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Self-regulated learning strategies in higher education: Fostering digital literacy for sustainable lifelong learning

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Abstract

This paper aims to examine how self-regulated learning strategies (SRLS) can foster the enhancement of digital literacy in digital learning to increase efficiencies in human capital for sustainable development in lifelong learning. Digital disruption in the education sector is unavoidable. The results of this study will be useful for educators and students to establish guidelines on how to utilize SRLS to enhance digital literacy competence and hence lifelong learning as developing human capital for the future workplace is crucial. Since research supports the fact that digital natives lack digital literacy, this paper look at how SRLS can foster digital literacy because it assists students to manage their learning independently online. Furthermore, there is a dearth of evidence on the effects of SRLS on digital literacy. How SRLS can elevate digital literacy is still rudimentary. To fulfill the purpose of the study, four hypotheses were formulated. A cross sectional survey of full-time undergraduates from IT or Multimedia programs to examine the relationships between the use of self-regulated learning strategies towards digital literacy in digital learning within from selected private universities with blended learning environments in the central region of Malaysia.A total of 563 respondents were analyzed via Structured Equation Modelling using Partial least Squares (PLS) to obtain the final results. The results of the hypotheses revealed three out of four hypotheses were supported corroborating that three domains of SRLS (metacognitive knowledge, resource management, and motivational beliefs) showed a significant positive influence on digital literacy.

Keywords Self-regulated learning strategies · Digital learning · Higher education · Digital literacy · Lifelong learning · Blended learning · SmartPLS

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1 Introduction

In this highly interconnected and technologically rich world, university students need to acquire more skills, adaptability, and flexibility to prepare themselves for the future workplace that is rapidly changing mainly due to digital disruption across numerous industries. A disruption in the education sector is a sudden interruption that brings a disruptive change to redefine the quality of learning. In the education sector, students need to learn, unlearn and re-learn to retune and upskill themselves throughout their lifetime as the velocity of skills demanded by employers is increasing. Therefore, this presents an opportunity for students to be lifelong learners. Lifelong learning is the ability to continuously attain, fine-tune, and transfer knowledge and skills throughout their lifespan (Parisi et al. 2019). To do this, higher education institutions must rethink ways to speed up the quality of learning by fostering digital literacy.

Blended learning which combines face to face classroom teaching with digital learning continues to grow in popularity in higher education, to streamline and enhance student learning, supporting collaboration and creativity and equipping students with the skills they require to work and live in an increasingly digitized world. Digital learning is any type of online or offline learning in which instructions and content are accompanied by technology. Scholars articulated that digital literacy is a much-needed prerequisite for students to excel in a blended learning environment (Tang and Chaw 2016; Techataweewan and Prasertsin 2017). Although these digital generations are undeniably engaged with technologies and they are very comfortable and confident using technology to accomplish tasks, many educators tend to assume that students today have digital literacy. Nevertheless, university students lack the inadequate digital literacy skills needed for digital learning (Muresan and Gogu 2013). The reason for this difficulty is that many students who enter higher education have no digital literacy needed for digital learning (European Commission 2013). This is probably because students might be using technology for social media or entertainment but not for learning (Prior, Mazanov, Meacheam, Heaslip and Hanson 2016; Shopova 2014). Examples include not engaging in a thoughtful process while learning online(Vissers et al. 2018), not being able to evaluate and integrate digital information effectively(Tang and Chaw 2016; Ng 2012; O'Sullivan and Dallas 2010; Tenku Shariman et al. 2012), not able to critically judge the suitability of a large amount of information online(Greene et al. 2014), not understanding the ethical and social usage of information, interpret the reference to a paper or journal, search databases effectively(Shopova 2014), not able to regulate and discern the validity and value of information found online (Tenku Shariman et al. 2012) and not understanding copyright issues when using digital information for sharing purposes (Tenku Shariman et al. 2012).

Besides the need to acquire digital literacy in digital learning, acquiring self-regulative abilities is also a must in digital learning. In digital learning, being able to pursue academic goals independently is expected of students. Self-regulative abilities are the skills of learners to utilize self-regulated learning strategies in managing their learning progression. Examples of self-regulated learning strategies include effort regulation, critical thinking, peer learning, task value beliefs, and help-seeking strategy. Self-regulated learning strategies are key in developing digital literacy skills (Shopova 2014; Janssen et al. 2013; Greene et al. 2014; Yang et al. 2014). Additionally, self-

regulation is a factor that leads to successful online learning (Ejubovic and Puška 2019). Moreover, self-regulation and digital literacy are notably among the most prominent skills for education and work (Scott 2015).

Nevertheless, some researchers reported that there is little evidence on the impact of self-regulated learning strategies towards digital literacy (Argentin et al. 2014) and how to promote the level of digital literacy in students warrants further investigation since there is no one specific strategy or set of strategies to achieve online success (Ting 2015). Hence, further investigation is needed to look into the particularities of SRLS in digital learning environments towards digital literacy (Greene et al. 2014). Moreover, additional research on identifying comprehensive strategies to improve digital literacy among university students is rudimentary (Shopova 2014). To top it all, there is a pressing need to invest in digital literacy enhancement for economic growth and competitiveness (European Commission 2010; Greene et al. 2014; Krish et al. 2017; Chelghoum 2017; Gurung and Rutledge 2014). Hence, it is crucial to examine how self-regulated learning strategies can help elevate digital literacy among students, as there is still a dearth of research investigating self-regulated learning strategies on digital literacy enhancement. By bridging this gap, this study will reveal valuable information on which self-regulated learning strategies drive digital literacy enhancement in digital learning within the blended learning environment in higher education institutions. It is important to consider how different self-regulated learning strategies influence students' digital literacy in light of sustainable lifelong learning. In light of the aforementioned, in the context of countries, only a few studies surrounding self-regulated learning strategies have been conducted in Asia (Li et al. 2018) as compared to Europe and America (Richardson et al. 2012).

The purpose of this study is to evaluate the relationship between self-regulated learning strategies and digital literacy in digital learning within a blended learning environment in higher education institutions in Malaysia. The paper starts with a literature review of the main concepts. Self-regulated learning strategies and their relation to digital literacy are also discussed and followed by the formulation of research hypotheses. The method adopted in this study is based on literature review and hypotheses development. Data analysis and findings are discussed in Section 4. Section 5 presents the overall conclusion of the study and finally, Section 6 presents the limitation and future research.

2 Literature review

2.1 Education in the age of disruption

UNESCO Education for Sustainable Development (ESD) empowers people to change the way they think and work towards a sustainable future. ESD aims to improve access to quality education on sustainable development at all levels and in all social contexts, to transform society by reorienting education and help people develop knowledge, skills, values, and behaviors needed for sustainable development. Current technological disruption is profoundly changing the education industry and in this age of disruption, it allows institutions to rethink their current higher education model. Disruption is quietly changing the landscape of education, whereby digital technology has become

an integral part of education, where learning is becoming more flexible, more formative and more personalized focusing on experiences that cultivates curiosity, unleashes creativity, more hands-on and engaging. Routine cognitive work is disappearing. Thus, digital learning is on its way to becoming a staple pedagogical approach in many higher education institutions in many developing nations to achieve ESD because education is being radically disrupted by new technologies. Equipping students with the ability to deal with new technological opportunities and challenges is one way to better prepare young people for the uncertainties of the future.

2.2 Blended learning

A partially digital learning environment where traditional face-to-face classes are supported by online activities conducted through blended learning software is called blended learning (Anthonysamy et al. 2020). (refer to Fig. 1). Blended learning is also known as Hybrid Learning, Flipped Classroom (Bowyer 2017) and blended e-learning or blended e-learning system (Graham 2006) in the literature. The rise of blended learning and the prevalence of affordable devices has become a trend in higher education institutions as students are accustomed to using their digital devices for almost anything such as communication, collaboration, accessing multiple sources of information for solutions.

Digital learning is any kind of learning that is facilitated by technology where students have some amount of control over certain aspects of their learning such as time, place and learning pace (Horn and Staker 2011). The time factor is no longer confined by the academic structure of institutions. Internet-enabled devices have allowed many individuals to learn or perform tasks at any time. The place element describes learning does not only happen in the classroom but anywhere and everywhere. With digital learning, the pace of learning is also not determined by the lecturer. Digital learning is known to have several advantages which include collaboration and access to content that extends beyond the classroom. With the rise of digital learning, students can plan and manage flexibly to attain a learning goal. Nonetheless, apart from the many benefits digital learning offers, it requires greater discipline (Azizan 2010).

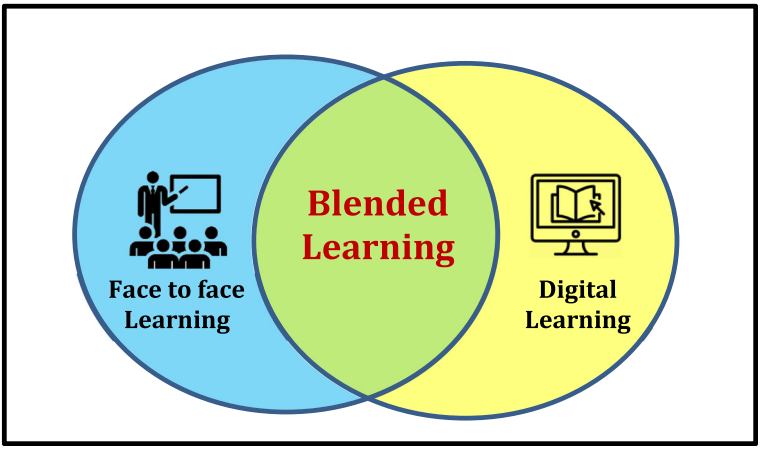

Fig. 1 Blended learning environment

Thus, for learners to engage actively in the digital learning process, they need to acquire some amount of self-regulated abilities to construct their learning beyond the classroom.

2.3 Self-regulated learning strategies

Self-regulated learning is a method students use to self-manage and organize their mental abilities into task-related skills for learning (Zimmerman 2001). Self-regulated learning involves a continuous process of self-monitoring and self-directing towards a learning goal. This continuous process includes self-checking progress, self-reflection on outcomes and able to regulate efforts towards failure. However, for students to be self-regulated, they need to be aware of their thought processes and motivated to take part in their learning process (Zimmerman 2001). This can be acquired through the use of self-regulated learning strategies. Self-regulated learning strategies are techniques to actively engage with themselves and the environment through cognitive, metacognitive, behavioral and motivational components. Examples of self-regulated learning strategies are planning, critical thinking, peer learning, effort regulation, and goal orientation. Self-regulation is desirable because students who utilize self-regulated learning strategies in digital learning perform better than those who do not (Greene et al. 2018).

Literature has presented are 14 self-regulated learning strategies (SRLS) framed within the social cognitive theory and these SRLS can be classified into four domains: (1) cognitive engagement, (2) metacognitive knowledge and (3) resource management (Zimmerman and Martinez-Pons 1986) and (4) motivational belief (Pintrich 1999). Figure 2 shows the four domains and the list of self-regulated learning strategies. Cognitive engagement involves the amount of mental effort and willingness of students to attain, retrieve and retain knowledge as well as to take on a learning task at hand. For example, a student will persistently add to figure out a subject material to understand it. Metacognitive knowledge denotes in-depth thinking in which a student is well aware of their cognitive processes. Students who are aware of their metacognition knowledge, will, therefore, will be able to make better use of their knowledge and skills in their

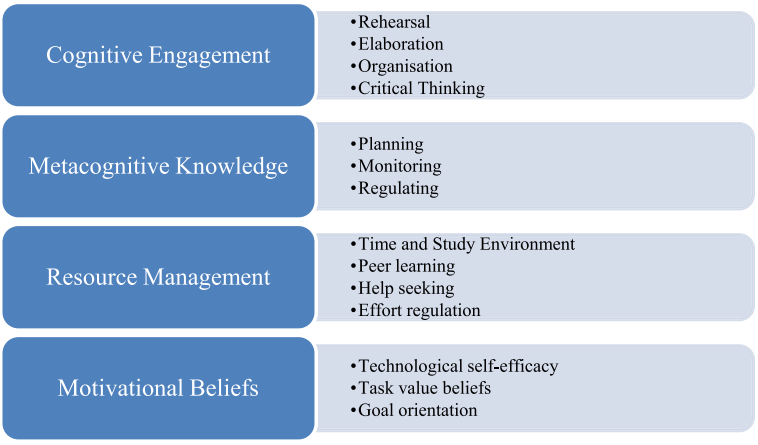

Fig. 2 Domains and SRLS (Zimmerman and Martinez-Pons 1986; Pintrich 1999)

learning journey. For example, fine-tuning and checking through an academic task before a submission is an act of metacognitive thinking. Resource management involves using the available resources wisely, for example, time management, peer learning, help-seeking, and environmental structuring to assist in students' learning process. Motivational beliefs consist of the forces that encourage students to engage or pursue a goal. For example, learning software or task on their own is an indication of motivation to complete an academic task. The adoption of SRLS help students regulates their learning while increasing their independence and proficiency. Moreover, self-regulated behavior has been seen to be an important predictor of learning and performance (Haron et al. 2015).

2.4 Digital literacy

Recent authors define digital literacy as the ability and awareness to use emerging digital technologies to perform tasks while demonstrating proper attitude in a digital learning environment (Perera et al. 2016). Following the model developed by Ng (2012), digital literacy embraces the perspective of cognitive, technical and socio-emotional learning in an offline or online mode (Ng 2012). A cognitive aspect includes choosing the technology, searching, assessing and selecting information using critical thinking skills, etc. Technical abilities are a key component of digital literacy and its dimensions include owning the skills required to operate digital technologies for learning. The socio-emotional dimension is associated with the behavior of an individual in using digital technologies. Digital literacy has also been identified as the key competence in the Europe 2020 Strategy (European Commission 2010) because it can be considered as the spine in the current educational pedagogy as it plays a vital role in a student's education life. Digital literacy significantly enhances graduate employability because of it empowers graduates to achieve more in a digital economy (Mehrotra 2017). In the labor market, 90% of jobs require excellent digital literacy competency.

As society becomes more digital in their everyday task, knowledge, attitude, and skills are essential to be digitally literate. Being digitally literate today is not confined to having digital skills which refer to just understanding the hardware and knowing how to use the software. Digital literacy as a set of competencies to fit into a knowledge society. These competencies include knowledge, skills, behavior to effectively use digital technology and smart devices such as smartphones, tablets, laptops and personal computers for purposes of collaboration, communication, support, and expression. Digital literacy includes information management, digital skills, ethical awareness, etc. It has been posited that to make effective use of technology for learning, one needs to have a certain level of digital literacy (Tang and Chaw 2016).

To be considered as digitally literate, Mohammadyari and Singh (2015) stated that people must have multiple literacies to use digital technology efficiently and effectively as digital literacy requires an understanding of the various types of information as well as an integrated understanding of these types. In other words, digital literacy means more than just being able to use computers or technologies for a task. An individual needs to develop function skills, values, attitude and behavior to become a digitally-literate person. Digital tasks include reading digital instructions from the user interface, using digital tools to reproduce or create something new, using online materials to construct new knowledge, evaluating the validity of Internet information, and having a

proper understanding of Internet ethics. Digital skills or technical literacy only focus on how to use technology while digital literacy goes beyond operational skills. For example, a digital skill would include a student knowing how to download an image to insert into presentation software. Digital literacy would focus on choosing the appropriate image, recognizing copyright licensing or getting permission to use the images (Bali 2016).

2.5 Self-regulated learning strategies towards digital literacy

Digital literacy is neither a catchphrase nor just a physical proficiency for devices. Digital literacy refers to the attitude, ability, and awareness to use digital technology to appropriately access, identify, manage, analyze, construct new knowledge and communicate with each other (Ng 2012; Mohammadyari and Singh 2015; Perera et al. 2016) in digital environments. Digital literacy embraces the perspective of cognitive, technical and socio-emotional learning in an offline or online mode (Ng 2012).

The acquisition of digital literacy is enabled from having a different mindset that can adapt to new requirements by ever-changing technologies (Coiro et al. 2008). This mindset is necessary for today's education because digital literacy is critical for the labor market. The ability to search, critically examining information before integrating them into a meaningful output during online learning requires effective self-regulated learning (Greene et al. 2014). Students with good self-regulated abilities can manage attention, working memory and have inhibitory control online (Lee et al. 2015).

Literature has proven that self-regulated learning strategies are vital to foster digital literacy competency. Greene and researchers reported self-regulated learning strategies such as planning, monitoring, effort regulation, and critical thinking have a major part in the development of digital literacy (Greene et al. 2018). Similarly, van Laer and associates echoed that the adoption of self-regulated learning strategies is needed as it may potentially reduce students' struggle with digital literacy (Van Laer and Elen 2017). Furthermore, Zylka and authors reported a positive relationship between metacognitive knowledge and digital literacy (Zylka et al. 2015) which indicates that metacognitive process may facilitate the higher acquisition of digital literacy. Likewise, planning and self-monitoring, which are two aspects of metacognition process are critical aspects of digital literacy (Greene et al. 2014) because it reflects one's thinking and academic behavior (Pintrich 1999).

Based on the above discussion, therefore, the following hypothesis was derived:

Hypothesis 1 (H1): *There is a positive relationship between cognitive engagement (CE) and Digital Literacy (DL).*
Hypothesis 2 (H2). *There is a positive relationship between metacognitive knowledge (MK) and Digital Literacy (DL).*
Hypothesis 3 (H3*). There is a positive relationship between resource management (RM) and Digital Literacy (DL).*
Hypothesis 4 (H4). *There is a positive relationship between motivational beliefs (MB) and Digital Literacy (DL).*

3 Method

This study was based on the cross-sectional survey of full-time undergraduates from IT or Multimedia programs to examine the relationships between the use of self-regulated learning strategies towards digital literacy in digital learning within from private universities with blended learning environments in Malaysia. A university who adopts a combination of face-to-face teaching accompanied by technology into the classroom is considered to implement a blended learning approach. The cross-sectional study design was adopted which involved the collection of data at a single point of time (Sekaran and Bougie 2013) which is appropriate for hypotheses testing.

The main instrument for this study was a questionnaire, which consisted of three sections. The first section comprised of demographic related questions for example age, gender, nationality, year of study and field of study. The second section consisted of the frequency of use of self-regulated learning strategies within the four domains (cognitive engagement, metacognitive knowledge, resource management, and motivational beliefs) in the form of 5-point Likert scale (1 (Never), 2 (Rarely), 3 (Sometimes), 4 (Often) to 5 (Always). Likert-type scale guidelines developed by Brown (2010) was followed. Similarly, the third section comprised questions related to digital literacy domains (Technical literacy, cognitive literacy, and socio-emotional literacy) also using the same 5-point Likert scale as used in the second section to measure the frequency of use. The likert scale does not have a neutral mean because in purposive sampling, the respondents were chosen purposively. Hence, they should have a perception of their SRLS and digital literacy frequency of use. Likewise, Moser and Kultan (1972) reiterated that by having a neutral mid-point, it may provide uninformative data.

Several prior relevant studies were reviewed to develop the self-report instrument. This is to ensure a comprehensive list of measures was included. To assess students' use of self-regulated learning strategies, Motivated Strategies for Learning Questionnaire (MSLQ) was adapted because it has been used widely used to assess students' self-regulatory behavior (Pintrich et al. 1991) in the online environment (Zhu et al. 2016) among undergraduates (Broadbent 2017). Furthermore, digital literacy items were developed based on the model developed by Ng (2012), and tools developed by van Laar and associates (Van Laar et al. 2017). Figure 3 shows the research model for this study.

Purposive sampling was employed in this study. The primary consideration in purposive sampling is the judgment of who will be able to provide the best information to achieve the objectives of the study. Malaysia comprises of public and private universities. Public universities are funded by the Malaysian government, where else private universities are self-funded. Since the adoption of blended learning in public universities in Malaysia is low, where only 13% of academicians adopted blended learning approach (Embi et al. 2014), only local private universities located in the central region were studied because 53 local private universities are in the central region of Malaysia which constitutes 68%. Out of 53 private universities, informal interviews were carried out to identify whether blended learning was implemented for their full-time undergraduate programs. Apart from that, website searching for all 53 universities were also carried websites were searched to check if the university is implementing a blended learning approach for their undergraduate programs. After the interview and website search, a total of seven universities were identified. The

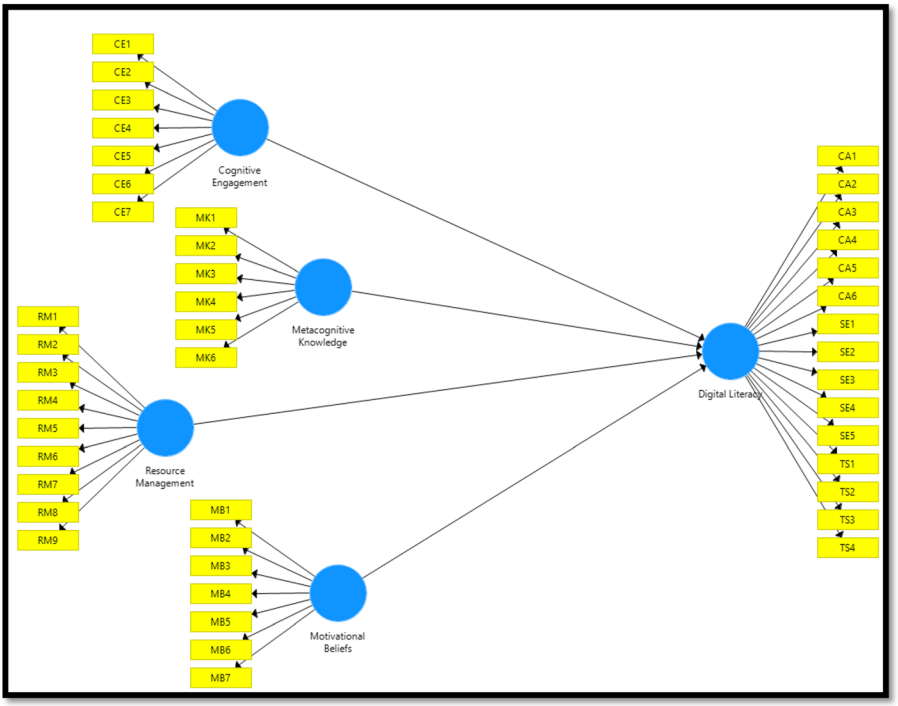

Fig. 3 Research model

population size based on these seven universities fulfilling the test criteria is 45,466 Malaysian undergraduates (eIPTS 2018). G Power Software (v 3.1) was used to calculate the sample size using a significance level of 0.05, an effect size of 0.15 with four predictors (exogenous variables). The confidence level of 95% with a 5% margin of error is accepted widely for most social science research (Sekaran and Bougie 2013). Although a minimum sample of 129 generated by G Power was deemed sufficient for analysis in this study, a total of 770 questionnaires were distributed.

To initiate contact and obtain consent from universities, emails were sent to the Head of Departments / Programme Coordinators / Subject Coordinators of the universities to seek permission for data collection. These emails mentioned the objectives as well as the significance of this study. The emails also expressed the researcher's commitment towards keeping respondent anonymity and asked for voluntary participation. Once permission was granted, time and date were scheduled. The final survey was administered between March 2019 and April 2019 on-site at each of the seven universities. For the administration and collection of the survey, the researcher relied on a research assistant recruited through a research grant. Before the survey was carried out, the research assistant read a briefing note to notify respondents that the research is of voluntary participation. The briefing note also included the aim of research and that their responses will remain strictly confidential as it will be used for the research study only. The research assistant then distributed the questionnaires in class and waited for respondents to complete the questionnaire to collect the answered questionnaires. Upon completing the questionnaire, a small gift was presented as a token of appreciation. Out

of 770 questionnaires that were distributed, 726 questionnaires were returned, with 563 being cleaned, completed and usable for this study.

SPSS (Statistical Package for the Social Sciences)(v.25) was used to key in each respondent's response and to test for normality and common method variance (CMV) where biasness can be caused by the instrument rather than the respondent. Upon confirming the data set showed no evidence of common method variance, Structured Equation Modelling (SEM) using partial least squares was employed in this study to test the relationship between self-regulated learning strategies and digital literacy. The data analysis comprised of 2 parts: (1) checking the internal consistency reliability (2) testing the formulated hypotheses using multiple regression analysis.

4 Data analysis

4.1 Descriptive statistics

The study focused on selected private universities located within the central region of Malaysia implementing blended learning for their undergraduate programs. Data were collected full-time undergraduates pursuing a course in IT or Multimedia who have enrolled in at least one blended learning course.

The final data set used for analysis comprised mostly of males (70.3%) and the remaining being females (29.7%) with the majority being Malaysians (85.1%). As for the age group of these students, 45.1% fell in the age group between 19 to 20 years of age, 49.9% fell in the age group between 21 to 22 years of age and 5.0% fell in the age group between 23 and 24 years of age. The IT undergraduates consisted mainly of first-year respondents (37.7%), followed by second-year students (34.5%) and third-year students (25.7%). Most of the students were pursuing an IT degree (96.8%), where else the remaining were pursuing a multimedia degree (3.2%).

4.2 Internal consistency reliability

Internal consistency reliability measures the consistency of an instrument to be reproduced. Cronbach alpha has been a predominant measure in gauging reliability where it assumes factor loading to be the same for all items. The generally accepted Cronbach's alpha value is 0.7 (Sharma 2016). Composite reliability, which also evaluates the internal consistency of a set of indicators takes into account the indicator loadings, examines the relationship between the latent variable and its indicators, thus being more superior than Cronbach Alpha (Hair et al. 2017). Hair et al. (2019) recommends an acceptable composite reliability value between 0.70 and 0.90 (Hair et al. 2019). Moreover, to achieve sufficient convergent validity, Average Variance Extracted (AVE) which AVE which explains the degree to which a latent construct explains the variance of its indicators was assessed through satisfactory values scores of higher than 0.5.

When factor loadings were analyzed through PLS Algorithm in SmartPLS, some items were found to have low factor loadings of less than 0.4. Thus, factor loadings of items equal to or less than 0.4 (Hulland 1999) were identified and removed. Subsequently, new factor loadings were then re-calculated after running PLS Algorithm for

the model as shown in Fig. 3. The indicator loadings, CR, AVE, CA and VIF values are presented in Table 1. All loading scores were met in this study.

Examining the degree to which indicators differentiate across constructs is necessary and important and is measured using discriminant validity. The three approaches to evaluating discriminant validity are cross-loading criterion, Fornell and Larcker's criterion and Heterotrait-Monotrait ratios (HTMT) (Hair et al. 2019). Cross-loading criterion, which checks whether the indicator's outer loading on the associated construct is greater than any of its cross-loadings on other constructs. On the other hand, Fornell and Larcker's criterion compares the square root of AVE values with the latent variable correlations where the square root of each construct's AVE should be greater than its highest correlation with any other construct. HTMT is the mean of all correlations of indicators across constructs measuring different constructs (Hair et al. 2017). HTMT ratios were also tested where values must be greater than 0.85 (Kline 2011) or greater than 0.9 (Gold et al. 2001).

Table 2 indicates that all constructs exhibit satisfactory discriminant validity which reveals that the study has no issue of discriminant validity.

4.3 Hypothesis testing

Table 3 present the standardized beta (β), standard error, t-values, *p* values and effect size, f^2. The constructs of metacognitive knowledge, resource management, and motivational beliefs were found to have t- value ≥1.645, with 0.05 level of significance except for cognitive engagement construct. Three out of the four tested hypotheses were significantly positive and supported. Only one hypothesis was not supported and rejected. Cognitive engagement shows no relationship with digital literacy. Cognitive engagement comprises mostly basic strategies for acquiring, retaining and retrieving knowledge. Since digital literacy encompasses cognitive, technical and socio-emotional literacy, the findings show a negative relationship between cognitive engagement and digital literacy. In the structural model analysis, path analysis was performed to test the four hypotheses formulated as shown in Fig. 4. Based on the path coefficient (β) as shown in Table 3, it is evident that metacognitive knowledge (β = 0.253) is the most important predictor, followed by motivational beliefs (β = 0.251), resource management (β = 0.159) and lastly cognitive engagement (β = 0.029). R^2 was used to assess the predictive power of the structural model. The R^2 value was 0.346 which suggests that 34.6% of the variance in digital literacy can be explained by cognitive engagement, metacognitive knowledge, resource management, and motivational beliefs. The R^2 value of 0.346 indicates a substantial model (Cohen 1988). Figures 4 and 5 illustrates the results of the path analysis and the relative values of path analysis respectively demonstrating the significance of relationships.

5 Discussion and conclusion

This study is motivated by the lack of digital literacy skills among students in higher education. It seeks to contribute towards a better digital learning competency through the use of self-regulated learning strategies. This study also intends to determine the impact of self-regulated learning strategies on digital literacy in a blended learning

Table 1 Indicator reliability analysis (Loading items, Average Variance Extracted (AVE), CR(Composite Reliability) and VIF (Variance Inflation Factor) values for the measurement model

Construct	Item	Loadings	AVE	CR	CA	VIF
Cognitive Engagement	CE1	0.578	0.620	0.773	0.773	1.178
	CE2	0.639				1.321
	CE3	0.625				1.191
	CE4	0.477				1.249
	CE5	0.568				1.237
	CE6	0.518				1.123
	CE7	0.595				1.202
Metacognitive Knowledge	MK1	0.735	0.695	0.818	0.723	1.484
	MK2	0.683				1.547
	MK3	0.677				1.356
	MK5	0.632				1.203
	MK6	0.709				1.309
Resource Management	RM1	0.463	0.670	0.776	0.767	1.168
	RM2	0.600				1.272
	RM3	0.621				1.310
	RM4	0.547				1.228
	RM7	0.478				1.137
	RM8	0.683				1.439
	RM9	0.623				1.391
Motivational Beliefs	MB1	0.667	0.722	0.845	0.786	1.741
	MB2	0.735				1.910
	MB3	0.690				1.547
	MB4	0.700				1.608
	MB5	0.677				1.388
	MB6	0.546				1.361
	MB7	0.609				1.405
Digital Literacy	TS1	0.639	0.581	0.900		2.055
	TS2	0.713				2.553
	TS3	0.759				2.525
	TS4	0.684				1.936
	CA1	0.764				2.469
	CA2	0.728				2.258
	CA3	0.700				1.904
	CA4	0.665				1.809
	CA5	0.597				1.526
	SE1	0.578				1.585
	SE2	0.618				1.690
	SE3	0.486				1.370
	SE4	0.66				1.880
	SE5	0.569				1.524

Note: MK4, RM5, RM6, and CA6 were deleted due to low loadings

Table 2 Discriminant validity evaluation

Cross-loadings Criterion					
	Cognitive Engagement	Digital Literacy	Metacognitive Knowledge	Motivational Beliefs	Resource Management
Cognitive Engagement. Item 1	**0.574**	0.253	0.277	0.329	0.174
Cognitive Engagement. Item 2	**0.639**	0.223	0.287	0.273	0.268
Cognitive Engagement. Item 3	**0.625**	0.267	0.334	0.272	0.173
Cognitive Engagement. Item 4	**0.475**	0.059	0.211	0.256	0.187
Cognitive Engagement. Item 5	**0.567**	0.173	0.288	0.304	0.257
Cognitive Engagement. Item 6	**0.520**	0.200	0.287	0.229	0.274
Cognitive Engagement. Item 7	**0.598**	0.244	0.338	0.325	0.248
Digital Literacy. Item 1	0.230	**0.764**	0.412	0.336	0.267
Digital Literacy. Item 2	0.255	**0.728**	0.366	0.372	0.266
Digital Literacy. Item 3	0.318	**0.700**	0.395	0.413	0.311
Digital Literacy. Item 4	0.324	**0.665**	0.378	0.365	0.334
Digital Literacy. Item 5	0.279	**0.597**	0.276	0.336	0.284
Digital Literacy. Item 6	0.230	**0.578**	0.258	0.352	0.300
Digital Literacy. Item 7	0.187	**0.618**	0.325	0.310	0.265
Digital Literacy. Item 8	0.137	**0.486**	0.237	0.192	0.201
Digital Literacy. Item 9	0.229	**0.660**	0.346	0.277	0.286
Digital Literacy. Item 10	0.271	**0.569**	0.268	0.326	0.261
Digital Literacy. Item 11	0.238	**0.639**	0.263	0.248	0.215
Digital Literacy. Item 12	0.242	**0.713**	0.319	0.297	0.289
Digital Literacy. Item 13	0.274	**0.759**	0.376	0.338	0.335
Digital Literacy. Item 14	0.258	**0.684**	0.304	0.346	0.396
Metacognitive Knowledge. Item 1	0.311	0.358	**0.737**	0.340	0.356
Metacognitive Knowledge. Item 2	0.418	0.262	**0.683**	0.402	0.313
Metacognitive Knowledge. Item 3	0.431	0.335	**0.674**	0.417	0.312
Metacognitive Knowledge. Item 4	0.296	0.358	**0.633**	0.301	0.297
Metacognitive Knowledge. Item 5	0.329	0.373	**0.709**	0.334	0.431
	0.348	0.330	0.325	**0.666**	0.261

Table 2 (continued)

Motivational Beliefs. Item 1					
Motivational Beliefs. Item 2	0.361	0.388	0.370	**0.735**	0.359
Motivational Beliefs. Item 3	0.369	0.333	0.363	**0.690**	0.375
Motivational Beliefs. Item 4	0.351	0.308	0.353	**0.700**	0.362
Motivational Beliefs. Item 5	0.325	0.357	0.392	**0.677**	0.386
Motivational Beliefs. Item 6	0.210	0.270	0.221	**0.546**	0.279
Motivational Beliefs. Item 7	0.306	0.303	0.356	**0.610**	0.351
Resource Management. Item 1	0.212	0.188	0.286	0.359	**0.464**
Resource Management. Item 2	0.247	0.242	0.318	0.352	**0.603**
Resource Management. Item 3	0.142	0.301	0.286	0.249	**0.619**
Resource Management. Item 4	0.326	0.229	0.283	0.310	**0.542**
Resource Management. Item 5	0.282	0.191	0.299	0.242	**0.477**
Resource Management. Item 6	0.182	0.321	0.285	0.252	**0.685**
Resource Management. Item 7	0.244	0.275	0.308	0.365	**0.625**

Fornell-Larcker's Criterion

	Cognitive Engagement	Digital Literacy	Metacognitive Knowledge	Motivational Beliefs	Resource Management
Cognitive Engagement	**0.574**				
Digital Literacy	0.383	**0.659**			
Metacognitive Knowledge	0.512	0.497	**0.688**		
Motivational Beliefs	0.493	0.497	0.517	**0.663**	
Resource Management	0.386	0.441	0.502	0.513	**0.579**

Heterotrait-Monotrait ratios

	Cognitive Engagement	Digital Literacy	Metacognitive Knowledge	Motivational Beliefs	Resource Management
Cognitive Engagement					
Digital Literacy	0.451				
Metacognitive Knowledge	0.723	0.603			
Motivational Beliefs	0.667	0.582	0.688		
Resource Management	0.611	0.554	0.731	0.728	

Table 3 Hypotheses testing

Hypothesis	Std Beta	Std Error	t-value	p value	Decision	f^2
H1 Cognitive Engagement - > Digital Literacy	0.068	0.045	1.514	0.13	Not Supported	0.068
H2 Metacognitive Knowledge - > Digital Literacy	0.253	0.048	5.283**	0.00	Supported	0.253
H3 Motivational Beliefs - > Digital Literacy	0.251	0.048	5.254**	0.00	Supported	0.251
H4 Resource Management - > Digital Literacy	0.159	0.042	3.796**	0.00	Supported	0.159

*Note:*** $p < 0.05$*

environment in higher education institutions in Malaysia. It examines the domains of self-regulated learning strategies namely cognitive engagement, metacognitive knowledge, resource management, and motivational belief that foster digital literacy. The results of the study affirmed the positive roles of metacognitive knowledge, resource management and motivational belief strategies in enhancing the digital literacy of university students in digital learning in a blended learning environment in higher education institutions in Malaysia. As such, a new SRLS-DL model may be derived from this study to further enhance the digital competency of university students which is given much emphasis by higher education institutions to improve student outcomes.

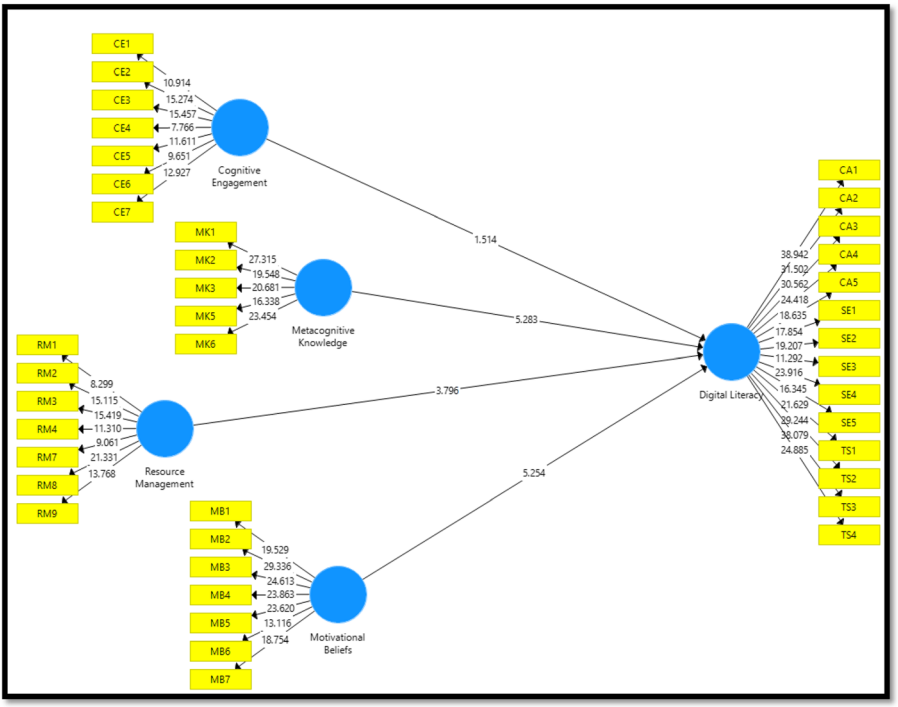

Fig. 4 Results of path analysis

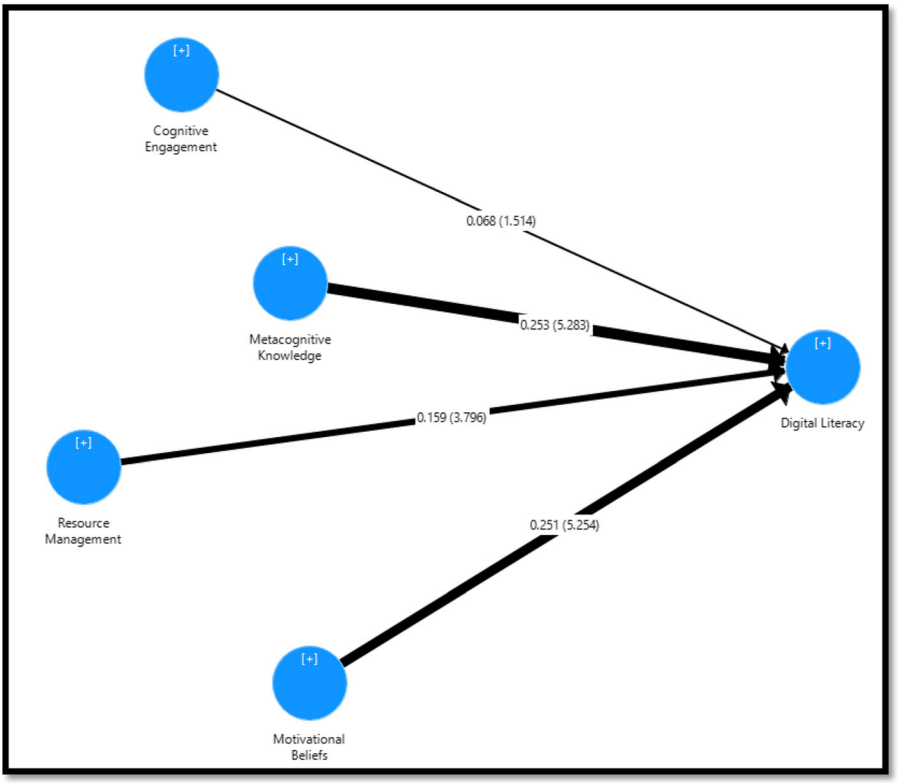

Fig. 5 Relative values of path analysis

Out of the four hypotheses, three were found significant and positive (H1, H2, and H3), whereas H1 was found to be not significant. The rationale and possible explanation of the results are explained below:

> H1: There is a positive relationship between Cognitive Engagement and Digital Literacy (Not Supported).

Though some prior research had reported positive findings between cognitive engagement and digital literacy (Greene et al. 2018; Yang et al. 2014), this study revealed the contrary. This may be because cognitive engagement involves superficial strategies for knowledge acquisition which are not required for digital literacy enhancement. Although cognitive engagement refers to concentration and efforts to master a task or subject, surprisingly it does not contribute to mastering digital literacy skills.

> H2: There is a positive relationship between Metacognitive Knowledge and Digital Literacy (Supported).

Findings from this study revealed that the metacognitive knowledge domain was the most significant with the t-value of 5.283. Metacognitive knowledge strategies are

based on three functions – planning, monitoring and regulating which are indeed needed to enhance digital literacy in digital learning. Many findings from the literature reported similar findings of metacognitive knowledge strategies contributing a major part in the development of digital literacy (Greene et al. 2018; Zylka et al. 2015; Greene et al. 2014). Metacognitive practices increase students' abilities to be critically aware of their thinking and learning which explains how metacognitive strategies can improve digital literacy among students. Hence, students should be equipped with environments where they can do practice these metacognitive strategies. Different technology or interactive media can be used to ensure the use of metacognitive strategies by students with the lecturer's supervision as guidance.

> H3: There is a positive relationship between Resource Management and Digital Literacy (Supported).

Resource management strategies that comprise of time and study environment, peer learning, help-seeking and effort regulation involve the use of behavioral and environmental components that have been proven in this study to improve digital literacy. Past research had discovered that effort regulation strategy to improve digital literacy (Kiliç-Çakmak 2010). Thus, this study confirms that managing resources are critically important in enhancing digital literacy among students. Ultimately, students who know to manage their resources may increase their beliefs to perform digital academic tasks better, thus foster improved digital literacy.

> H4: There is a positive relationship between Motivational Beliefs and Digital Literacy (Supported).

Results from this study showed that the motivational belief domain was the second most significant with the t-value of 5.254. Therefore, researchers can agree to the fact that improving students' digital literacy abilities depends on the students' motivation to a large extent. Motivational belief strategies concern self-efficacy, task value beliefs, and goal orientation to increase the students' willingness to learn to perform a task in a digital learning environment and thus digital literacy can be improved. For example, if students can see the value that they will obtain upon completing a certain task, they will be naturally motivated to carry out that task. Thus, lecturers can provide direct training to students to enhance their motivational beliefs.

Overall, the study reported that self-regulated learning strategies can foster digital literacy in digital learning within a blended learning environment. Thus, it can be postulated that metacognitive strategies, resource management and motivational belief domains of self-regulated learning strategies are key domains to improving university students' digital literacy competency as revealed in Fig. 5. As such, the need for self-regulated learning initiatives and promotion is essential to ensure students become more digitally literate learners.

6 Conclusion

The research explored the influence of self-regulated learning strategies on digital literacy in digital learning within blended learning environments. The result showed that self-regulated learning strategies have a large influence in fostering digital literacy. However, not all SRL domains exhibit a positive relationship with digital literacy. The dimension of cognitive engagement proved to have no influence on digital literacy where else all other domains demonstrated a positive relationship with digital literacy. Thus, to foster digital literacy competency among students, the following dimensions are useful: metacognitive strategies, resource management strategies and motivational belief strategies. In other words, students must develop metacognitive processes, utilize resource management and motivational belief strategies to elevate their digital literacy competency. The role of self-regulation is inevitable in fostering digital literacy enhancement as it may contribute to the more efficient and critical use of digital tools. The ability to self-regulate is at the heart of twenty-first-century learning to foster sustainable lifelong learners.

This study contributes to a substantial number of prevailing concerns revealed in the literature surrounding digital literacy whereby a deeper understanding is gained on the studied constructs towards nurturing digital literacy skills among university students for education sustainability in the age of disruption. Digitally-literate students will be able to perform digital tasks better, have a better learning experience and thus be better lifelong learners.

The outcome of this research may also be useful for educators to establish guidelines to use self-regulated learning strategies in digital learning. Since educators are primarily involved in the students' regulation practice, lecturers can help educate and facilitate students on effective and useful ways to improve their digital literacy competency through self-regulated learning strategies. With the availability of technology and tools in digital learning, self-regulation is needed to achieve digital literacy as well as prepare students to be a part of the digital future.

7 Limitation and future research direction

The result of this study is based on a survey from respondents from IT or Multimedia degree programs from selected private higher education institutions in the central region of Malaysia. Since the respondents were selected using purposive sampling, generalizing the findings is difficult. Moreover, only private universities in Malaysia that had adopted blended learning approaches were selected. Hence, this study was unable to incorporate data from another study context such as public universities or universities from different regions. Due to cultural differences within the same country, students from different regions might have different educational perceptions. Hence, it is recommended for future scholars to include comprehensive coverage of the area. This study may also be extended or replicated to students from other programs that have a blended learning environment.

Secondly, the study adopted a quantitative research design using only the questionnaire. Although the questionnaire might not be as accurate as self-report instruments essentially require respondents to provide their perceptions toward their use of self-

regulated learning strategies and digital literacy. Therefore, it is difficult to gauge their true opinions of their use of self-regulated learning strategies and digital literacy. Quantitative studies can be short-lived because they measure learning experiences over a short period and hence able to capture just that moment of a students' lives. Nonetheless, it is recommended that future studies use a triangulation method such as observation, interviews to collect data to validate the findings.

Thirdly, this study examined self-regulated learning strategies by domains towards digital literacy. Thus, an in-depth relationship between strategies of each domain is not measured. Future studies can look into evaluating the relationship of each self-regulated learning strategy towards digital literacy. For example, the relationship between help-seeking strategy under the research management domain and digital literacy is not known.

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