordance Actualization in the ATISD could be identified as one major process rather than individual processes. The reduction into individual processes may however be helpful theoretically.

Implications for Researchers

Firstly, the young Information Systems (IS) researcher needs to be critical in adopting theories especially *mid-range* theories to explain phenomena. Mid-range theories are theories borrowed from IS reference disciplines (Grover & Lyytinen, 2015). For instance, Cognitive Load Theory (CLT) used in this study is a mid-range theory borrowed from Psychology. It proved insufficient in fully explaining the IS phenomena identified.

Secondly, the young researcher in an effort to bring research closer to reality and happenings around us needs to observe the opposite way to gap-spotting. Concerning the former, gap-spotting solely by looking at research contributions is not enough to contextualize research to current happenings. The researcher needs to be more observant of issues surrounding us in our daily activities and based on that, find a practical problem and problematize it epistemologically. This form of reverse thinking and research would close the distance between most research and basic real-life occurrences.

Implications for Practitioners

The push to make legal the use of smartphones in Ghanaian senior high schools should not be solely informed by the technology providing solutions in teaching or learning. The smartphone affordance, among students, would be quickly recognized and appropriated accordingly. Noting the 'positive' and 'negative' smartphone affordances existent, and rise in mental load and knowledge retention effects following the appropriation, it would be better to enforce the current tradition – where smartphones are illegal to use in Senior High Schools. However, should there be any need to make smartphones legal, there would be a need for a psychological evaluation and assessment to ascertain the mental effort of the students. Other ways should be proposed to increase the mental efforts of the students before they are allowed to appropriate the smartphone in learning activities.

Limitations and Future Research Directions

With regards to practical methods, this study was plagued by the coronavirus pandemic – thereby making it barely impossible to administer questionnaires in the face-to-face mode and observe sample intervals even as the systematic random sampling technique was adopted. Also, the data analysis exposed adjusted goodness of fit indices (agfi) value of below the recommended 0.90 even as the goodness of fit indices (gfi) passed the recommended value. With the other fit indices passing the recommended values and modification indices set right, it was interesting to find out the agfi fell short of 0.001. Furthermore, there was a limitation to the choice of respondents. The study initially willed to use GIMPA students as respondents in the sample size. However, there is no objective proof that only GIMPA students within the specified age range responded even though the google forms link was shared with the WhatsApp groups and emails of these students. Now, some directions for future research. The structural equation model performed in this study revealed a fairly significant covariance between smartphone appropriation and mental effort. This is a non-directional path so no deductions were made. We suggest that future research could build on this and find the actual relationship between these two important variables. The measurement of smartphone appropriation is fairly prone to more questioning since affordances exists outside the basis of knowledge with regards to a particular observer. We recommend that future research in this domain finds a better and more objective measurement of this latent construct. This study could be subjected to replication in other settings such as smartphone appropriation and organizational performance to prove whether the findings would still hold true.

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