Medical students' technology use for learning: Contributing factors and self-regulation

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Research Article

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Abstract

Background: With medical education shifting towards student-centered models, medical students are expected to be self-regulated learners. Advancement in technologies has been suggested to be supportive of students' self-regulated learning (SRL). There is an urgent need to understand what factors contributed to students' self-initiated technology use, and how does students' technology use influence their SRL.

Method: This study took place in a midwestern university medical school, which implements a flipped classroom model where students are required to learn independently all the course materials before class. Twenty-six first- and second-year medical students participated in a semi-structured interview about their self-initiated technology use, contributing factors towards technology use, and SRL strategies they adopt in learning. A qualitative description methodology using thematic analysis was used to identify key themes from the interview data.

Results: Medical students reported the use of four types of technologies for learning: video resources (supporting rehearsal, elaboration and planning), review resources (supporting rehearsal, effort control, and self-assessment), management tools (supporting organization, elaboration, goal-setting, and time management), and social media (supporting help-seeking and effort regulation). Three key determinants of students' self-initiated technology use were identified, which were: perceived usefulness, subjective norms, and educational compatibility.

Conclusions: By probing medical students' self-initiated technology use, SRL strategies, and determinants of technology use, this study suggested that in self-directed learning environment, medical students used a variety of third-party resources to facilitate learning and develop necessary learning strategies. This study also provided important implications for medical educators and instructional designers to better support students' effective use of technologies for learning.

Introduction

As medical-education curricula shift from a teacher-guided to a student-centered model (Brydges et al., 2009), medical students' success increasingly requires that they be self-regulated learners (White, 2007). Meeting the needs of patients and the healthcare professions in the 21st century likewise requires that they become lifelong learners (Brydges et al., 2015; Lucey et al., 2018). And, from an accreditation perspective, the Liaison Committee on Medical Education (LCME) made it clear in their **Standard 6.3** that medical-school faculty must ensure their curricula include "self-directed learning experiences and time for independent study to allow medical students to develop the skills of lifelong learning."

Self-regulated learning (SRL) is a "proactive process that students use to acquire academic skills, such as setting goals, selecting and developing strategies, and self-monitoring one's effectiveness" (Zimmerman, 2008, p.166). Technology use has been found to benefit medical students' SRL development: e.g., with multimedia tools improving their knowledge and skills (Petty, 2013), tablets helping with self-monitoring (Alegría et al., 2014), and social media providing social support (Gray et al., 2010). Nevertheless, students'

self-initiated technology use is still mostly for social and recreational purposes, while their academic uses of technology are generally confined to searching, storing, or sharing information (Echenique et al., 2015; Yot-Domínguez & Marcelo, 2017). As such, there is an urgent need to boost students' self-initiated use of digital technology for learning purposes, and thus to better understand why they self-initiate currently.

Based on the Theory of Planned Behavior (Ajzen, 1985) and the Technology Acceptance Model (Davis, 1989), attitudinal factors, perceived behavior control, and subjective norms can be identified as three key determinants of students' self-initiated technology use for learning (Lai, 2013; Lai et al., 2012). Specifically, attitudinal factors include perceived usefulness, i.e., one's degree of belief that using a particular system will enhance one's performance (Davis, 1989); attitude to technology use, i.e., individual positive or negative feelings about the behavior (Fishbein & Ajzen, 1975); and educational compatibility, i.e., how congruent leaning behavior is with one's learning expectancy (J.-L. Chen, 2011a). Perceived behavior control mainly refers to the "perceived availability of support in the environment that encourages and facilitates the adoption of technology" (Lai, 2013, p.104). Lastly, subjective norms are learner-perceived social influences over the target behavior (Ajzen, 1985). Accordingly, the two research questions explored in this study are:

RQ1: What types of technologies did medical students adopt for learning, and how were they used to support SRL strategies?

RQ2: What factors affected these students' self-initiated use of learning technologies?

Method

Setting

This study took place in a university medical school in the Midwestern U.S., and was approved by the designated school's Institutional Review Board. An innovative curriculum focusing on competency-based learning and using the flipped-classroom model has been in place at this institution since Fall 2016. In this curriculum, students are required to independently review around 15 hours of online readings and videos before class each week; and classroom activities focused largely on small-group discussions and case-based learning.

Participants

In October 2018, an interview invitation was sent out to 380 pre-clerkship medical students, with the aim of recruiting 30. In the event, 14 first-year and 12 second-year students volunteered. Later that semester, each participated in a 30-minute semi-structured interview about the technologies they adopted, what SRL strategies such adoption supported, and why they adopted certain technologies during pre-class learning.

Analysis

All interviews were audiotaped and transcribed verbatim, and thematic analysis used as a to analyze the interview data (Gale et al., 2013). This involved multiple layers of coding and interpretation. In the first stage, the researchers familiarized themselves with the data by repeatedly reading the transcripts and considering themes that emerged from them, including technology types, learning strategies, and the challenges of transitioning to medical school.

The second stage utilized a combination of top-down and bottom-up coding. Categories of students' self-reported technology use were generated inductively. The SRL framework(Pintrich, 2004; Pintrich & Zusho, 2007) was adopted to code students' SRL strategies into cognitive and behavioral types (Table 1). Factors affecting technology use were explored using the framework developed by Lai and colleagues (2012), which includes three attitudinal factors, two behavior-control factors, and one subjective-norm factor

Table 1. Cognitive and Behavioral SRL Strategies

Phase	Cognition	Behavior
Forethought	• Goal-setting • Activation of prior knowledge	• Time and effort planning • Planning for self-observation of behavior
Monitoring	• Metacognitive awareness	• Awareness and monitoring of effort, time use, need for help
Control	• Rehearsal • Elaboration • Organization • Critical thinking	• Increase/decrease effort • Persist, give up • Help-seeking
Reflection	• Cognitive judgments and evaluations • Attribution	• Choice behavior

Source: Pintrich and Zushuo (2007), p. 745

Results

Students' technology use and SRL

The technologies the participants reported using for learning were of four types: video resources (used by 22 of 26 students), review resources (20), management tools (19), and social media (12).

Video resources

The most frequently used video resources were Boards & Beyond (used by 15 out of 26 students), followed by Pathoma (11), SketchyMedical (9), YouTube (6), Osmosis (5), and Khan Academy (3). These resources were mainly for rehearsal, elaboration and planning. For rehearsal, students mentioned that such resources helped them retain information and “explain things in a way easier to understand and process.” For elaboration, they said some of the video resources helped them summarize concepts, make connections among concepts, or build up to bigger concepts. For example: “Sketchy pharm videos helped to kind of make it [learning concept] a category for me and look at it as a more cohesive thing.” Using video resources also helped students plan their learning time and effort more effectively, based on “a big picture” of the week ahead, “without going into the rabbit hole and getting lost in details.”

Review resources

For review resources, students mainly reported the use of question-bank and flashcard software, including Anki (14), UWorld (3), and Firecracker (2), especially for self-assessment, but also for rehearsal and effort control. For rehearsal, a majority of these students cited their need to “remember drugs’ and diseases’ names” or to improve long-term retention. Many students mentioned that spaced repetition helped them check their understanding. As one explained, “you take the fifty flashcards, you go through them and then fifteen minutes later these flashcards will pop up again and you have to do them again. Then a day later, then three days later, then a week later […] It’s meant to cement the material”. In terms of effort control, the Anki flashcard app had an adaptive algorithm that helped students decide whether to increase or decrease their efforts, which one student characterized as “most effective”.

Some students also mentioned integrating multiple resources to build their SRL strategies. For example, one used an Anki deck called Lightyear together with Boards & Beyond videos that closely aligned with that deck’s content, for 30 minutes of review before going to bed. He called this combination “awesome.”

Management tools

In the category of management tools, students reported using note-taking tools the most. These included Microsoft OneNote (10), Notability (6), Good Notes (1), PDF Expert (n=1), Cram Fighter (n=1), and Focus Booster (n=1). Students said they used these tools mainly for organization and elaboration, but also for goal-setting and time management. Some said using OneNote and Notability made it easier for them to organize different learning resources including diagrams, photos and screenshots; to color-code and draw; and to make connections among various learning materials. Some also used these tools to set themselves learning goals: e.g., by copying and pasting learning objectives into their note-taking tools and trying to address each of them throughout the learning process, as part of building “a very big picture” of what to do going forward.

In addition, one student mentioned that using Cram Fighter helped her plan and manage time by providing a personalized study schedule; and another said Focus Booster helped her to manage attention and learning time, and thus increased productivity.

Social media

Among social media, students reported the use of Facebook groups the most (n=9), with Instagram (n=2), Reddit (n=2), and Snapchat (n=1) lagging far behind. Social media were mainly used for help-seeking and effort regulation. Facebook groups were created by students to share resources, post reminders, ask and answer questions, and to provide social and emotional support to one another. A few participants mentioned their use of social media beyond their medical-school cohorts, to connect with wider communities, e.g., pathologists on Instagram, or successful students from other schools on Reddit.

Factors affecting students' self-initiated use of technology for learning

Our data suggested that there were three key determinants of students' self-initiated use of technology for learning. Each is dealt with in turn in its own subsection below.

Perceived usefulness

Perceived usefulness was the most frequently cited contributing factor to students' technology use, mentioned by 19 of the 26 participants. The foremost reason for adopting learning technologies was a belief that such resources would help increase learning efficiency and effectiveness. Many students mentioned that when they "couldn't memorize things" or realized something was "not working", they would "turn to resources more" to "help information stick", "get a good quick overview", or "help explain concepts in a way easy to understand and process."

Subjective norms

Subjective norms were the second most frequently mentioned determinant of students' technology use, with 13 participants noting that this influence was usually either from classmates or students in higher years. They tended to trust the latter group, as "they have already been through it and [… have] mastery of what they should and shouldn't be doing, and they've been open about it." In a few cases, social influence came from a broader community like Reddit or YouTube. Two students mentioned that they trusted medical students on Reddit as a source of information on what technological learning tools were helpful.

Educational compatibility

The third contributing factor was educational compatibility: i.e., whether technology accords with students' learning preferences, goals, and/or current situation. In our sample, 11 students mentioned that they chose to use certain digital technologies because "technology is more integral to medical school" than to undergraduate studies, or because they identified themselves as visual learners, or because technology "suits the way I think".

Constraining factors

As well as contributing factors, a few students shared how certain personal and contextual factors hindered their technology use. One major constraining factor was educational incompatibility. As one student explained, “I tried being more technology-based, taking everything on my computer, but it just wasn’t working for me. So I switched back to writing my notes.” Another constraining factor was that students could feel overwhelmed by what they saw as a massive overabundance of potentially useful technology. As one put it, “first year was very confusing to me because I was trying to explore different technologies, different apps, which kind of hindered my learning process. As I progressed to M2 I started eliminating things, began to realize what worked for me […] and eliminated the other stuff”. A third constraining factor was a lack of facilitation, especially from the faculty. One student saw faculty members as “reluctant to admit that these are pretty good resources.”

Discussion

Through interviews with 26 first- and second-year medical students, we found that they used video resources the most, followed by review resources, management tools, and social media, to support their learning. The three key determinants of such use were perceived usefulness, subjective norms, and educational compatibility.

Technology use to support SRL

Specifically, video resources were used to support SRL strategies such as planning, rehearsal, and elaboration; review resources for rehearsal, effort control, and self-evaluation; management tools for goal-setting, time management, elaboration, and organization; and social media for help-seeking and effort regulation. While some prior studies (Echenique et al., 2015; Yot-Domínguez & Marcelo, 2017) reported that students primarily used technology for socializing rather than learning, this study found the opposite. This might be because those earlier studies were conducted in traditional, non-flipped learning contexts for non-medical students. That is, in the flipped-classroom model, where self-directed learning is expected, students can be expected to use technological resources for learning. This is consistent with prior findings by Burk-Rafel et al. (2017) regarding the ubiquitous adoption of third-party study resources and minimal use of coursework resources among a group of students preparing for the USMLE Step 1 exam. Another recent article went so far as to deem third-party video and test-prep resources “the de facto national curriculum of preclinical medical education” (D. R. Chen et al., 2019).

While medical students are expected to be self-regulated learners, becoming more self-regulated never happens on its own. The demands of the curriculum and the nature of medical school require students to be proactive learners and accountable for their own learning. As one of our participants noted, “I realize that one day I’m going to be in front of a patient and the amount of knowledge and integration that I provide will be beneficial for their care [… so] my level of understanding and my level of retention is really going to play a crucial role.” However, participants also expressed frustration that they “don’t know how to learn by themselves”, “felt overwhelmed at first”, or that “too much freedom” was provided. This suggests

that, while medical students may be capable of self-regulating their learning to some extent, explicit guidance and intentional efforts are still needed to support their SRL development, especially during their initial transition into medical school (Brydges & Butler, 2012; Durning et al., 2011; White et al., 2013; Zheng et al., 2020). Examples of such interventions might include embedding interactive functions into instructional videos (Delen et al., 2014; Schwan & Riempp, 2004); embedding note-taking and glossary functions into electronic notebooks (Hadwin & Winne, 2001); and providing opportunities for a learner and a more experienced peer or expert to proactively engage in co-regulated learning and reflection (Bransen et al., 2020). Also, at an early point in medical students' transition from undergraduate study, medical educators should consider providing workshops covering the technological learning resources that are available, what learning purposes those resources could serve, and SRL skills such as how to plan, monitor, and self-evaluate one's own learning.

Factors contributing to technology use

Our results regarding the factors that contributed to technology use largely aligned with the Theory of Planned Behavior (Ajzen, 1985) and the Technology Acceptance Model (Davis, 1989), with some differences. Perceived usefulness was found to be a major contributor to use, corroborating previous findings that this construct is the strongest predictor of both technology adoption and technology-adoption intention (Yousafzai et al., 2007). Among medical students, perceived usefulness may arise from perceptions that the current USMLE Step 1 test-prep curriculum is inadequate (Burk-Rafel et al., 2017; Khalil et al., 2019).

Students also need to use technologies that are educationally compatible with their particular learning needs or learning preferences. In our case, the medical school curriculum itself – with its vast amounts of information – innately required students to self-direct their learning; and this contributed strongly to the participants' decisions to adopt technology for learning. However, technologies are not necessarily compatible with all students' learning preferences. As one noted, "I am not really an auditory learner, so I don't really do videos too much." Thus, designing technology-facilitated learning environments that are congruent with learning expectations and learning preferences is important (J.-L. Chen, 2011b).

We found subjective norms to have both contributory and constraining influences on medical students' technology use for learning. On the one hand, norms communicated by classmates and more senior medical students had a positive impact on technology adoption, especially in the early days of medical school, in keeping with prior research findings.(Sawang et al., 2014) On the other, faculty members resisted our participants' use of outside learning resources – or at least failed to positively endorse it – perhaps due to uncertainty about such resources' benefits to learning or the USMLE Step 1(Werner & Bull, 2003), and/or to an institutional culture that rejects "teaching to the test" (Burk-Rafel et al., 2017). The high levels of adoption of outside resources by students suggests that the subjective norms of other students outweighed those of the faculty. Interestingly, however, prior studies guided by the Theory of Planned Behavior and/or the Technology Acceptance Model have generally treated social norms as an aggregate of social influences from teachers and peers (Lai et al., 2012) and have not specifically

examined how different sources of norms might impact students' technology adoption differentially. Doing so will likely be essential to a clear understanding of medical students' technology adoption. In addition, as Burk-Rafel et al. (2017) noted, it may be worth examining the "the appeal of these resources" and exploring "the feasibility and appropriateness of formal incorporation of these or related tools into core medical curricula" (p. 572).

In summary, our findings on contributing and constraining factors shed new light on how to support medical students' use of technology for SRL. Medical educators should strive to increase contributing factors (i.e., perceived usefulness, subjective norms, and educational compatibility) and decrease constraining ones (e.g., overwhelming choice of technological tools and a lack of faculty support). Ultimately, students must see the value of technological tools to the achievement of their learning goals. In this regard, Lai (2015) recommended that educators provide affection, capacity, and behavioral support.

To increase the benefits of subjective norms, formal opportunities should be provided for classmates and more senior students to share their successful learning experiences, communicate effective ways of using technologies for learning, and provide encouragement and social/emotional support to students selecting technologies for learning (Lai et al., 2012). The current study, by identifying faculty resistance as a constraining factor, implies that teachers' pedagogical advice and cognitive/metacognitive scaffolding will also be critical to medical students' active exploration of technologies for learning purposes.

Limitations and future directions

Several limitations of our study should be acknowledged. Its single data source, interviews with a small sample of 26 students, was not sufficient to draw any conclusions that could be generalized to a broader population. In addition, our recruitment method could have led to selection bias: i.e., students who were more enthusiastic about technology use and SRL might have been more likely to volunteer. Nevertheless, it is hoped that this descriptive study will point the way for future quantitative studies that explore the structural relationships among medical students' technology use for learning, the factors contributing to and impeding such use, and their SRL strategies.

Conclusions

As medical education transitions from traditional lecture-based curricula to integrated competency-based ones, students are increasingly expected to take responsibility for their own learning outside of class, supported by learning technologies. This qualitative study identified a range of specific technological tools as useful to medical students' development of various SRL strategies. Its findings also imply that medical educators and instructional designers should pay special attention to such tools' perceived usefulness, their educational compatibility, and whether adopting them is supported by instructors and peers; and provide explicit guidance for students' selection of learning technologies that will maximize SRL development.

Declarations

Ethical approval and consent to participate: Research within this manuscript was approved as an exempt study by the institutional review board of Michigan State University. Written informed consent was obtained from all study participants. The study protocol was carried out in accordance with the Declaration of Helsinki.

Consent for publication: Not applicable

Availability of data and materials: The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The author has no conflicts of interest.

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Author's contributions: BZ contributed to study design, data collection, data analysis, drafting, and finalizing the manuscript.

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