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A self-regulated learning management system: Enhancing performance, motivation and reflection in learning

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A self-regulated learning management system: Enhancing performance, motivation and reflection in learning

Abstract

Practising self-regulated learning is essential in one's lifelong learning journey. As educators, we can assist our students to regulate their learning effectively, whether this is in an online learning environment or any other. However, many factors affect how well learners regulate their learning. Research reveals that self-regulated learning practices vary and warrant further exploration. This study specifically investigates how the guided practice of self-regulated learning behaviour affects learning in the online learning environment. To guide students in managing their learning more effectively, an automated self-regulated learning management system was developed. The system assists students in practising the cognitive, meta-cognitive and motivational aspects of self-regulated learning. 155 postgraduate students in two online healthcare-related courses were randomly selected to be involved in the study. Trace data from the self-regulated learning management system was used to triangulate the students' self-reports in relation to their self-regulated learning behaviours. Non-parametric statistical tests were used in the analysis. Findings indicate that the use of the self-regulated learning management system facilitated and aided students in practising more effective self-regulated learning behaviours thus impacting positively on learning motivation and metacognitive reflection. However, its effect is inconclusive in relation to academic performance. In summary, positive changes were made to their self-regulated learning behaviours and these subsequently improved their self-regulation and related outcomes.

Practitioner Notes

1. Educators should not assume that all adult students are self-regulated learners with effective study skills.
2. Guiding adult students through the learning and application of self-regulated learning skills within the course of study can help them in their learning process, especially in an online learning environment.
3. The level of learning motivation and metacognitive reflection can be enhanced through the practice of self-regulated learning skills within the course of study.
4. The use of educational technology can enable the learning and application of self-regulated learning skills within a course.
5. The practice of self-regulated learning skills within the technological system should be personalised and adaptive.

Keywords

self-regulated learning, self-regulated learning management system, learning motivation, metacognitive reflection, online courses, healthcare education

Introduction

Self-regulated learning is the self-directed process in which learners plan, monitor, evaluate and reflect on their learning by means of relevant enablers and strategies (Ben-Eliyahu, 2019; Khiat, 2017; Pintrich, 2004; Tock & Moxley, 2017; Zimmerman, 2008, 2013). The cycle of self-regulation consists of a forethought and planning phase, a performance-monitoring phase and a performance-reflection phase (Zimmerman, 2008). In the forethought and planning stage, the learners rely on self-regulated learning enablers such as goal setting, time management, task appreciation to plan their learning process that involves completing learning tasks (Ambrose et al., 2010; Khiat, 2017; Schunk, 2001; Zimmerman, 2008). The learners first evaluate the objective, structure and difficulty level of each learning task. From there, they appraise the adequacy of their existing knowledge and skills in relation to completing the learning tasks successfully. The learners then establish their own learning goals and formulate the appropriate learning strategies to manage the learning tasks to the best of their existing abilities and resources (Ambrose et al., 2010; Khiat, 2017).

In the performance-monitoring phase, the learners rely on both self-regulated learning enablers and strategies when they are doing the learning tasks. The learners flexibly use their planned strategies of (among others) reading, writing, listening, asking, note-taking, memorisation techniques and collaborating with peers, to achieve their set learning goals (Ambrose et al., 2010; Doyle, 2008; Newman, 2008). At the same time, they manage and monitor their learning process through the practice of self-regulated enablers such as time management, procrastination minimisation and emotional regulation (Ambrose et al., 2010; Khiat, 2017; Paris & Paris, 2001; Zimmerman, 2008). The self-regulated learning enablers and strategies are typically cognitive in nature.

During the performance-reflection phase, the learners seek feedback, either through self-observation or from teachers or peers, on the attainment of the learning task objectives and the effectiveness of the self-regulated learning enablers and strategies used. The learners then deliberate on possible means to strengthen or improve their self-regulated learning processes, should it be necessary. Such reflective processes are usually metacognitive as they seek to monitor, understand, and improve the cognitive learning enablers and strategies in the planning and monitoring stage. During the reflection process, the enablers and strategies of the subsequent self-regulated learning cycle are then modified, if essential, to foster more successful learning in future (Khiat, 2017; Zimmerman, 2008). Such learner reflection leads to the understanding of one's approach to learning to learn. In brief, the self-regulated learning cycle is anchored on the growth of the learners' cognition and metacognition through the deliberate practice and enhancement of their utilised self-regulated learning enablers and strategies in the learning process with the aim of fostering successful learning.

The social aspect of learning regulation is important too as learners do not learn in silos. Co-regulation of learning can take place through the interaction of learners within the social environment. Such interpersonal interactions in learning creates socially shared goals, tasks and responsibilities among the learners in a collaborative learning environment (Hadwin et al., 2011). Such co-regulation of learning occurs in both physical and online learning environments (Panadero & Järvelä, 2015). Thus, the learners both self-regulate and co-regulate their cognition, emotions and strategies in fulfilling their shared academic goals (Järvelä & Hadwin, 2013). The realisation of both self and co-regulation of learning could have a stronger effect in enabling effective and reflective learning (Akyol & Garrison, 2011).

Self-regulated learning, academic performance, learning motivation and metacognition

Self-regulated learning is positively related to academic performance, learning motivation and metacognition (Pintrich, 2004; Schmitz & Wiese, 2006; Tock & Moxley, 2017; Zimmerman, 2008, 2013). Research showed that self-regulated learning is associated with academic performance (Bellhäuser

et al., 2016; Barnard et al., 2009; Broadbent, 2017; De la Fuente et al., 2017; Lee et al., 2019; Lee et al., 2010; Panadero, 2017). Poor self-regulated learning leads to lower academic performance and higher course attrition.

Learning motivation is perceived as the level of interest, effort and readiness in engaging and completing a learning task (Alderman, 2008; Lavasani et al., 2011; Mega et al., 2014). Motivation guides the learners' value perception of the learning tasks, goal orientation, learning attribution and the level of persistence and effort they devote to in achieving the learning tasks. An academically motivated student would be more eager to learn and readily spend more time on the tasks, anchored on the optimal flow experience where they are fully concentrated and energised (Csikszentmihalyi, 1990). As such, the sustainability of the self-regulated learning processes depends significantly on the motivation of the learners (Pintrich, 2000; Wang & Holcombe, 2010; Zimmerman, 2008). Learners' reflection on their learning behaviours, cognitions and emotions are essential metacognitive processes that strengthen their self-regulation in academic learning or professional development (Flavell, 1979; Keyko et al., 2016; Pintrich, 2004; Zimmerman, 2008, 2013). As such, metacognitive reflection by learners can have diagnostic, predictive and/or prescriptive effects on their learning regulation. In summary, self-regulated learning, academic performance, learning motivation and metacognitive reflection are interdependent and they contribute collectively to the successful learning.

Technology enabled self-regulated learning intervention

Self-regulated learning is a skill that can be learnt and mastered (Schunk, 2005; Zimmerman, 2015). Students can be taught self-regulated learning strategies through courses, workshops or other learning resources (Bellhäuser et al., 2016; Claessens et al., 2007; Dörrenbächer & Perels, 2016; Häfner & Stock, 2012; MacCann et al., 2012). Alternatively, forms of self-regulated learning enablers and strategies can be embedded within courses through direct instruction (Azevedo et al.; Khiat, 2019; Zimmerman, 2008) and guided practice (Lee et al., 2010).

Educational technologies are leveraged to foster self-regulated learning behaviours and processes within an online or blended learning environment (Azevedo et al., 2018; Kitsantas et al., 2015; Poitras & Lajoie, 2018). Through the process of distributed self-regulated learning, the actualisation of self-regulated learning is shared between the learners and the leveraged educational technology, expanding the learners' capacity beyond what they can achieve alone. The meta-analysis on the effects of self-regulated learning scaffolds on academic performance in computer-based learning environments are generally positive (Zheng, 2016). The use of technological tools can scaffold self-regulated learning effectively to promote and augment self-regulated learning behaviours (Panadero et al., 2016).

Most blended and online learning environments incorporate the use of a learning management system, for example, Blackboard. Educators or researchers have embedded selected self-regulated enablers and strategies such as time management, goal setting, reflection diaries, and note-taking via learning management systems (Azevedo et al., 2018; Kitsantas et al., 2015; Poitras & Lajoie, 2018). These projects mostly only covered some self-regulated learning elements instead of the whole spectrum of self-regulated learning enablers and strategies. On the other hand, the complete self-regulated learning cycle of planning, monitoring and reflection has seldom been examined in relation to learning in the existing literature. Besides, there are currently few purpose-built systems for students to practise the full spectrum of self-regulated learning strategies and skills consistently in a course. Thus, developing and evaluating a purpose-built learning management system to guide self-regulated learning within a course would significantly add to this unexplored area of self-regulated learning, filling the gap in this body of knowledge. On another note, Matcha et al. (2020) reported that learning analytics dashboards that have focused on self-regulated learning usually do not offer effective self-regulated learning strategies and support metacognition. Thus, the effect of systems that helped students to practise self-regulated learning

during study might not be fully investigated. In this study, a prototype of a self-regulated learning management system that is focused on imparting self-regulated learning skills is thus developed. This, in turn, allows the evaluation of the system in terms of improving self-regulated learning throughout the cycle of planning, monitoring and reflection, which has seldom been done before. This translates to the following research questions.

Research Question 1. Is there a positive relationship between the use of a self-regulated learning management system and the practice of self-regulated learning?

Academic performance is commonly the key outcome of learning effectiveness in researching self-regulated learning. There are studies done to investigate the effect of one or some self-regulated learning enablers or strategies on academic performance within the curriculum. Such incorporation of self-regulated learning elements within the learning management systems has shown promising results in improving or enhancing academic performance (Azevedo et al., 2010; Khiat, 2019; Winne & Hadwin, 2013). However, the outcomes of self-regulated learning are multi-faceted and not solely restricted to academic performance. Self-regulated learning can also increase learning motivation and metacognitive reflection that can serve learners positively throughout their lifelong learning journey (Zimmerman, 2008, 2013). Nevertheless, there are few studies that focus on the whole cyclical self-regulated learning process and its relationship to the domains of metacognitive reflection and learning motivation (Khiat, 2017; Pintrich, 2004; Schmitz & Wiese, 2006; Tock & Moxley, 2017; Zimmerman, 2008, 2013). Thus, to fill the gap in this body of knowledge, it would be useful to investigate if self-regulated learning improves learning motivation and metacognitive reflection in the context of the full spectrum of self-regulated learning scaffolders that are systematically incorporated within a purpose built self-regulated learning management system. From this, the following research questions are formulated:

Research Question 2. Is there a positive relationship between the practice of self-regulated learning and academic performance?

Research Question 3. Is there a positive relationship between the practice of self-regulated learning and learning motivation?

Research Question 4. Is there a positive relationship between the practice of self-regulated learning and learning reflection?

Method

Two online courses related to clinical research and regulatory practices were selected to be the research context. Students signed up for these courses as part of their continuing and professional healthcare education. They generally had at least a bachelor's degree and were studying or working in the professional fields related to healthcare. Students could pay to enrol in the course throughout the year and were given 12 months to complete it. To be awarded a certificate of completion, the students were required to view video annotated lectures and pass each topical summative assessment. The students were given six attempts to achieve a pass score of 70% for each summative assessment that was made up of multiple-choice questions. Learning in the course was self-paced and no instructor intervention was present throughout the course duration.

165 students were selected to be involved in the study based on a selected enrolment period required for sufficient meaningful data to be collected. 83 of them were randomly selected to be in the intervention group. An invitation was sent to the 83 students to inform them to use the electronic Personalised Self-Regulated Learning (ePSRL) Management System concurrently while engaging in their courses as a mandatory course requirement. 76 of them participated but seven of them did not

use the system at all as they had not logged into their courses during the study duration. On the other hand, the remaining 82 students were placed in the control group, that is, they did not use the ePSRL Management System. However, data from three students were not included in the analysis as they had not logged into their courses during the study duration. The control group would still have access to pdf guides on the selected aspects of self-regulated learning as part of their orientation, like all the earlier batches. In summary, in the random sampling process, 76 students were in the intervention group while 79 were in the control group in the eventual analysis stage.

Design and implementation

The electronic Personalised Self-Regulated Learning (ePSRL) Management System was developed as a purpose-built learning management system to foster self-regulated learning throughout the whole learning process. It was designed to guide, monitor, sustain and improve self-regulation in the student's learning journey. The system was integrated with the learning management system their courses resided. Therefore, using the ePSRL Management System did not create any inconvenience to the students as the concurrent use of, and switching between both systems was seamless.

The self-regulated learning components of ePSRL were structured according to the different self-regulated learning stages as proposed by Zimmerman (2008) and were presented in the table below.

Table 1

Components of ePSRL and self-regulated learning phases

Component	FPP	PMP	PRP
The Self-Regulated Learning Experience	√		
Personalised Study Plan	√	√	
Learning Monitoring and Appraisal		√	√
Learning Analytics Dashboard		√	√
Forethought and planning phase – FPP			
Performance-monitoring phase – PMP			
Performance-reflection phase – PRP			

The Self-Regulated Learning Experience is a self-directed mini course that provides a comprehensive diagnostic tool for students to self-appraise their levels of competence in the various domains of self-regulated learning. Based on the results of the student's diagnostic results, a personalised study content grounded on their perceived weaknesses in the identified self-regulated learning domains is developed for each student.

Personalised Study Plan is structured as a calendar. In the study plan, students create or complete learning tasks related to the learning objectives of the course. Each task is marked with a stipulated completion timeline within which the student can choose to do it. Multiple learning resources or activities can be included in each task for learning personalisation. Instructors and students tag goals to the learning tasks.

Learning Monitoring and Appraisal provides a venue where students reflect on the learning resources and/or tasks in terms of their value, sufficiency and difficulty. At the same time, the students record the emotions they have experienced during the learning. Students also reflect on their content mastery (student's accuracy, depth and width of knowledge acquisition), learning confidence mastery (student's self-efficacy in the process of knowledge acquisition) and strategic mastery (efficiency of the student's learning strategies). Students also use personal reflective diaries to reflect on their learning.

Learning Analytics Dashboard is where all the self-regulated learning data of each student, are captured real time. It provides a holistic view of the student's progress and growth in the different self-regulated learning domains. The students can track their progress in the domains of goal management, time management, procrastination management, task appreciation and emotional regulation. With these real time data, the students are able to reflect on and adjust their learning strategies in a timely manner for the maximum learning effect.

In short, the ePSRL Management System documents and captures the self-regulated learning processes practised by the students. Through the documentation process, students are directed to practise the cognitive, metacognitive and motivational aspects of self-regulated learning where they practise self-regulated learning strategies, reflect on the content knowledge, task knowledge and strategic knowledge. This in turn helps the students to regulate their strategies and learning emotions to maximise learning in different learning environments.

Measures and analysis

The cycle of self-regulation consists of a forethought and planning phase, a performance-monitoring phase and a performance-reflection phase (Zimmerman, 2008). The self-regulated learning cycle is anchored on the development and progress of the students' cognition and metacognition, as facilitated by motivation, through the deliberate practice of self-regulated learning enablers and strategies to set the stage for them to study effectively. In this study, data related to the cognitive, metacognitive and motivational aspects of self-regulated learning were collected and analysed.

Self-report is the most common method to assess self-regulated learning behaviours, allowing the students to consciously evaluate the extent to which their behaviour is aligned with the examined criteria (Andrade & Du, 2007; Roth et al., 2016). However, self-reports should be triangulated with other objective measures to enhance reliability and validity (Maag-Merki et al., 2013). Other self-regulated learning measures can include observations of overt behaviour, interviews, trace data through learning management systems, think aloud protocols and reflective diaries (Roth et al., 2016; Zimmerman, 2008). In this study, a combination of data collection methods was employed to ensure data triangulation.

While the Motivational Strategies for Learning Questionnaire, by Pintrich et al. (1991), had been commonly used to measure self-regulated learning (Cho et al., 2017), it was designed for face-to-face learning context and had not been fully validated for online learning environments. As such, in the online learning context of this study, to assist the participants to self-appraise their level of self-regulated learning competence, a 33-item survey was slightly customised based on the one validated by Khiat (2017) to evaluate the level of self-regulated learning perceived by online adult students. The survey was used to measure the effectiveness of the six self-regulated learning enablers (Goal setting, time management, procrastination management, task appreciation, emotional regulation and self-monitoring) and the five self-regulated learning strategies (Active listening, critical reading, mnemonics, note-taking and understanding check). Student responses were measured on a seven-point Likert scale from strongly disagree to strongly agree. Examples of the questionnaire items are

shown in the table below.

Table 2

Selected items in self-regulated learning diagnostic tool

Self-regulated learning enablers
The negative emotions I experienced during learning prevent me from learning better subsequently.
I do not set timelines to achieve the learning tasks in my studies.
I reflect on the learning strategies I have used in my studies.
Self-regulated learning strategies
I use memory aids / mnemonics to remember content during assessment.
I relate the readings to my personal thoughts and experiences on the related topics.
I do not know how to make notes from my readings.

In this study, the evaluation of the ePSRL Management system was based on and customised according to the four-level training evaluation model of Kirkpatrick (1994). The rationale was the system is built to train, guide, practise and inculcate self-regulated learning. Through the practice of the self-regulated learning cycle, the students become better aware of the self-regulated behaviours that are specifically beneficial to their learning context and are more likely to employ them flexibly in their learning (Pintrich, 2004; Zimmerman, 2008). As such, in this study, evaluation of the practice of self-regulated learning was conducted in the domains of awareness, understanding and application. The extent of adoption was not captured as it was not possible to track if the students still practise self-regulated learning after the end of their courses. The statistical test aimed to investigate if there was any significant difference in the participants' perception of awareness, understanding and application. Data was captured from 76 students who provided feedback on the system, learning resources and tasks in the course, The Self-regulated Learning Experience. Student responses were measured on a seven-point Likert scale from strongly disagree to strongly agree. Examples of the feedback items are shown in the table below.

Table 3

Selected feedback items in ePSRL Management System

I am now more aware of active listening and its importance as a practice of self-regulated learning.
I learnt more about how to listen actively during lectures in this course.
I will practise active listening in this course.

Simply defined, learning motivation is perceived as the level of interest, effort and readiness in engaging and completing a learning task (Alderman, 2008; Lavasani et. al, 2011; Mega, et. al, 2014).

An academically motivated student would be more eager to do the learning tasks and more readily spend more time on them. In this study, the amount of time spent on learning resources and duration calculated from enrolment date to course completion were used to characterise the motivational level of the students.

During the metacognitive part of self-regulated learning, the students evaluate or seek feedback on the task content learnt, the effectiveness of their self-regulated learning enablers and strategies used in achieving their task goals and reflect on how they could be strengthened or improved. To evaluate if this metacognitive process had taken place, usage on two types of reflection was captured voluntarily- Scaffold reflection and Self-reflection. Scaffold reflection were guided reflection items set in the course in the discussion forum or through reflection questions pegged with assessment, while self-reflection consists of entries input the students have detailed in the learning reflective diary. The number of such entries were collected as evidence of metacognitive behaviour and only reflections that were deemed to be meta-cognitive in nature was counted in analysis. The table below shows examples of scaffold reflection.

Table 4

Selected scaffold reflection items

Choose one learning activity that you feel you engaged productively in. Why?

Do you think you have achieved all learning objectives in this lesson?

If not, how do you intend to close the gaps on the parts of the lesson that you feel you have not understood?

To measure academic performance, the mean assessment result, attempts per assessment and course completion rate were used. Assessment results included the mean score of the summative assessments and the number of attempts to pass each topic summative assessment was included as the students were given up to six attempts each to pass each topic's summative assessment. As such, it could be assumed that an academically stronger student would take lesser attempts to pass each assessment. Course completion rate was also an indicator of academic performance as each student was given up to 12 months to complete the course, after which he or she is considered to have failed the course.

In summary, trace data from both the ePSRL Management System and the learning management system were used to triangulate self-reports provided by the students in relation to their self-regulated learning behaviours. Student self-reports for the intervention group included:

- A self-regulated learning diagnostic survey of 33 items
- Sets of questionnaire items to measure the level of awareness, understanding and application self-regulated learning before and after use of ePSRL Learning Management system
- Student trace data related to both intervention and control groups from the systems and included the:
- Course completion

- Quiz data
- Time they spent on the learning resources
- Reflective posts.

Results

Each research question was addressed by two or more hypotheses. Each hypothesis was evaluated on its statistical and practical significance. As the normality of the relevant dependent variables above could not be assumed, non-parametric tests were used throughout the analysis. Wilcoxon Signed-Ranks test was used to analyse students' perceptions, in the intervention group, of the ePSRL Management System before and after use. Mann-Whitney Test was used to investigate if there was any significant statistical and practical difference between the control group and intervention group in terms of the investigated variables. Chi-square test of independence was used to evaluate if there was any statistical difference in the number of students missing the course completion deadline between the control and intervention groups. To interpret practical significance, Hattie's (2009) definition of effect size was used, with an effect size of 0.2 considered as small, 0.4 as medium and 0.6 as large.

Research Question 1: Is there a positive relationship between the use of a self-regulated learning management system and the practice of self-regulated learning?

Three hypotheses are investigated to address the above research question.

Hypothesis 1: *Students perceive increased awareness of self-regulated learning after they have used the self-regulated learning management system.*

A Wilcoxon Signed-Ranks test showed $Z = -4.788$, $p = 0.000$, $d_{Cohen} = 1.314$ and the mean rank before and after the use of ePSRL Management System are 25.64 and 40.12 respectively. This indicated that there were both statistical and practical significance of the increase in the participants' perception of their awareness of self-regulated learning. In conclusion, the participants acquired a higher level of awareness of self-regulated learning after they used ePSRL Management System in their courses.

Hypothesis 2: *Students perceive they understand the use self-regulated learning strategies more after they have used the self-regulated learning management system.*

A Wilcoxon Signed-Ranks test showed $Z = -4.181$, $p = 0.000$, $d_{Cohen} = 1.093$ and the mean rank before and after the use of ePSRL Management System are 26.22 and 44.52 respectively. This indicated that there were both statistical and practical significance of the increase in the participants' perception of their understanding of self-regulated learning. In conclusion, the participants understood more of self-regulated learning strategies after they used ePSRL Management System in their courses.

Hypothesis 3: *Students perceive they are more likely to apply self-regulated learning strategies after they have used the self-regulated learning management system.*

A Wilcoxon Signed-Ranks test showed $Z = -2.832$, $p = 0.005$, $d_{Cohen} = 0.687$ and the mean rank before and after the use of ePSRL Management System are 34.48 and 39.04 respectively. This indicated there were both statistical and practical significance of the increase in the participants' perception of themselves applying self-regulated learning. In conclusion, the participants applied

more regulated learning strategies after they used ePSRL Management System in their courses.

In summary, the participants were more aware of self-regulated learning, understood the use of self-regulated learning strategies more and applied them more regularly after the use of the ePSRL Management System.

Research Question 2: Is there a positive relationship between the practice of self-regulated learning and academic performance?

Three hypotheses are investigated to address the above research question.

Hypothesis 4: Students who use the self-regulated learning management system score higher mean assessment results in the course than those who do not.

Academic Performance – Mean assessment result. The Mann–Whitney U test was not significant with $U = 805.500$ and $p = 0.542 > 0.05$. Thus, there was no significant difference in the mean assessment result between participants who used the ePSRL Management System and those who did not.

Hypothesis 5: Students who use the self-regulated learning management system require lesser attempts per quiz in the course than those who do not.

Academic Performance – Mean attempts per quiz. The Mann–Whitney U test was not significant with $U = 821.000$ and $p = 0.612 > 0.05$. Thus, there was no significant difference in the mean attempts per quiz between participants who used the ePSRL Management System and those who did not.

Hypothesis 6: Students who use the self-regulated learning management system require lesser attempts per quiz in the course than those who do not.

Academic Performance – Course completion deadline. The course completion deadline between the participants who used the ePSRL Management System and those who did not was statistically significant, $\chi^2 (df = 1) = 7.053, p = 0.008 < 0.05$. This showed that course deadline attainment varied as a function of the group type. It could be seen that the proportion of participants who met the course completion deadline was significantly higher in the group of participants who used the ePSRL Management System as compared to the participants who did not use it. Deadline attainment rate for the students who used the ePSRL Management System and those who did not use it were 88.2% and 70.9%, respectively.

In summary, participants who used the ePSRL Management System in their course had a higher probability of meeting the course completion deadline as compared to participants who did not use the system. However, all participants performed equally/no differently in their mean assessment result and mean attempt per quiz. This indicated that it was inconclusive if there was a difference in academic performance between the participants who practised self-regulated learning in the ePSRL Management System as compared to participants who did not use the system.

Research Question 3: Is there a positive relationship between the practice of self-regulated learning and learning motivation?

Two hypotheses are investigated to address the above research question.

Hypothesis 7: Students who use the self-regulated learning management system spend more time per

month in the course than those who do not.

Learning Motivation – Time spent in system per month. The Mann–Whitney U test was significant with $U = 1698.000$, $p = 0.000 < 0.05$ and $dCohen = 0.809$. Thus, there were both statistical and practical significance in the difference of the time spent in the system per month between participants who used the ePSRL Management System and those who did not.

Hypothesis 8: *Students who use the self-regulated learning management system complete the course in shorter time than those who do not.*

Learning Motivation – Months to complete course. The Mann–Whitney U test was significant with $U = 550.000$, $p = 0.003 < 0.05$ and $dCohen = 0.677$. Thus, there were both statistical and practical significance in the difference of the months taken to complete course between participants who used the ePSRL Management System and those who did not.

In summary, participants who used the ePSRL Management System in their course spent more time in learning and finished the course in a shorter time as compared to participants who did not use the system, indicating they were more motivated in their learning.

Research Question 4: Is there a positive relationship between the practice of self-regulated learning and learning reflection?

Two hypotheses are investigated to address the above research question.

Hypothesis 9: *Students who use the self-regulated learning management system post more scaffold reflections per month than those who do not.*

Learning Reflection – Scaffold reflections per month. The Mann–Whitney U test was significant with $U = 2551.500$, $p = 0.026 < 0.05$ and $dCohen = 0.261$. Thus, there were both statistical and practical significance in the difference of the number of scaffold reflections posted per month between participants who used the ePSRL Management System and those who did not.

Hypothesis 10: *Students who use the self-regulated learning management system post more self-reflections per month than those who do not.*

Learning Reflection – Self reflections per month. The Mann–Whitney U test was significant with $U = 2274.000$, $p = 0.003 < 0.05$ and $dCohen = 0.428$. Thus, there were both statistical and practical significance in the difference of the number of self-reflections posted per month between participants who used the ePSRL Management System and those who did not.

In summary, participants who used the ePSRL Management System in their course posted more reflections per month as compared to participants who did not use the system. This indicated that the participants who practised self-regulated learning in the ePSRL Management System were more inclined to exhibit metacognitive reflection in their learning as compared to participants who did not use the system.

Discussion

There are two key findings in the study. First, the participants increased their awareness, knowledge and practice of self-regulated learning while using a system that allowed them go through the full self-

regulated learning cycle to practise the different self-regulated learning enablers and strategies within an online continuing professional development course. Previous studies stated that the effectiveness of self-regulated learning differs in physical and online classes (Sedrakyan et al., 2018). Research (such as Dignath & Büttner, 2008; Ferreira & Simão, 2012) showed that effective self-regulated learning interventions, with selected self-regulated learning enablers or strategies, are usually implemented with the students physically in class, before the start of the course. However, other studies (such as Bellhäuser et al., 2016; Feng & Chen, 2014) reported that online training courses to enable students to learn self-regulated learning had been positive from the perspectives of the users, in terms of self-regulated learning knowledge, behaviours and usefulness. In the case of this research, the learning and practice of self-regulated learning occurred concurrently with the conduct of the course through the ePSRL Learning Management System.

Our findings indicated that the incorporation of a self-regulated learning management system helps students to practise self-regulated learning effectively in an online learning environment. It also showed that the use of the self-regulated learning management system while that studying is taking place is equally effective in promoting the practice of self-regulated learning as compared to conducting that training before the course begins. On another hand, no previous study had specifically explored the use of a self-regulated learning system within a course to promote the full spectrum of self-regulated learning enablers and strategies through the cycle of the forethought and planning phase, the performance-monitoring phase and the performance-reflection phase. In this study, the ePSRL Learning Management System brought a learner through the full self-regulated learning cycle, using the full suite of self-regulated learning enablers and strategies, through scaffolding activities and analytics. This demonstrated that the use of a self-regulated learning management system, in the context of actualising the self-regulated learning cycle and strategies, increases students' awareness of self-regulated learning, teaches them self-regulated learning strategies and promotes more frequent use of the strategies during learning, from the perspectives of the students.

The next finding validated the effect of self-regulated learning on learning motivation and metacognitive reflection. However, its effect on academic performance was inconclusive. It might be expected that the practice of self-regulated learning would improve academic performance (Adams & Blair, 2019; Alsalem et al., 2017; Claessens et al., 2007; De Jager, 2014; MacCann et al., 2012). However, participants who used the ePSRL Management System in their course performed equally/no differently in their mean assessment result and mean attempt per quiz as compared to participants who did not use the system. On the matter of whether the practice of self-regulated learning would improve course completion rate, the results were different. Participants who used a self-regulated learning management system had a higher probability of meeting the course completion deadline as compared to participants who did not. Future work is needed in exploring the possible causes of this difference.

On the other hand, the system increased student learning motivation and metacognitive behaviour in their learning. Participants who used the ePSRL Management System in their course invested more time learning, finished the course in a shorter timeframe and reflected on their learning more as compared to participants who did not use the system. This finding supported the studies done by Keyko et al. (2016), Pintrich (2004), Schmitz and Wiese (2006), Tock and Moxley (2017) and Zimmerman (2008, 2013) that stated that self-regulated learning increases learning motivation and meta-cognitive activities. This finding thus further demonstrated that self-regulated learning has a positive effect on academic performance, learning motivation and metacognitive reflection.

Limitations

The participants in this study were working in the domain of healthcare in Singapore. As such, future studies should be conducted to investigate the use of a self-regulated learning management system on

learners from other fields. Furthermore, the two sets of students were not matched for variables such as age, gender and ability.

It should also be noted that this study did not investigate specifically each self-regulated learning enabler or strategy promoted and practiced within the self-regulated learning management system. Thus, the significance of each self-regulated learning component in effecting changes in learning was not known. More investigation is needed to understand the effectiveness of each component of such a system and how they interact with one another in assisting students to regulate their learning. Qualitative research with in-depth observations of student and faculty perceptions of learning with a self-regulated learning management system is also recommended.

While the findings showed that the use of such a self-regulated learning management system improves self-regulated learning, future research should be considered to understand each individual component associated with self-regulation within courses and their effect on learning.

Conclusion

In conclusion, the study showed that the use of a self-regulated learning management system can affect self-regulated learning behaviours in terms of awareness, knowledge and practice and to increase course completion rates, learning motivation and metacognitive reflection significantly. It also contributed to the literature in relation to the incorporation of development of a learning management system that is entirely anchored on self-regulated learning components, an area that is seldom investigated. Importantly, the findings implied the benefit to learning if self-regulated learning components are incorporated in courses.

Abbreviations

ePSRL: e-Personalised Self-Regulated Learning

Conflict of interest

The authors declare that there are no competing interests.

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Ethics approval

This project is approved by the Ethics Committee at National University of Singapore.

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