The Current State of m-Learning in Higher Education: A Survey Study of Mobile Technology Usage in the Classroom

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Abstract. Existing research acknowledges the proliferation of mobile devices in society, but very few studies have sought to understand the demographics of the students who actually utilize mobile technology for their learning needs. Despite the pervasiveness and attention given to m-learning, there is still a lot of unknowns about how to integrate mobile technology into learning practices. Therefore, this paper describes an exploratory survey study that examined U.S. college and university students' responses to collect data about current mobile technology use. Novel to this study, gaining a clearer picture of mobile technology from students, educators and researchers can better apply m-learning to target desired learning behaviors and outcomes. Results suggest students have access to many mobile devices, however, they tend to be very selective in what device they choose to use for their learning. The findings indicate that their use of mobile technology is highly dependent upon the characteristics of the learning activity they are engaging in, and the subject matter. Students also reported mobile devices having a positive impact on their learning for quick, just-in-time learning activities.

Keywords: Higher education · m-Learning · Mobile technology · Survey study

1 Introduction

The use of mobile technology for educational purposes is referred to as mobile learning, or m-learning [1–3]. Mobile technology consists of devices such as smartphones, tablets, and even laptops [4]. More recent form factors for m-learning consist of wearable technology such as smartwatches and eyewear. Even before the arrival of smartphones in 2007, educators and researchers have worked diligently to investigate best practices for incorporating earlier iterations of mobile technology into their instructional practices with the hopes of enhancing the learning experience for students. With the premise of access to information "anytime, anywhere" [5, 6], the study of mobile devices as a learning tool has shown to increase students' perceptions of engagement, enjoyment, and collaboration [2, 7, 8].

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Research efforts also suggest that using mobile devices for learning generally has positive effects on learning gains [9, 10], however, there are still only a few studies that actually focus on measuring learning outcomes [11]. At the same time, the implementation of mobile devices for learning purposes may be prevented from going more mainstream due to common technological challenges associated with learning activities and improper consideration of learning content [12–15]. Due to the smaller screen size, more restrictive input abilities, processing and battery power, research in this area suggests not all learning tasks are appropriate for mobile devices [16–19].

Existing research acknowledges the proliferation of mobile devices in society, but very few studies have sought to understand the demographics of the students who actually utilize mobile technology for their learning needs. Despite the pervasiveness and attention given to m-learning, there is still a lot of unknowns about how to integrate mobile technology into instructional practices. Therefore, this chapter describes an exploratory survey study that examined U.S. college and university students' current mobile technology use for learning. By gaining a clearer picture of mobile technology usage from the students' perspective, educators and researchers are more likely to achieve desired learning behaviors and outcomes with m-learning.

2 Scholarly Justification

2.1 Current State of Mobile Technology in Higher Education

Over the years, mobile technology has revolutionized the way people interact and engage in the world around them, including in academia. With the creation of mobile technology such as laptops, smartphones, tablets, and smartwatches, demand for constant and immediate access to information and communication has increased. Currently, approximately more than 5 billion people use mobile devices, and over half of these connections can be attributed to smartphones [20]. In a 2018 survey of over 64,000 undergraduate students from 130 international institutions including the United States, it was found that less than 1% of students reported having no access to mobile devices [21].

In other related research, students report that they are indeed using mobile technology to engage in a variety of academic activities. Previous research has reported students' reliance on mobile devices to communicate and collaborate, view grades and assignments, participate in "live" classroom activities, and research information [22]. There is evidence that mobile devices are allowing students to uniquely manage and engage in their learning experience by equipping them with access, just-in-time information, and connectedness [23]. Yet, higher education institutions and faculty members are still hesitant to embrace mobile learning due to the uncertainty of best practices in implementing in the learning environment without causing disruptions [24]. What might be a source of trepidation, there is a lack of empirical evidence of best practices for integrating mobile technology in educational settings to enhance teaching and learning experiences [25].

2.2 The Potential of m-Learning

Educators and researchers continue to consider m-learning, in large part, due to its practical ability to provide instant, on-demand access to a personalized world filled with tools and resources for students [16]. Mobile devices are also typically smaller and cheaper than larger technology, such as desktops, making them more affordable, accessible, portable, and useful for students [26, 27]. Another reason educators and researchers consider mobile technology as a learning tool is due to its ability to provide new learning possibilities beyond conventional learning environments. In theory, students can participate in learning activities in remote geographies who do not typically have access to computers. Likewise, mobile technology has been at the forefront of a new wave of educational innovations designed to meet the learning needs of students with learning exceptions (physical or cognitive) [28, 29]. Furthermore, the form factor of mobile devices naturally creates the ability to create more authentic and collaborative learning experiences that other computing technology cannot, integrating learning science thought to provide deeper learning opportunities [30].

The learning potential of mobile technology has advanced with the evolution of the internet. Web 2.0 is often referred to as the second phase of the evolution of the internet. The technology and services of Web 2.0 encourage flexible web designs, richer user interfaces, collaborative content, new apps, social networks, and continued collective intelligence [31]. m-Learning embodies 2.0 as it involves the use of wireless-enabled mobile devices within and between pedagogically designed learning environments [32]. Learners can utilize mobile to improve critical reflective skills, facilitate group communication, develop an online e-portfolio, curate a world-wide network, and learn how to leverage technology and maximize their learning experiences [33]. Embedding mobile devices in the classroom can help instructors facilitate group collaboration and empower both instructors and students to apply technology in a variety of learning environments and activities seamlessly [34].

Insight to the actual learners who are using mobile devices to engage in mobile learning also remains unclear. The assumption is often made that the most frequent group to use mobile devices are younger learners, who are considered to be tech-savvy or *digital natives*. Prensky [35] described digital natives as young people born after 1980 who possess unique knowledge and skills regarding technology because they are growing up in the digital age. A childhood during this age of technology, however, does not automatically bestow technological expertise. Margaryan, Anoush, and Littlejohn [36] found that younger students are far from being technologically-fluid digital natives, but instead, they tend to use mobile devices more actively than older students. More interestingly, younger and older students were both described to be unaware of how to use new technologies to support their learning effectively. Higher education students today are a diverse mix of younger and older learners, who may be employed, are potentially parents or caretakers, and are much more mobile than previous generations [37]. They possess a unique set of needs with solutions that are both inside and outside the classroom. Students have strong expectations of constant access to learning platforms, instructional materials, and resources to learn anywhere and anytime [38]. Considering the portability, mobile technology uniquely offers many opportunities to engage with learning, but their use does not always guarantee that effective learning has

or will take place [39]. Notwithstanding the gap in the research of just how to integrate m-learning to enhance learning outcomes, the potential for mobile learning is evident. More research is required to understand learners' mobile device usage and perceptions who are engaging in mobile learning, and thus to identify how to best support their needs to achieve desired learning outcomes.

2.3 Measuring the Impact of m-Learning

To assess the impact of mobile technology to date, past research interests heavily relied on understanding m-learning using instruments such as the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM) questionnaires. Both instruments have shown to be useful to understand why a user may first decide to use a particular technology and for what purposes. Specifically, the UTAUT is designed to identify the intention to accept or use a given technology based on performance expectancy, effort expectancy, social influence, and facilitating conditions [40]. The Technology Acceptance Model (TAM) is a model that also describes the behavioral factors that influence technology use such as perceived usefulness, ease of use, intention, and actual usage of the technology [41, 42]. Both instruments have been used to identify the reasons for the adoption of mobile devices by students for learning purposes, the potential of the devices, how much time they use mobile devices, and what challenges they face when using mobile devices.

2.4 Overview of the Present Study

As such, the purpose of this survey study was to better understand mobile devices usage trends in higher education by answering the following questions:

Q1: What devices do students own?
Q2: How do students use mobile devices to learn?
Q3: What learning activities do students use mobile devices for learning?
Q4: How much time do students spend using mobile technology for learning?
Q5: How has mobile technology impacted students learning?
Q6: What challenges do students encounter while using mobile devices for learning?

3 Method

3.1 Design and Analysis

This research was an exploratory survey study with the goal of investigating post-secondary students' mobile device usage for learning. A survey design was suitable since the purpose was to collect primary data to ascertain students' behaviors and attitudes of m-learning [43]. One electronic survey form was developed and distributed to collect both quantitative and qualitative data. A visual display of the results was created for quantitative results; at the same time, the qualitative data was parsed into themes.

Only fully completed surveys were included in the final analysis. A total of 475 individuals began the survey, out of which 250 either did not meet eligibility requirements for the study or did not complete the form in entirety. After these incomplete survey attempts were removed from the data records, the survey submissions of 225 eligible participants created the final data set.

3.2 Participants

Participants for this study (N = 225) were recruited from 2-year and 4-year post-secondary schools (e.g., colleges, universities, and vocational schools) across the United States. To be eligible for the study, participants were required to have experience using a mobile device (i.e., smartphone, tablet, or smartwatch) within a learning context. Ages ranged from 18 to 60 (Median = 25), representing 15 different majors, most prominently business (25%), health sciences (20%), and natural sciences (14%) majors, as shown in Table 1. At the time of completing the survey, most students reported that they were going to school full-time taking 4–5 courses (49%) on average. Other demographic information is presented in Fig. 1 and Table 1.

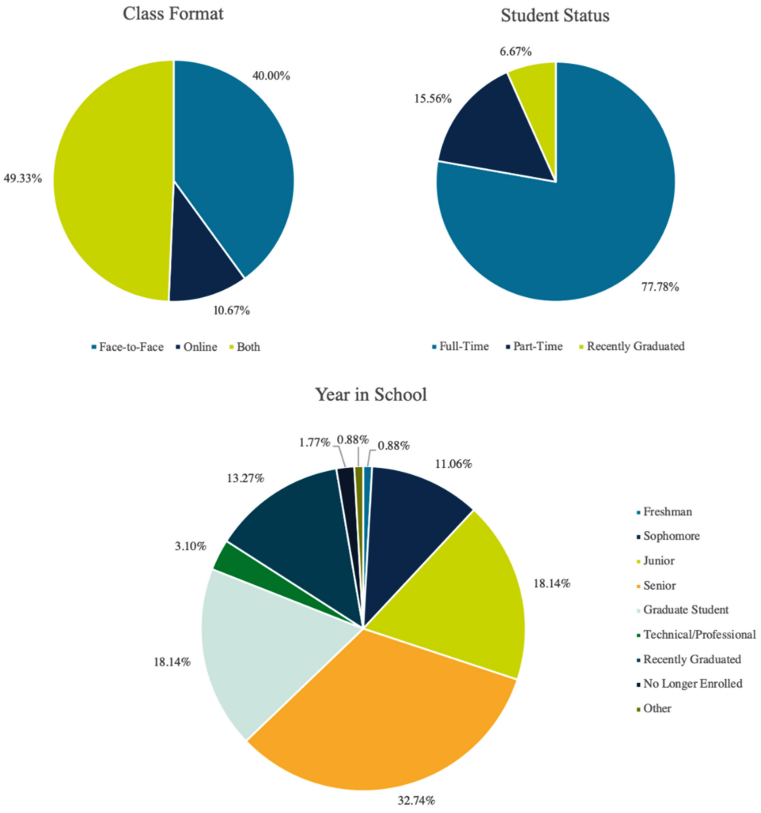

Fig. 1. Participant demographics including their typical class format, student status, and year in school.

Table 1. Breakdown of students' majors participating in the present study.

Majors	Count	%
Accounting/Business/Economics/Finance/Hospitality	58	21.40%
Anthropology/Sociology/Social Work	9	3.32%
Art/Architecture/Music/Performance	6	2.21%
Biology/Chemistry/Earth Sciences/Physics	32	11.81%
Communications	7	2.58%
Computer Science/Information Science	18	6.64%
Criminal Justice/Government/Law	10	3.69%
Education	16	5.90%
Engineering	21	7.75%
English/Composition/Literature	4	1.48%
History/Languages/Philosophy/Religious Studies	10	3.69%
International studies	4	1.48%
Mathematics/Statistics	2	0.74%
Medicine/Pharmacology/Nursing/Wellness	50	18.45%
Psychology/Human Development	18	6.64%
Other (please specify):	3	1.11%
I do not have a declared major	3	1.11%

Note: The results in this table also includes students with more than one major.

3.3 Instrument

As shown in Table 2, the online survey was created in the Qualtrics© online survey platform and captured information pertaining to demographics, mobile usage, and mobile attitudes. The demographics portion of the survey consisted of six items capturing participant characteristics and school-related details. The rest of the survey consisted of questions concerning mobile usage as well as attitudes and perceptions of m-learning. The survey items were based on the widely used Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM) questionnaires [21, 40, 44–47]. Adaptations to these instruments were made to incorporate recent literature and measure finer points of students' habits and perceptions of m-learning [48]. Item-types for the survey consisted of Likert scales and open-ended responses. For example, some items asked students to rate the likelihood of them completing different types of learning activities on a smartphone, a tablet, and a smartwatch from Not At All Likely (1) to Very Likely (5). The survey took participants approximately 15 min to complete.

Table 2. Summary of survey questions.

	Item
Demographics	1. Age 2. Year in school 3. Field of study 4. Student status 5. Course load 6. Class format
Mobile usage	7. Have you used mobile devices for learning-related purposes? 8. What mobile devices do you own? 9. How often do you carry your mobile devices with you? 10. What is the likelihood of you using a mobile device to complete learning activities? 11. How often do you use mobile devices to learn? 12. What type of mobile devices do you use for learning? 13. What type of learning apps do you use on your mobile device? 14. What apps do you use most frequently for learning on your mobile devices? 15. How much time do you typically spend engaging with learning on your mobile devices? 16. What are the challenges you have encountered while using mobile devices for learning? 17. I'm easily distracted if I use a mobile device for learning 18. I'm easily distracted if I use a computer/laptop for learning 19. I'm easily distracted if I use paper and pencil for learning
Attitude towards mobile learning	20. How has the development of mobile technology impacted your learning?
Instructors' role in m-learning (students' perception)	21. How often do you expect your course assignments and materials to be accessible on your mobile devices? 22. How often do your instructors assign you an assignment that requires the use of mobile devices? 23. How often have you received formal training (e.g., tutorial, guide, expert training) to assist you in using mobile devices in your courses or to enhance your learning? 24. Based on your learning preferences, how important is it that your instructors incorporate mobile learning experiences in your course(s)?

(*continued*)

Table 2. (*continued*)

	Item
Mobile technology policy and procedures	25. Does owning mobile devices change how often you would use a computer lab on campus? 26. Does owning mobile devices change how often you would use a library? 27. Does your institution have a mobile strategy? A mobile strategy is a plan on ways to incorporate and leverage the use of mobile devices to ensure success for the school and all people who use the mobile experiences 28. Are you aware of any policies that prohibit the use of mobile devices in your course(s)?
Future of mobile technology	29. Have you used mobile devices to engage with augmented reality or virtual reality? 30. How do you see your use of mobile devices for learning change in the next two years? 31. Is there anything else you would like to mention in regards to mobile learning and the future of education?

3.4 Procedure

Participants for this study were recruited from a research pool managed by an educational software company of post-secondary students from schools located across the U.S. Through various ways of contact (i.e., public ads, social media, and in-class announcements), students voluntarily opt into the pool by providing their permission to be contacted to participate in educational research efforts. Having previously elected to join the research pool, participants received invitations via email to participate in a survey study. The recruitment email stated the purpose of the study was to learn how students used mobile devices in learning experiences, and that eligible individuals must possess experience using a mobile device within a learning context. Interested volunteers accessed the survey link within the email and proceeded to complete the survey in a new tab. After accessing the survey, participants first viewed a brief landing page that summarized the purpose of the study, outlined the monetary incentive, stated that no known risks were associated with the survey, along with contact information for the research team. Students provided their informed consent to participate voluntarily by clicking "continue" at the bottom of this screen. The online survey form recorded responses for three days, after which the link closed. Upon successful completion, a "thank you" message displayed to participants as confirmation. An incentive of $7 (USD) was paid to participants who submitted fully completed surveys.

4 Results

4.1 Ownership by Mobile Device Type

For brevity, only the most informative results and findings were selected for inclusion in this paper. Of the 225 participants who reported having used mobile devices for learning purposes, 99.56% owned a smartphone, 57.78% owned a tablet, and just 29.33% owned a smartwatch. As shown in Table 3, the overall ownership trend was consistent across majors, however, there were noticeably more owners of mobile devices by those who took online and blended courses.

Table 3. Participants' ownership of mobile devices breakdown by major and class formats.

	Smartphone	Tablet	Smartwatch
Majors			
Accounting/Business/Economics/Finance/Hospitality	100.00%	66.67%	24.56%
Anthropology/Sociology/Social Work	100.00%	60.00%	20.00%
Art/Architecture/Music/Performance	100.00%	66.67%	0.00%
Biology/Chemistry/Earth Sciences/Physics	96.88%	37.50%	28.13%
Communications	100.00%	57.14%	42.86%
Computer Science/Information Science	100.00%	55.56%	16.67%
Criminal Justice/Government/Law	100.00%	70.00%	20.00%
Education	100.00%	68.75%	31.25%
Engineering	100.00%	52.38%	33.33%
English/Composition/Literature	100.00%	25.00%	50.00%
History/Languages/Philosophy/Religious Studies	100.00%	37.50%	12.50%
International Studies	100.00%	25.00%	0.00%
Mathematics/Statistics	100.00%	50.00%	50.00%
Medicine/Pharmacology/Nursing/Wellness	100.00%	66.67%	44.44%
Psychology/Human Development	94.12%	41.18%	23.53%
Other	100.00%	42.86%	33.33%
I do not have a declared major	100.00%	100.00%	0.00%
Class Formats			
Online	100.00%	70.83%	37.50%
Face-to-face	98.89%	43.33%	30.00%
Both	100.00%	66.67%	27.03%

Note: The results in this table also includes students with more than one major.

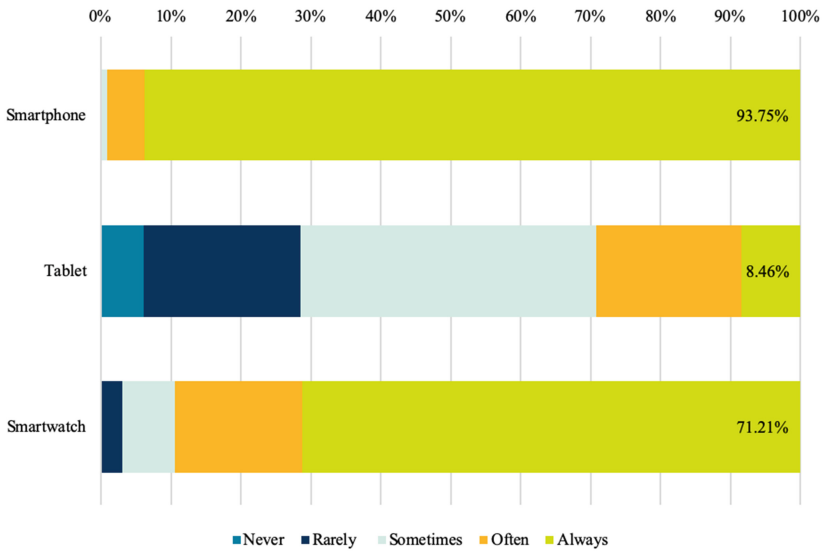

Fig. 2. The rate of students regularly carrying three mobile devices with them.

Additionally, as shown in Fig. 2, 93.75% of participants always carry their smartphones with them, about 71.21% always wear their smartwatches, and 8.46% of participants always carry their tablets. As far as conducting learning activities on a mobile device, smartphone owners did so 96% of the time, tablet owners 79.23% of the time, despite not constantly carrying tablets with them; and smartwatch owners only 9.10% of the time.

4.2 Mobile Device Usage for Learning

As shown in Fig. 3, while most of the participants majoring in most disciplines all reported using smartphones for learning, students majoring in English/Composition/Literature reported the lowest usage rate of 75.00%. For mobile learning with tablets, the usage rates vary widely by major with a range from 0% to 66.67%. The top five majors include Criminal Justice/Government/Law, Medicine/Pharmacology/Nursing/Wellness, Education, Accounting/Business/Economics/Finance/Hospitality, and Anthropology/Sociology/Social Work. Students who use smartwatches for learning were concentrated in five major categories with usage rate from 3.31% to 10%: Medicine/Pharmacology/Nursing/Wellness, Criminal Justice/Government/Law, Education, Engineering, and Biology/Chemistry/Earth Sciences/Physics.

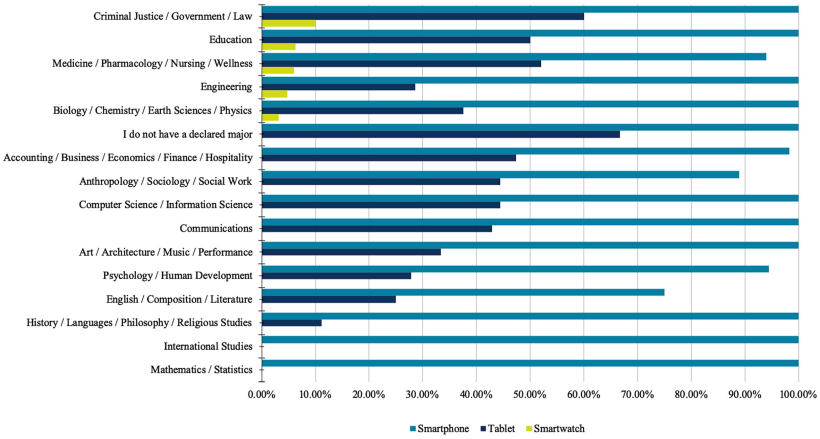

Fig. 3. The usage rate of mobile learning of students majoring in different areas.

Further comparison was conducted to discover whether the usage for learning on devices differs across class format. Across the three class formats, high usage for learning on smartphones was consistent, as shown in Fig. 4. Students who typically enroll only in face-to-face courses tend to use tablets for learning less than students who take only online courses or a combination of the two. Moreover, students who typically take online courses were 10 times more likely to use smartwatches than students in face-to-face or both formats of courses.

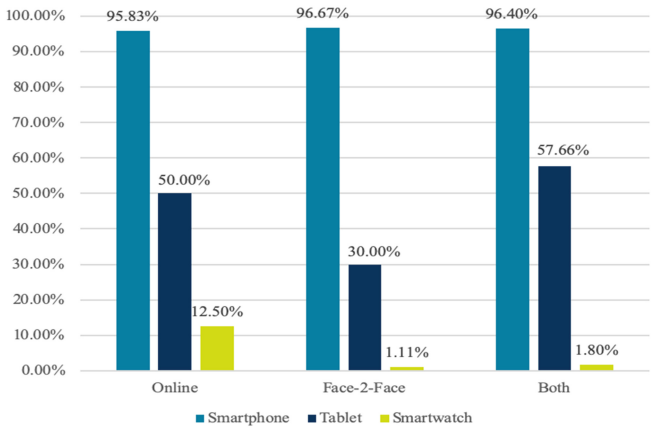

Fig. 4. The usage rate of mobile learning of students who typically take different formats of classes.

4.3 Types of Learning Activities and Applications with Mobile Devices for Learning

To add clarity about what students are engaging in during m-learning, participants were asked which specific learning activities and applications they use. As shown in Table 4, the top Very likely activities by device type were accessing and storing resources for smartphones, reading and taking notes on tablets, and setting priorities and watching due dates on smartwatches.

Table 4. Top Very Likely and Not At All Likely learning activities by type of mobile devices.

	Activities on Smartphones by Smartphone Owners			
	Top Very Likely Activities		Top Not At All Likely Activities (>10%)	
1	Accessing immediate information	78.13%	Accessing immediate information	20.09%
2	Increasing the number of available resources/sources	74.11%	Increasing the number of available resources/sources	14.29%
3	Saving/storing information	70.54%	Saving/storing information	11.61%
4	Looking up grades	55.80%		
5	Receiving feedback or help	53.57%		
	Activities on Tablets by Tablet Owners			
	Top Very Likely Activities		Top Not At All Likely Activities	
1	Completing reading	47.69%	Listen to your audio version of your textbook	16.92%
2	Taking notes	43.08%	Communicating with a classmate	15.38%
3	Accessing course materials	43.08%	Communicating with an expert from your field of interest	15.38%
4	Looking up grades	40.00%	Taking notes	13.08%
5	Communicating with professors	34.62%	Collaborating with others for group projects	13.08%
5	Complete other tasks/assignments for a course	34.62%		
	Activities on Smartwatches by Smartwatch Owners			
	Top Very Likely Activities		Top Not At All Likely Activities	
1	Monitoring and prioritizing task/to-do list for courses	9.09%	Completing writing assignments	74.24%
2	Staying up to date with current events in school/courses	9.09%	Completing reading	72.73%
3	Accessing immediate information	4.55%	Taking notes	72.73%
4	Communicating with a classmate	4.55%	Accessing course materials	72.73%
5	Increasing the number of available resources/sources	3.03%	Complete other tasks/assignments for a course	71.21%

Participants were also asked about which applications they use for mobile learning. To narrow down the list for smartphones and tablets, only the top five m-learning applications with over 50% of responses were reported, as shown in Table 5. Only the top three m-learning applications for smartwatches were reported. Internet apps were listed most often via smartphones and tablets, and productivity tools such as email apps was list first for smartwatches. Flashcards was accessed the second most often across all three mobile device types. In the follow-up, open-ended questions that asked participants to name three applications that they use most frequently, flashcards including Quizlet, Pearson Prep, Study Blue, and Smart Flashcards, and productivity apps such as Google Doc, Translate, and Mail were listed as the most commonly listed. The pattern of learning activities and applications with mobile devices appeared to be consistent in participants taking different class formats and majoring in disparate areas.

Table 5. Top mobile applications that students use.

	Smartphone	Tablet	Smartwatch
1	Internet browser (e.g., Safari, Chrome) (84.33%)	Internet browser (e.g., Safari, Chrome) (78.64%)	Tools (e.g., calculator, email apps, dictionary) (50.00%)
2	Flashcards (e.g., Pearson Prep, Brainscape, Quizlet) (76.96%)	Flashcards (e.g., Pearson Prep, Brainscape, Quizlet) (68.93%)	Flashcards (e.g., Pearson Prep, Brainscape, Quizlet) (33.33%)
3	Tools (e.g., calculator, email apps, dictionary) (72.81%)	Note taking (e.g., OneNote, Evernote) (65.05%)	Task organization (e.g., Smart Study Plan, Reminder) (33.33%)
4	Documentation (e.g., iWork, MS Office, Google Drive) (57.14%)	Tools (e.g., calculator, email apps, dictionary) (62.14%)	
5	Note taking (e.g., OneNote, Evernote) (52.53%)	eReading (e.g., Kindle, Pearson eText, iBook) (59.22%)	

4.4 Time Spent Using Mobile Technology for Learning

As shown in Table 6, participants were also asked about how much time they perceive they engage with learning on their mobile devices. Overall, 30% of students spend 1–2 h a day using mobile devices for learning purposes; another 33% spend 60 min a week; only around 13% of them spend more than three hours a day. If breaking the data down by class format, differences can be observed. About 42% of students typically taking online courses spend 60 min a week, which is about 10% higher than students typically taking face-to-face and both class formats. In the group of students who reported that they spend more than three hours a day on mobile learning, the number of students typically taking both class formats nearly doubled the number of students typically taking online courses. Inspecting the data across majors, it can be found that 50% or more of our participants use mobile devices for learning daily in majors such as

art, international studies, and medicine. Interestingly, 33.33% of students who majored in art, 25% international studies, and 23.53% computer science were the top three disciplines reporting they spend three hours or more per day on mobile learning.

Table 6. Time spent on mobile learning by class format and by major.

	10 min a week	20 min a week	30 min a week	60 min a week	1-2 h a day	3 h + a day
Overall	2.28%	9.13%	12.33%	32.88%	30.14%	13.24%
Class Format						
Online	4.17%	4.17%	12.50%	41.67%	29.17%	8.33%
Face-to-face	2.35%	11.76%	11.76%	32.94%	29.41%	11.76%
Both	1.82%	8.18%	12.73%	30.91%	30.91%	15.45%
Major						
Accounting/Business/Economics/ Finance/Hospitality	1.79%	3.57%	12.50%	33.93%	33.93%	14.29%
Anthropology/Sociology/Social Work	0.00%	40.00%	0.00%	40.00%	20.00%	0.00%
Art/Architecture/Music/Performance	0.00%	0.00%	0.00%	33.33%	33.33%	33.33%
Biology/Chemistry/Earth Sciences/Physics	3.33%	6.67%	3.33%	40.00%	36.67%	10.00%
Communications	0.00%	0.00%	28.57%	28.57%	28.57%	14.29%
Computer Science/Information Science	5.88%	23.53%	11.76%	11.76%	23.53%	23.53%
Criminal Justice/Government/Law	0.00%	10.00%	10.00%	70.00%	10.00%	0.00%
Education	7.14%	14.29%	7.14%	57.14%	7.14%	7.14%
Engineering	9.52%	4.76%	14.29%	38.10%	28.57%	4.76%
English/Composition/Literature	0.00%	0.00%	25.00%	50.00%	25.00%	0.00%
History/Languages/Philosophy/Religious Studies	0.00%	12.50%	12.50%	62.50%	12.50%	0.00%
International studies	0.00%	0.00%	0.00%	50.00%	25.00%	25.00%
Mathematics/Statistics	0.00%	0.00%	50.00%	50.00%	0.00%	0.00%
Medicine/Pharmacology/Nursing/Wellness	2.22%	8.89%	15.56%	22.22%	35.56%	15.56%
Psychology/Human Development	6.25%	6.25%	6.25%	43.75%	25.00%	12.50%
Other (please specify):	0.00%	14.29%	19.05%	33.33%	19.05%	14.29%
I do not have a declared major	0.00%	0.00%	33.33%	0.00%	66.67%	0.00%

Note: The results in this table also includes students with more than one major.

4.5 Impact of Mobile Technology on Students Learning

According to the results from the impact of learning on mobile devices question, mobile learning has played an important role in their learning experience. As shown in Fig. 5, 76.26% of participants reported that mobile technology had a positive impact on their learning and only less than 4% reported negative impact. Moreover, none of the students who typically take online classes think mobile technology impacted their learning negatively. There were about two times of students typically taking face-to-face classes reported negative impacts than students typically taking both formats of classes, as shown in Fig. 6.

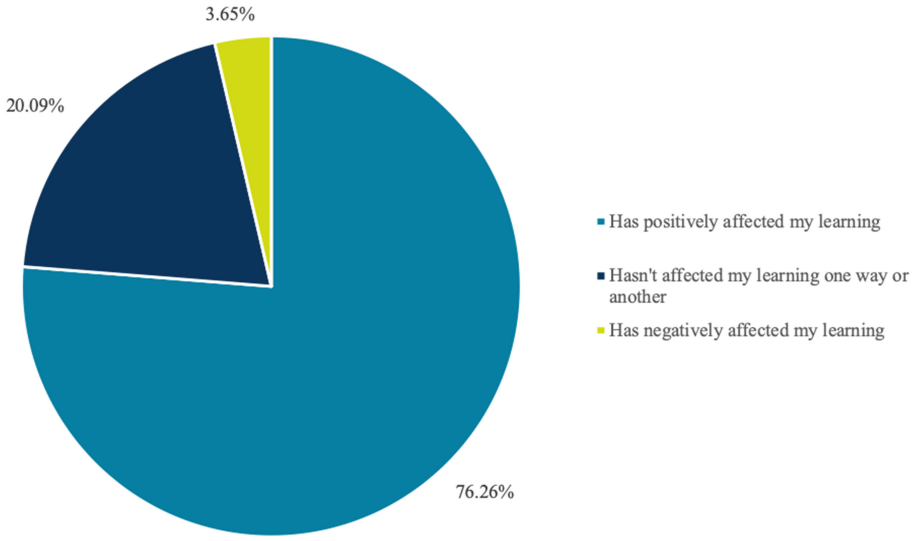

Fig. 5. Impact of the development of mobile technology on students' learning.

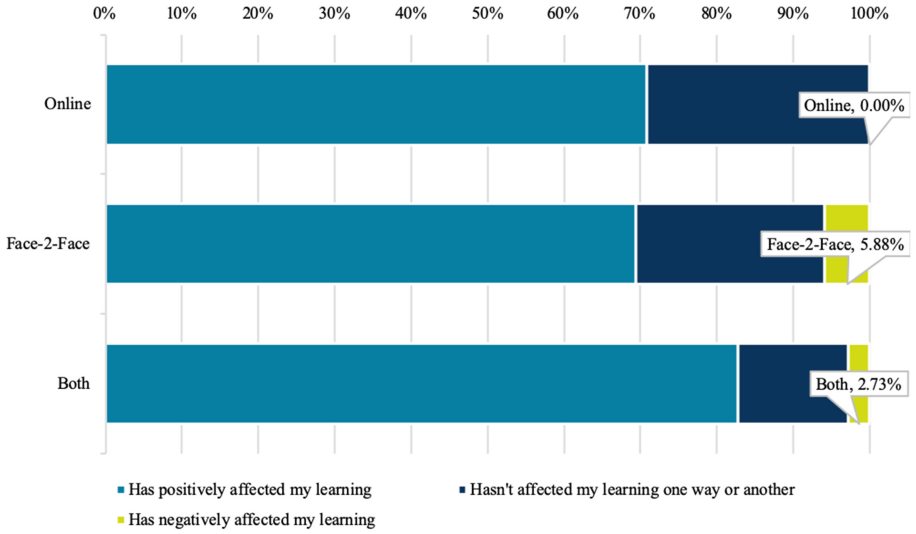

Fig. 6. Impact of the development of mobile technology on students' learning by class format.

4.6 Challenges of Using Mobile Devices for Learning

Participants were also asked what challenges they met while using mobile devices for learning. The biggest challenge reported by students was the small screens, followed by bad user experience/design of mobile applications, compatibility of applications, and internet connectivity. Price of devices and availability of device brands and versions

were the least concerned. The pattern basically kept consistent across mobile devices for learning, as shown in Table 7. It was also found that half of the other challenges that students specified was related to the social aspect of the technology being a distraction. Moreover, in another question, almost 50% of students reported they agree or extremely agree that they are easily distracted when using a mobile device for learning.

Table 7. Challenges of using mobile devices for learning.

	Overall	Smartphone	Tablet	Smartwatch
Small screens	24.01%	24.10%	23.51%	20.00%
Bad user experience/design of mobile apps	21.14%	21.48%	20.20%	20.00%
Compatibility of apps between mobile devices and computer	19.55%	19.18%	21.52%	15.00%
Internet connections	17.97%	17.87%	17.22%	20.00%
Price	10.02%	10.00%	10.26%	15.00%
Various availabilities	5.56%	5.57%	5.96%	10.00%
Other (please specify):	1.75%	1.80%	1.32%	0.00%

5 Discussion

5.1 Q1: What Devices Do Students Own?

One of the major research questions of this study looked to discover how students use mobile devices for learning, if at all. Prior to understanding students' usage and attitudes regarding mobile learning, it is necessary to know the current situation of their ownership of mobile devices. Considering almost unanimous ownership and access, results from this survey study offered validation of pervasiveness of mobile technology in the hands of students everyday.

5.2 Q2: How Do Students Use Mobile Devices to Learn?

Of the different types of mobile technology, the majority of students reported that they complete learning activities using smartphones, compared to just over half using tablets, and only a few using the newer technology of smartwatches. This trend is supported by the fact that modern smartphones are smaller and more portable yet packed with comparable processing power as tablets. Smartwatches on the other hand are the epitome of portability, however, the small screen size makes it challenging to complete any learning activities on them. Of those students from majors who reported owning and using smartwatches for learning, most of them come from disciplines that require them to use their hands (i.e., doctor conducting surgery, chemists in a research lab, or an engineer crafting or manipulating materials), or are not expected to use their phones openly (i.e., lawyer in a courtroom or a teacher in a classroom). The majors

currently using smartwatch technology might just be early adopters, because smartwatch use is expected to grow in other disciplines as and software developers and educators continue to acquaint themselves with better ways to provide learning experiences on the relatively new smartwatch technology. Examining the m-learning across majors, interestingly, students in more writing-centric majors reported using mobile devices the least. This trend could be attributed to the form factor. One of the main constraints of mobile technology is the smaller, compact screen sizes make tasks such as writing papers, and switching between numerous sources complicated and time-consuming.

5.3 Q3: What Learning Activities Do Students Use Mobile Devices for Learning?

Additionally, based on the question about what type of learning activities students per device, the applications the list of top applications they access for learning appear to be more lower-level learning activities such as quick, short bursts of time. Learning activities that require more challenging and complicated activities such as writing papers, designing projects, and the like are better reserved for more stationary computing. On the contrary, smartwatches serve more immediate, brief, finite tasks. Regarding reading and writing tasks, smartphones may serve more quickly accessible tasks, whereas tablets are used for more prolonged reading and writing tasks.

5.4 Q4: How Much Time Do Students Spend Using Mobile Technology for Learning?

In alignment with the question about how much time students spend using mobile technology for learning, what was found is that, indeed, mobile technology, including newer form factors smartwatches, are frequently used amongst students. Almost at a rate of complete saturation, higher than projections [49, 50], almost all students are in contact with a computing device even more so than standard computers like desktops and laptops. Furthermore, the results from the time spent using mobile devices for learning rival those of other means of learning such as desktops and laptops. As much as a third of students reported spending an hour using mobile technology for learning. That is approaching the behavior for standard study habits which suggest average college students spend about 1–3 h studying per day [51–53]. Additionally, the major students reported that m-learning has had a positive impact on their learning. Only a small percentage reported an adverse reaction to m-learning. It could be the case that with a more strategic approach to designing mobile learning activities, even fewer students will have a negative response to m-learning. Nevertheless, any educational technology product would be elated with such low adverse numbers. These findings together give credence to the notion that students are comfortable engaging in learning activities using mobile devices. Moreover, this finding is encouraging that more should continue to be done to design and develop learning activities for mobile devices.

5.5 Q5: How Has Mobile Technology Impacted Students Learning?

Given the rates of both mobile device ownership and engagement in learning activities on mobile devices, educators can assume that, required or not, students are comfortable with performing learning activities on their mobile devices. And this finding is not isolated to students studying in certain disciplines. Does this mean that all instruction should be designed for delivery via mobile devices? The present study suggests otherwise. Students who reported taking online courses also more often indicated that they perform learning activities with their mobile devices. Perhaps students who are more comfortable with technology in general lean towards both online courses and newer technological ideas, such as m-learning. However, the *cause in effect* could not be determined from this study. Instructors may also play a role in this finding as well. For example, instructors who teach online or blended (e.g., incorporate both online and face-to-face elements) courses may be more comfortable using technology in their instructional practices and, subsequently, m-learning appears more frequently within those courses.

5.6 Q6: What Challenges Do Students Encounter While Using Mobile Devices for Learning?

Based on the challenges students reported, m-learning is limited by the small viewing area. To compound this issue, educational software despite being accessible via mobile technology would benefit from better design considerations for mobile devices. Technology heuristics such as responsive design might need better design considerations so the user experience is more user-friendly [54, 55]. Moreover, distraction was largely recognized in students' m-learning experience. The self-management element was suggested to be helpful to address the distraction issue. Therefore, learning designers might also need to consider embedding this element in the design of m-learning applications [56].

5.7 Limitations

A limitation of this study is the small sample size with respect to the number of students nationwide. Without a larger sample size, it is difficult to generalize these results beyond the superficial. However, the findings of this study can serve as a provisional indication of how mobile technology is currently used in higher education in the United States. Another possible limitation is the potential propensity of respondents and the instructors who taught the respondents might have had towards technology. Participants in this study were recruited from a pool created by an educational courseware company. It could be the case that they are more comfortable with educational technology and hold a more positive attitude towards educational technology as a result of their respective instructors exposing them to educational courseware.

6 Conclusion

Given how mobile devices seem *sine qua non* to students in the United States and across the globe, educators would be remiss not to consider ways to integrate the technology into their teaching practices. Suggested by the results from this survey study students have access to many mobile devices, however, they tend to be very selective in what device they choose to use for their learning. The findings indicate that their use of mobile technology is highly dependent upon the characteristics of the learning activity they are engaging in, the subject matter, and can be motivated by many things including their interest to have immediate access to information or course materials. Regardless of the class formats, face-to-face, online, or both, today's student appears to recognize the positive impact mobile devices have on their learning. As such, the results from this study should be encouraging that more research is needed to help explore the ways educators can help support learners as they engage in mobile learning experiences.

Past research for m-learning offers many definitions and frameworks, which can make it hard for practitioners and learners to determine which one to consider. Each day mobile technology continues to evolve and advance, sparking changes in how we view and experience learning. Already the next phase of mobile, Mobile 3.0, is anticipated to include artificial intelligence and machine learning that will result in a virtual classroom that can be viewed on mobile devices [57]. Soon learners will be able to engage in mobile learning experiences that include location-based learning, augmented reality, wearable learning, learning implants, and ambient intelligence [58]. Therefore, creating successful mobile learning experiences will require careful planning, appropriate pedagogy, and sufficient technological support [33]. Sharples et al. [59] emphasize that we cannot determine how technology will be used until we explore its use in real settings with real people. Future research should continue to explore mobile learning from the instructors perspectives, paying close attention to the existing challenges. Additionally, there is a dire need for an evidence-based framework for designing m-learning experiences in higher education for face-to-face or virtual environments. The best way to develop a concrete definition and framework for mobile learning is to continue to explore the characteristics of those who are currently using mobile devices to help identify the areas where they need the most support.

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