Analysing the Relationships between Digital Literacy and Self-Regulated Learning of Undergraduates – A Preliminary Investigation

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Abstract

Advances in technology access allow undergraduates to personalize their learning to their individual interests via the creation and use of informal personal learning environments (PLEs). A comprehensive understanding of how every day digital technologies are adapted and used to create such PLEs and their impact on acquisition and development of students' digital literacy (DL) and self-regulated learning (SRL) skills, is still lacking. This paper presents the initial exploratory quantitative phase, of a longitudinal mixed methods study planned to identify and describe the relationship between DL and SRL skills of students, when using PLEs. Structural equation modelling was used to analyze data collected from 202 participants in online surveys. The results confirm that DL components effect some SRL sub processes and some evidence was obtained for reciprocal relationships. Implications for Information Systems theory and practice are discussed together with future research opportunities.
Keywords: Digital Literacy, Self-regulated learning, Personal learning environments.

1. Introduction

Ubiquitous access to 'everyday digital technologies' [51] enables technology to be seamlessly incorporated in to the lives of current undergraduate students [17]. These technologies include social or entertainment technology (such as web 2.0 tools), digital media tools, programming tools, software applications and all manner of digital devices. Students are able to customize their learning to their personal interest via the construction of technology based informal personal learning environments (PLE) [48], using these technologies. Such PLEs, encompass an extensive collection of freely available tools and services accessible on the students' personal digital devices. Components and content of the PLE is altered to fit individual learning needs[15] and it is rarely limited to a single technology or even device [49].

For example, students are constantly accessing information via online search in various formats such as text and multimedia in and outside of their classes. They are using informal and formal social networks such as Facebook and LinkedIn to connect with friends and peers to share, verify, validate and supplement learning. They discuss and reflect on information collaboratively using a multitude of internet based communication tools such as Twitter or Skype. Collection and sharing of information and artefacts via file sharing and synchronization tools such as Evernote and Dropbox also abounds. Many are also creating and generating information via participation in forums, blogs and wiki's. Thus, these students are creating PLEs to supplement many of their learning needs on their own, using tools and technologies of their choice [15].

The study of such PLEs have gained increasing interest [39].There is scope, however, for consideration of the learning opportunities afforded by the combined use of various tools and technologies to construct an informal PLE [24]. How learning actually takes place when students select their own digital technologies to engage in informal learning activities initiated and controlled purely by them, together with how the use of such PLEs impact the digital and learning skills of students also warrants further study [11]

Self-regulated learning (SRL) encompasses a vital aspect of the PLE [34].Prior research shows that the creation and use of a PLE allows learners to regulate their own learning, thereby significantly enhancing their learning outcomes [17].

Moreover, PLEs are shown as a context of developing a working knowledge of digital technology and understanding of how it can be effectively used for educational purposes. i.e. 'Digital Literacy' (DL) skills [30]. Researchers acknowledge that the lack of digital literacy skills could impact learning skills and performance of students [33].

Assume a common scenario of a student trying to use the online search tools of his/her PLE for accessing information to supplement learning. The student should be able to effectively plan the search task while demonstrating an ability to monitor and evaluate the impact of the search results on the required learning. These are some component skills of SRL [54]. Moreover, the student should also exhibit an ability to competently use the search tools, while being knowledgeable of issues related to web based activities such as plagiarism. These are aspects of DL. Without successfully applying both skill sets the student would not be able to complete the search task effectively.

Moreover, previous research posits a positive correlation between DL and SRL skills of learners [52] and that DL requires effective SRL [20].

Following a similar line of reasoning, we suggest the further examination of these interactions between DL, SRL and informal PLEs via a broad mixed methods study. This paper presents one component of a proposed larger study. The specific aim of this paper is to investigate the direct relationships between DL and academic SRL skills of undergraduates within the context of their technology based informal PLEs.

We develop and empirically test structural models for the explanation and prediction of relationships between DL components of students and component skills of self-regulated learning. This research contributes to the Information Systems literature in investigating and clarifying how different digital skills of students could impact their academic self-regulatory behaviours. It investigates if the interaction with technology for learning and different digital skills developed herein might be changing student SRL behaviours. Via empirical evidence, we hope specifically to understand and describe how technological adoption in learning settings can improve self-regulated learning.

In the subsequent sections relevant literature on PLE, DL and SRL within the context of informal learning is reviewed. This review guides the development of our research model. Next, we describe our research methodology and discuss the data analysis process and results. The paper concludes with a discussion of our results, expected contributions and directions for future research.

2. Related work

2.1. Personal Learning Environments (PLE)

Personal learning environments (PLEs) considered as a form of Technology-Enhanced Learning (TEL) is characterized by the principles of learner autonomy, ownership and empowerment [5] . Contemporary practice acknowledges the PLE to be a diffuse concept, thought to innately embody the private and unique nature of its user. However, the relative novelty of the PLE concept and the different ways of implementing, demands for more empirical research in order to validate the usefulness of students' PLEs in diverse informal settings.

In [4] it is noted that researchers seem to consider the PLE mainly from a technology oriented perspective while a few studies, take a different standpoint, viewing the PLEs primarily as an educational concept [50]. For these researchers a PLE is not a software application or collection of tools, but more of a new method of using technologies for learning.

Consequently, in this study the PLE is viewed as a concept, recognized as a new approach to the use of digital technologies in learning [18]. It is defined as comprising of all the different tools undergraduates use in their everyday life for learning. This definition reflects the core concepts of these environments: self-regulation and adaptation to personal needs [28], by including frequently used technologies and tools for providing a natural connection between formal and informal learning [10].

2.2. Digital Literacy (DL)

The term , Digital literacy (DL), while used in an erratic manner in literature [12], is a very broad concept, not restricted to any particular skill set, technology form or information and concentrates on personal capabilities and attributes[3].

According to [13] DL consists of: photo-visual literacy; reproduction literacy; branching literacy; information literacy; socio-emotional literacy and real-time thinking skill. These multiple literacies were incorporated in to technical, cognitive and social-emotional dimensions of online and offline learning with digital technologies [36]. The technical literacy dimension includes having the relevant technical and operational skills to use digital technologies for learning. The cognitive literacy dimension is associated with critical thinking applied to searching, evaluating and selecting information and digital tools and technologies for learning, while being knowledgeable about related ethical, moral and legal issues. The social-emotional literacy dimension involves using online resources in a responsible manner, observing 'netiquette' such as showing respect while avoiding misinterpretation and misunderstanding and showing an awareness of privacy and individual safety concerns.

In keeping with these conceptualizations, digital literacy in this paper, refers to the collection of literacies associated with the usage of digital technologies. Technologies could include desktops, mobile devices (e.g. laptops, tablets, smartphones, PDAs), Web 2.0 technologies and other collaborative resources on the internet as well as any open source or commercially available software packages.

We adopt Ng's [36] digital literacy framework to underpin our conceptualization of digital literacy. This framework effectively draws together the broad definitions of digital literacy present in literature, while imbuing the varying literacy concepts referred to above. It has particular value because of its emphasis on different types of digital literacies envisioned as undergraduates' skills, which is the main focus of our study. Further, it is in keeping with our own conception of DL as skills that students autonomously acquire outside formal education via the use of a PLE.

2.3. Self-Regulated Learning (SRL)

Self-Regulated Learning (SRL) is defined as self-generated thoughts, feelings, and actions that are planned and cyclically adapted to the attainment of personal learning goals [55]. It is stated that the component skills include: (1) goal setting , (2) determining and implementing good strategies for realizing the goals, (3) monitoring performance consistently for improvement, (4) reorganization of one's physical and social environment to be attuned with one's goals, (5) efficient time management, (6) appraising one's methods and related results, and (7) acclimating future methods [54].

Contemporary research acknowledges SRL to be a core skill for students to succeed in informal learning environments [4]. Moreover, the use of technology is acknowledged to foster SRL in higher education contexts [10]. While the psychological and pedagogical theories around SRL precede the dawn of the PLE, SRL is regarded as an essential

characteristic of the PLE. Consequently, SRL is supported within the PLE through gathering independent resources in a manner that realizes an explicit learning goal. The PLE, therefore, allows learners to regulate their own learning, hence augmenting their learning outcomes [17].

Measuring self-regulation in learning involves the process of assessing how well students have developed the array of features consisting of (1) planning, (2) cognitive, (3) monitoring, and (4) regulating strategies. [44], as indicated by multiple measurement models of SRL present in contemporary literature [6]

These features, can be measured through the use of the Academic Self-Regulated Learning Scale (A-SRL-S) [32]This is a self-report measure based on the conceptualization and factors of the SRL framework detailed in [56]. It consists of seven sub processes. (1) Memory strategy pertains to strategies used for memorizing and retaining information [37]. (2) Goal-setting involves setting specific proximal goals for oneself [54]. (3) Self-evaluation is the constant reflection on and rectification of one's learning methods [56]. (4) Seeking assistance is actively obtaining help from teachers or peers to supplement learning [37]. (5) Environmental structuring is restructuring one's physical and social context to make it compatible with one's goals [54]. (6) Learning responsibility is ascribing causation to results, and adapting future methods [56]. (7) Organizing involves monitoring performance selectively for signs of progress while managing personal time use efficiently [54].

As such the A-SRL-S scale successfully addresses all features shared across often used multiple SRL models and is deemed suitable to represent the SRL construct as applicable in this research.

2.4. Connections between Digital Literacy and Self-Regulated Learning

Present day university students are required to be digitally literate, by possessing a working knowledge of digital technology and understanding it's usage for learning. But it must be accompanied by, among other aspects, strategies that promote, self-regulated learning, [1]. In [38] we discussed the indication of significant relationships between DL skills of students and their SRL skills using contemporary literature.

However most studies, when investigating these relationships, employed an experimental approach where a given technology was imposed on the students, and did not investigate how their current technological portfolio being used in daily life (i.e. everyday technologies) could have or is having an impact on their SRL skills. The generalizability of the findings of studies conducted in the formal classroom to an informal learning context is also limited. Therefore there is a lack of empirical evidence regarding how technology use affects SRL skills of students when learning within informal settings via the construction of PLEs. There is also a need to understand the self-regulatory processes of students engaged in the use of such learning environments.

Therefore we define the guiding mixed methods research question (RQ) for this study as follows:

RQ. To what extent and in what ways are the digital literacy skill levels of undergraduate students and their self- regulated learning skills interrelated?

In the quantitative phase of investigating this RQ, it is hypothesized that each individual component of digital literacy has a significant positive effect on each individual component of self-regulated learning. We also hypothesize that each individual component of self-regulated learning has a significant positive effect on the different components of digital literacy.

The focal objective for the qualitative phase, in investigating this RQ, is to explore and explain how the acquisition and use of technology within an informal PLE influences the development of digital literacy skill and SRL strategies of undergraduates.

It must be noted that this paper presents only the quantitative phase of investigating our research question. The following sections detail the research model and methodology used in this study.

3. Research Methodology

3.1. Research Model

In specifying the research model for this study, there were two alternative possibilities available. The first was to specify a non-recursive model which allowed for causal paths to backtrack between the digital literacy constructs and the self-regulated learning constructs. The related literature, however, does not justify such a model, as prior studies, where some relationships have been established, have used multiple different conceptualizations of DL components and SRL components. Making the collective findings inconclusive for validating the specification of a non-recursive relationship between the DL and SRL. Moreover the specification of a non-recursive model necessitates the satisfaction of multiple assumptions before they can be statistically validated making the evaluation process more difficult [9].

Therefore, the second possibility which was specifying two alternate recursive models, and evaluating these separately was adopted for this study. This was deemed the most suitable for this study due to the exploratory nature of the study. It was proposed that two alternate models would be specified and path analysis used for identifying significant paths which indicated relationships between DL components and SRL component from DL to SRL and SRL to DL.

3.2. Data Collection Instruments

Measurement scales for DL were drawn from the instrument used by Ng [36] consisting of technical literacy (TL) (6 items), cognitive literacy (CL) (2 items), social emotional literacy (SEL) (2 items).

The seven factor structure from the A-SRL scale [32] was used for measuring self-regulated learning. 1) memory strategy (MS) (14 items), goal-setting (GS) (5 items), self-evaluation (SE) (12 items), seeking assistance (SA) (8 items), environmental structuring (ES) (5 items), learning responsibility (LR) (5 items), and organizing (O) (6 items).The A-SRL scale was originally developed, used and proved with college students and allows measurement of SRL behavioural strategies. Unlike other measures for SRL which focus primarily on motivation (e.g. [40]), the focus of this instrument is situation specific SRL behaviours, as suitable for this study. Using a self-report instrument here, also allows us to view key variables through the eyes of actual students, which can capture data that an outside observer may miss.

However in addressing validity issues arising from using self-report measures, we assume that the participants, have the ability to verbally understand and report their thoughts and feelings. But this may not always be the case and can lead to measurement error [43]. To ensure face and internal validity as well as consistency, a pilot test was conducted among 18 first and second year undergraduate students, 5 postgraduate students and 2 academic staff members before it was released via email to the target population.

3.3. Data Collection

Data collection was performed online by using the survey application Qualitrics. As the study presented in this paper is a component of a larger study it was decided that the survey would be conducted in two parts. The digital literacy constructs, together with attitude, frequency of technology use, level of usage, digital skills development approaches, proficiency levels in technology use, usage ratings and perceptions of usefulness of various technologies were included in first survey together with social demographics of the respondents. The A-SRL scale items were included in a second survey. The respondents of the first survey were asked to indicate willingness to participate in the second survey and second survey was emailed to respondents who agreed to continued participation in the research.

This increased the risk of number of respondents decreasing from the first survey to the second. Moreover as the first and second survey responses would need to be matched to the relevant respondent, it was not possible to conduct the surveys anonymously. However, length of surveys are generally found to have a negative linear relation with response rates in web surveys [14] and thirteen minutes or less completion time is considered as the ideal length to obtain a good response rate from college students [23]. Therefore administering the survey in two parts was considered a good strategy for reducing optimizing and satisficing behaviour among respondents [29].

Moreover the separation of the two surveys is also a means of controlling common method bias arising from common sources, where the measurement of predictor and criterion variables have been separated by introducing a time lag between their measurement [41]. Other procedural remedies which were adopted to minimize common method bias in the surveys was to display each section separately to allow the participants to realize that they were viewing a different set of questions. The first survey was emailed across to a random sample of undergraduate students enrolled in courses within the Business faculty of a top university in the Asia-Pacific region. A total of 287 complete responses was obtained for the first survey, of which 264 were usable. 243 students indicated agreement to fill in second survey. However, only 215 responses were obtained for the second survey when it was emailed across, of which 202 were usable.

4. Data Analysis

Structured equation modelling (SEM) was the technique selected for investigating the interested phenomena. SEM enables characterization of real-world processes better than simple correlation-based models and is better suited for the mathematical modelling of complex processes [19]. Moreover, SEM assesses the supposed causation among a set of dependent and independent constructs via the structural model while evaluating the loadings of measurements on their expected latent constructs in the same analysis. Thus, SEM is acknowledged to be a more rigorous analysis of the proposed research model.

SEM techniques are divided in to two types as variance based and covariance based [19]. The former is thought to yield robust results regardless of sample size and normality issues [8]. Hence, due to the small sample size used in this study and its focus on investigating behavioural relationships, variance-based SEM or PLS-based SEM [8] was the technique adapted. Further, PLS-based SEM can be used in an exploratory study, where the theoretical knowledge is relatively limited [7]. Data analysis was conducted using WarpPLS 5.0.[25].

4.1. Measurement Model Evaluation

The fit of the internal structure of our model, which draws on prior developed constructs, was established through the more rigorous validity criteria of a reflective measurement model specified in WarpPLS.

Reliability and internal consistency for the measurement model was evaluated using Cronbach alpha and Composite reliability (CR). Both measures were considered as Cronbach alpha alone, is thought to under-estimate reliability [22]. A cut off value of 0.70 was adopted for both measures [2]. The CR together with Cronbach alpha for all constructs showed a value above 0.70. Convergent validity aims to ensure that each indicator of a given construct shares a high proportion of its variance. Indicator reliability was established by checking all cross loadings to be above 0.70 [2] where all indicators fulfilled this criteria. Next, the average variance extracted (AVE) values for each construct were examined. According to [2] any constructs showing an AVE of less than 0.5 are subject to insufficient convergent validity. All AVE values were greater than this threshold and convergent validity is established. Table 1 depicts associated measures.

Discriminant validity is the degree to which a latent variable differentiates from other latent variables. In order to establish discriminant validity we examined the cross loadings to

ensure that all indicators have the highest loading on the designed construct and lower loading values on the other constructs. It was seen that the last indicator for TL, 'I have good digital skills' had it highest loading on the CL construct. Consequently this indicator was dropped from subsequent analysis. Additionally the Fornell Larker criterion [16] was applied where the square root of each constructs' AVE value needs to be greater than its correlation with any other construct. Table 2 below provides the results for square root of AVE on the diagonal together with the correlations among the three constructs as off diagonal elements. It is seen that the discriminant validity requirements are met.

Table 1. CR, Cronbach alpha, and AVE values for the constructs.

	TL	**CL**	**SEL**	**MS**	**GS**	**SE**	**SA**	**ES**	**LR**	**O**
CR	0.96	0.93	0.964	0.986	0.967	0.983	0.972	0.944	0.961	0.969
Cronbach alpha	0.948	0.849	0.924	0.985	0.958	0.981	0.967	0.925	0.948	0.961
AVE	0.827	0.869	0.93	0.838	0.856	0.825	0.814	0.77	0.83	0.838

Table 2. Correlations and square root of AVE for the constructs.

	TL	**CL**	**SEL**	**MS**	**GS**	**SE**	**SA**	**ES**	**LR**	**O**
TL	**0.91**									
CL	0.897	**0.932**								
SEL	0.886	0.822	**0.964**							
MS	0.67	0.66	0.633	**0.916**						
GS	0.82	0.752	0.769	0.662	**0.925**					
SE	0.641	0.601	0.556	0.629	0.633	**0.908**				
SA	0.67	0.643	0.672	0.542	0.616	0.56	**0.902**			
ES	0.637	0.645	0.545	0.635	0.667	0.433	0.473	**0.878**		
LR	0.778	0.745	0.703	0.739	0.783	0.765	0.711	0.708	**0.911**	
O	0.731	0.699	0.678	0.721	0.749	0.729	0.699	0.622	0.836	**0.916**

In [41] the Harman Single Factor technique is recommended for assessing common method bias. If the single factor which is introduced in this manner (common latent factor) explains more than 50% of the variance, then common method bias may be present. [42]. When this technique was used factor analyses produced a single factor which accounted for 37.64% of the variance in the constructs. Although being simple this method does not statistically control for common method variance. It is also sensitive to the number of variables involved with greater chance for multiple common method factors to exist in larger models [11].The examination of full collinearity variance inflation factors (VIFs) is another method that is recommended for identifying common method bias. [27]. The average full collinearity VIF (AFVIF) for the measurement model was 4.629, where the acceptable level recommended is less than 5, although it would have been ideal if this value was less than 3.3.

4.2. Structural Model Evaluation and Discussion

Having established the validity and reliability of the measurement model the next step was to evaluate the structural model. The size and significance of the path coefficients examined the hypothesized relationships and the level of influence (p-value). The coefficient of determination could be evaluated from the R^2 value to measure the predictive accuracy. Effect size was also examined to understand the level of impact from one construct to another.

The two structural models corresponding to the two research models were evaluated using the warp3 PLS regression algorithm, which tries to identify a relationship defined by a

function whose first derivative is a U- curve, as found in most natural and behavioural phenomena [26]. After estimating p-values with both bootstrapping and jack-knifing resampling techniques, bootstrapping with 100 resamples was selected as the technique which provided the most stable coefficients.

The analysis results suggested that technical literacy (TL) had significant impacts on all of the sub processes of SRL as indicated in Table 3. Cognitive literacy (CL) had significant impacts on all of the sub processes of SRL except Goal Setting (GS). Social emotional literacy (SEL) had significant positive impact on Goal Setting (GS), Seeking Assistance (SA) and Environment Structuring (SA) sub processes only. Unexpectedly, SEL was seen to have a significant negative impact on Self Evaluation (SE). The expected variance in each SRL sub processes due to digital literacy components are shown in the last row of table 3.

Table 3. Path coefficients, significance levels, total effects, effect sizes and R-squared for DL component effects on SRL sub processes.

Path		MS	GS	SE	SA	ES	LR	O
TL →	ß	0.275***	0.621***	0.450***	0.218***	0.486***	0.557***	0.412***
	effect size	0.187	0.515	0.3	0.147	0.325	0.451	0.309
CL→	ß	0.355***	0.047	0.118*	0.182**	0.324***	0.22***	0.274***
	effect size	0.241	0.036	0.074	0.119	0.212	0.17	0.2
SEL→	ß	0.089***	0.184**	(-0.135)*	0.326***	0.124*	0.063	0.101
	effect size	0.057	0.143	0.082	0.22	0.07	0.046	0.07
	R-squared	0.485	0.694	0.292	0.487	0.607	0.667	0.579

Table 4. Path coefficients, significance levels, total effects, effect sizes and R-squared for SRL sub processes effects on DL components

Path		TL	CL	SEL
MS →	ß	0.09	0.116*	0.153*
	effect size	0.061	0.077	0.098
GS→	ß	0.46***	0.35***	0.499***
	effect size	0.382	0.27	0.389
SE→	ß	0.073	0.065	0.023
	effect size	0.049	0.041	0.014
SA→	ß	0.223***	0.215***	0.319***
	effect size	0.16	0.147	0.225
ES→	ß	0.065	0.137*	0.044
	effect size	0.042	0.089	0.025
LR→	ß	0	0.052	-0.009
	effect size	0	0.04	0.007
O→	ß	-0.087	0.027	0.028
	effect size	0.069	0.02	0.02
	R-squared	0.625	0.684	0.764

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Analysis indicated that most SRL sub processes did not have a significant positive impact on digital literacy components as shown in Table 4. GS, SA, MS and ES were the four sub processes which had an impact on CL. SEL was affected significantly positively by GS, SA and MS, while TL appeared to be the least affected by SRL sub processes, with only GS and SA having a significant positive impact. The expected variance in each DL component due to the sub processes of SRL are shown in the last row of table 4.

Our results indicate that possessing the applicable technical and operational skills to employ digital technologies for learning has a statistically significant positive effect on all of the self-regulation sub processes, supporting our initial hypothesis. While the small p-value (≤ 0.001) indicates strong evidence to support this effect, the effect sizes of TL on SRL processes are within the small to medium range for the sample of undergraduates considered [45]. Further TL has the highest impact on how students set achievable learning goals (GS).

The next highest impacts of TL is on taking responsibility for students learning actions and adapting (LR), closely followed by reorganization of their physical and social environment to ensure compatibility of goals (ES). A possible reason might be the prolific use of organizers and schedulers accessible on their mobile phones and other devices integrated on to their PLEs for planning and management of their activities. Further, communication tools such as Skype and messenger partnered with sharing mechanisms for artefacts produced such as Dropbox, enables fast feedback on tasks together with seamless collaboration. Moreover, web based formal an informal social network environments partnered with forums and blogs enable the restructuring of students' social environment to suit their goals.

There is significant evidence that the relationship between TL and GS is reciprocal. Possibly goal setting behaviours change the level of operational digital skills that students acquire and demonstrate and should be investigated further. Another possible indication of a reciprocal relationship is seen between TL and SA. However contrary to our initial hypotheses' each individual subcomponent of SRL does not affect TL.

CL which encompasses critical thinking applied to information and tool usage has the highest statistically significant positive impact on strategies used for remembering and recalling information (MS), again closely followed by its impact on ES. However the effect size is comparatively small.

It is also interesting that GS behaviours, an activity which one would assume needs critical thinking is not statistically affected at all by CL. However GS behaviours have a small yet significant positive impact on CL. This could mean that the manner in which students set achievable goals for themselves, changes the manner in which they select tools to be incorporated on to their PLEs and thereafter interpret information obtained.

There is indication of a possible reciprocal relationship between CL and SA, however the effect sizes in both cases are very small. Again contrary to our initial hypothesis SE, LR and O have no significant impact on CL.

SEL show its highest statistically significant positive impact on strategies used for obtaining assistance from teachers or peers to supplement learning (SA). A possible explanation is that demonstrating responsible behaviour and 'netiquette' when connecting with others over the social tools, such as social networks of ones PLE is important to ensure that assistance can be readily obtained from peers. Indeed this relationship appears to be reciprocal where the amount of help obtained seems to increase the level of responsible and strategic behaviour shown online by students.

While SEL does not have a very large impact on GS, goal setting behaviour does positively affect SEL, again providing indication of reciprocity. Surprisingly SEL shows a small yet significant negative impact on the student's self-evaluation (SE) strategies. Perhaps this is an indication of the challenges that connection with peers for education via social media bring across, such as lack of privacy and real friendship [53].

5. Conclusion and Outlook

Our research examined two models of the extent to which SRL sub processes and DL constructs influence each other. Empirical analysis applying PLS-SEM technique confirmed that there are indeed some significant influences of some DL component on some SRL sub process and vice versa, while providing indication of a few reciprocal relationships between the constructs examined. Therefore we can add further empirical validity and clarity to the claims that the use of technology impacts SRL skills [21] and show that some SRL skills are instrumental in developing DL skills [46]. Further, our findings shed light on the specific digital literacy skills that undergraduates cultivate by using information systems for construction of PLEs. We also provide an opening for a comprehensive dialogue among researchers interested in understanding the patterns, contexts and consequences of technology adoption for learning and its specific effects on students' self-regulatory behaviours. Further, the measurement model could confirm that the DL and SRL constructs we used have appropriate reliability and validity and could encourage other researchers in incorporating these constructs in their research. Moreover, as we have not considered cultural attributes

here, this research is ripe for replication in other cultural settings to determine if the relationships remain constant across different settings.

Next, our exploratory analysis paves the way for further research. A qualitative analysis incorporating the examination of mind maps of actual PLEs constructed by students, combined with face to face interviews could help in explaining and clarifying the above findings. This qualitative data collection is presently underway and findings will be forthcoming. We expect that the qualitative data will also enable us to identify specific affordances that technological tools integrated in to a PLE offers students. Thereby providing significant insights on design considerations for educational tool development.

Future work should be conducted with a control group of participants who will not be exposed regularly to technological tools via their university courses to eliminate single group threats which are a limitation of this study. Further a confirmatory study is propositioned to test specific hypothesis of the reciprocal relationships indicated in this exploratory study via a non-recursive research model and a larger sample. The effects of moderators such as gender, level of usage of tools, time spent using technology and proficiency levels and mediation effect of attitude towards learning with technology on the relationships between DL an SRL also warrant further investigation.

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