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Undergraduate students' perceived mobile technology-learning barriers in their academic studies: a study in Greece

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Abstract
Mobile technology is used by undergraduate students for educational purposes, it supported students' learning during the pandemic, while mobile learning may have potential benefits and barriers. This study investigates Greek undergraduate students' perceptions on mobile technology-learning barriers in their academic studies. This topic is of international interest and still underexplored in Greece. An online questionnaire was completed by 212 students, and this study is descriptive-inferential. Students' perceptions regarding major barriers, reveal both external (internet connectivity issues, high cost of mobile devices, outdated operating system) and internal (tutors' negative attitudes and insufficient knowledge for mobile technology-learning integration) barriers. Other obstacles are associated with student concerns about distraction, and inadequate training opportunities to use mobile technology in their studies. Students' confidence, attitudes and digital skills regarding mobile technology adoption/use are perceived as minor barriers (or no barriers). The findings have implications for students, university tutors and university stakeholders.

Keywords Mobile learning · Mobile technology · Barriers · Obstacles · University · Higher education · Student perceptions · Greece

1 Introduction

Mobile learning is associated with the educational use of mobile technology with the purpose to support, aid and enhance the educational process, anytime and anywhere; at the same time, the mobility of technology, learners and learning is considered [1–3]. Undergraduate students utilize their mobile devices (mobile phones, tablets, etc.) for educational purposes, and mobile technology has the potential to contribute towards a productive educational environment in tertiary education [4]. For example, evidence from a large scale study indicated that, appropriate use of smartphones can lead to better academic outcomes for higher education students [5]. Researchers [4, 6–10] report on the advantages and pedagogical affordances of mobile learning; indicative educational advantages/benefits include flexibility in learning in terms of space and time, portability, student motivation and engagement, collaboration and communication among students, personalization and sense of ownership. In parallel, potential barriers include technological barriers such as limited internet connectivity, hardware/software related barriers, instructional barriers (e.g., inappropriate material available for mobile devices, or difficulties in locating learning content), and inequality concerns for socially disadvantaged students [9, 11–15]. It is noted that mobile learning-technology barriers are similar to Information Technology

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(ICT) barriers; i.e., external (also called first-order) barriers and internal (also called second-order) barriers [11, 16, 17]. External barriers refer to obstacles that are extrinsic to students and include limited (or lack of) resources (e.g., access to equipment, digital educational resources), lack of support (e.g., availability of technical support), and lack of institutional strategies (e.g., university vision and plans). Internal barriers refer to obstacles that are intrinsic to students, which include knowledge, skills (e.g., competence to use the technology), personal beliefs and attitudes (e.g., negative views), as well as confidence/self-efficacy.

Many undergraduate students, across different countries, used their mobile devices/phones during the pandemic period, and relevant advantages and disadvantages were reported [15, 18, 19]. Research on mobile learning/technology is increasingly growing, and new evidence on students' perspectives on barriers will add value to this ongoing research topic. The purpose of this study is to explore undergraduate students' perceptions on mobile technology-learning barriers in their academic studies. Such an investigation is important because students' views on barriers to using mobile technology are linked to their educational practices, and may affect their academic performance. Identifying students' perspectives of barriers is important, since some obstacles may prevent the adoption of mobile-mediated learning in higher education. The focus of the studies below is on students' perceived barriers during and/or after the pandemic period; this is because the pandemic period is considered by researchers as a turning point that accelerated mobile technology utilization for educational purposes [13, 15, 20, 21].

In the USA, Elliot [14] reported that undergraduate students identify different types of barriers when they use their mobile phones for university work: technological barriers regarding hardware or software usability such as the physical dimensions of the device itself (e.g., small screen size); institutional barriers such as disconnect between the services provided by the university and those revealed by the students (particularly, with regard to digital platforms' choice); instructional barriers such as difficulties in finding learning content or inappropriate material for mobile devices (e.g., as poorly-scanned documents). Another study from the USA [22] reported that undergraduate students choose to use their mobile devices (phones and tablets) for online academic work or course learning activities for reasons of portability, convenience, and ease of use. However, there are also barriers that regard technology limitations (e.g., device design and compatibility issues).

A study that investigated postgraduate students' views of the use of WhatsApp as a communication tool during the pandemic [23] indicated that students and tutors in S. Africa relied on their mobile devices to communicate. Besides the benefits, a disadvantage is that a mobile app group can defeat its purpose if students use it for non-academic chats, and it can become a distraction.

Some research studies reported barriers linked to specific academic disciplines and/or applications. For example, barriers in the field of medicine were reported to include the lack of resources for mobile change at a hospital, unclear strategy/policy and regulation [24]. English as Foreign Language (EFL) students' beliefs revealed challenges and obstacles of virtual-reality mobile technology use in the language learning process; obstacles include difficulties to download or connect to the same tour simultaneously, incompatibility of some devices with the virtual reality application, and unsuitable app for short-sighted students [25]. Digital literacy and technical obstacles were reported by student teachers within a mobile-assisted EFL learning environment [26]. The use of electronic textbooks designed as mobile applications for learning vocabulary in English among Iranian students was explored by Xodabande & Hashemi [27]; EFL students' perceived challenges include health concerns, distractions linked to mobile environments, and external pressure resulting from excessive mobile technology use by students.

Another study [28], in Spain, explored students' perceptions of mobile devices' usage before and during the pandemic (students were studying Education and Communication-Information Science disciplines). Students reported as challenges (in particular, during the pandemic) their tutors' attitudinal and technical limitations; students believe that their tutors' skills when utilizing mobile technology for educational activities could be improved. Pakistani Library and Information Science students reported as barriers/concerns related to the use of mobile learning devices, the cost/maintenance of the devices, eye stress, quick outdated systems, and privacy issues [29]. In India [30], students studying Mathematics and English language identified the following as major obstacles that prevent mobile phone usage as an educational tool: unstable internet use, distraction (e.g., from incoming calls during the educational process), file-formats of contents that do not support browsing, and small screen/key size that make smartphones uncomfortable for learning.

A study in Nigeria [31] investigated online learning attitude and readiness of accounting students during the pandemic. No differences were detected in terms of gender or institution type. The authors recommend for universities to provide efficient online learning access and resources, and work towards bridging any existing institutional disparities in the availability and use of online learning facilities (including mobile technology). Digital inclusion is essential and it can be prevented by various obstacles such as limited digital skills, digital experiences/opportunities, and infrastructure [32].

In parallel, tutors' level of utilizing online/mobile resources for teaching purposes is important since, for example, appropriate use of online learning applications by tutors (for teaching, assessment, etc.) can stimulate students' learning [33].

In Greece, there is limited empirical evidence on the topic. Greek university students expressed acceptance of mobile phone usage in their studies [34] and behavioral intention to use their mobile devices for accessing eLearning platforms for educational purposes post-pandemic [35]. A recent study shortly after the pandemic [13] revealed student self-perceived barriers when they utilize their mobile phones for educational purposes: internet connectivity, invalid or unreliable sources of information, small screen size, distractions from social media, multiple operating systems, and difficulty in writing reports/assignments. These are similar to the concerns raised in the aforementioned international studies [20, 22, 23, 30].

Exploring higher education students' mobile learning-technology views shortly after the pandemic is a timely research topic, internationally. Although research evidence is increasing, a gap appears in the literature. On the one hand, university students express acceptance and positive attitudes regarding mobile technology use for academic purposes, and on the other hand mobile technology barriers have been reported. Research reported some barriers (e.g., technological such as infrastructure, institutional, support, concerns about distraction) as perceived by university students when mobile learning-technology is applied for educational purposes. However, students' beliefs on mobile technology-learning barriers have not been widely examined after the pandemic, and research should continue to explore their perceptions. Mobile learning is prevailing in higher educational settings due to advances in digital technologies and it is expected to play a basic role in the digitalization of higher education [13, 15, 21]. Since this topic is of international interest (there is relatively small number of research studies) and still underexplored in Greece, this investigation was conducted.

2 Methodology

2.1 Aim of the study

The aim and purpose of this study is to identify and investigate Greek undergraduate students' perceived mobile technology-learning barriers in their academic studies. The specific research questions are: (1) What are university students' perceptions about barriers to mobile technology use for educational purposes? (2) What is the type of these perceived barriers (e.g., external, internal)?

2.2 Sample and procedure

The sample consisted of 212 undergraduate students studying various academic disciplines across state universities in Greece (Table 1 shows the sample characteristics). 108 students were male, 104 were female, and about half of the sample are at-tending their first year of studies (in most academic disciplines/subjects undergraduate degrees are typically four years long, for polytechnic degrees it is five years, and for medical degrees six years; however, some students do not complete their degree by the end of the typical period). The most frequently used mobile device for educational purposes is the smartphone (daily use was reported by 95.28% of the participants), followed by the laptop (daily use: 49.06%, several times per week: 33.02%). Data was collected via an online questionnaire, in April and May 2023. The relevant link was forwarded via official university platforms (e.g., e-class) and social media, by encouraging students from different faculties/universities across Greece to complete it. With regard to identity verification process, we followed an authentication process by requiring/allowing only one response from each email account. We took into account ethical issues according to the General Data Protection Regulation, and the students participated voluntarily. All students were informed about the questionnaire's anonymity and about the utilization of data for research purposes (privacy and confidentiality issues were ensured). Informed consent was obtained from all subjects involved in the study.

2.3 Research instrument and data analysis

The online questionnaire consisted of two sections. The first one aimed to collect data on the characteristics of the participants (gender, year and field of study, frequency of mobile devices' usage in their academic studies) and the second section involved 18 statements/items regarding student perceptions on mobile learning-technology barriers. Most of the questionnaire items were adapted from a recent study [17] which investigated teachers' views on mobile learning-technology barriers in school education, by also taking into account the relevant literature on university students' perceived

Table 1 Description of the sample (N = 212)

Category	Category	Frequency	Percentage (%)
Gender	Female	104	49.06
	Male	108	50.94
Year of study	1st	99	46.70
	2nd	41	19.34
	3rd	39	18.40
	4th	19	8.96
	> = 5th	14	6.60
Faculty (Field of study)	Engineering	88	41.51
	Natural Sciences	77	36.32
	Social Sciences	28	13.21
	Humanities	14	6.6
	Health Sciences	5	2.36
Frequency of smartphone use	Every day	202	95.28
	Several times a week	10	4.72
Frequency of tablet use	Every day	8	3.77
	Several times a week	14	6.60
	About once per week	12	5.66
	About once per month	29	13.68
	Never	149	70.28
Frequency of laptop use	Every day	104	49.06
	Several times a week	70	33.02
	About once per week	19	8.96
	About once per month	8	3.77
	Never	11	5.19

barriers. The rationale and procedure for the instrument content (selection of barriers) was to initially identify from the literature broad barrier groupings-categories; afterwards, we selected and used specific statements associated with these groupings in order to measure them; in this way, the barriers cover established key issues/concepts within the research field. Indicatively, the groups regard technological barriers (e.g., outdated operating system, obstacles with internet connection), barriers regarding support (e.g., technical, administrative, educational support), barriers related to student and tutor digital skills, knowledge, and confidence, as well as student concerns. The presentation of the items was in random order and the students were asked to provide their responses on a 4-point Likert-type scale (1: not a barrier, 2: minor barrier, 3: moderate barrier, 4: major barrier). The original questionnaire [17] had good reliability and construct validity, satisfactory internal consistency (Cronbach's a coefficient was from 0.82 to 0.88). In this study, the range for Cronbach's alpha coefficient is from 0.601 to 0.809 (mentioned in results). Google Forms was used for designing the questionnaire.

The scope of this study is to highlight the barriers presented/revealed during the implementation of mobile learning. For this reason, a questionnaire was used and the correlation between the answers given by the participants was sought, and no comparison was made between the results of the various statements. Therefore, no parametric contrast statistics were performed. With regard to data analysis, R programming language (version 4.2.2) and R Studio (version 2023.03.0 + 386) were used for managing-processing the data and conducting the statistical analyses.

3 Results

3.1 Descriptive measures for barriers

A descriptive analysis was applied for the exploration of undergraduate students' perceived mobile learning and technology barriers in their academic studies. Table 2 presents students' response percentage frequencies on the 18 items (N = 212 students); the Table is organized by ranking major barriers in descending order, i.e., according to the last column. Problems with (or lack of) internet connection, high cost of mobile devices and outdated operating system were

Table 2 Students' response percentage frequencies on the 18 items (N = 212 students)

	Not barrier	Minor barrier	Moderate barrier	Major barrier
S06. Lack of, or problems with internet connection (e.g., weak Wi-Fi signal)	2.83	14.15	25.94	57.08
S04. High cost of mobile devices	3.30	14.62	33.02	49.06
S01. Outdated operating system, unable to support new applications	12.74	17.45	23.58	46.23
S15. Negative teachers' attitudes (towards mobile learning)	8.49	25.00	27.83	38.68
S14. Insufficient teachers' knowledge about the possibilities of integrating mobile devices in the classroom	12.26	20.75	37.26	29.72
S07. Inadequate training opportunities to utilize mobile technology in academic studies	7.55	24.53	38.68	29.25
S18. Distraction when using mobile devices for educational purposes (e.g. social media)	3.77	25.47	41.51	29.25
S08. Lack of technical/ administrative support	9.43	23.58	40.57	26.42
S02. Limited storage space or battery life	8.96	20.28	48.11	22.64
S09. Lack of educational support regarding ways to integrate mobile technology into the curriculum	12.74	30.66	33.96	22.64
S16. Concerns about privacy and security	14.62	29.72	35.38	20.28
S17. Concerns about student inappropriate behavior when using mobile devices	16.98	27.83	35.38	19.81
S05. Lack of good educational apps for mobile devices	8.96	23.11	49.53	18.40
S10. Unclear legislation/regulation for mobile devices' use in university classrooms	19.81	39.62	23.58	16.98
S11. Lack of students' technology skills	29.25	35.38	23.11	12.26
S13. Negative students' attitudes (towards mobile learning)	31.13	36.79	19.81	12.26
S03. Insufficient/small screen size of mobile devices	17.92	50.00	20.75	11.32
S12. Lack of student confidence in using mobile technology	35.85	32.55	20.28	11.32

perceived as major barriers; by 57.08% of participants for item S06, by 49.06% for S04, and by 46.23% for S01. Immediately after these technological barriers, students perceive as major barriers those associated with tutors' negative attitudes and insufficient knowledge regarding mobile technology-learning integration in university classrooms; about one third of the sample expressed such perceptions; 38.68% and 29.72% of the sample, for the items S15 and S14, respectively. Examples of other (major and moderate) barriers as expressed by several students, regard limited training opportunities to use mobile technology in the classroom, and student concerns about distraction. Students perceive as moderate barriers the lack of good educational apps for mobile devices (49.53% of participants for S05), and limited storage space (48.11% of participants for S02) (these are both technology related barriers), followed by concerns about distraction (S18), and lack of technical or administrative support (S08). In parallel, students' digital technology skills (item S11), negative attitudes towards mobile technology use and confidence in using mobile technology (items S13 and S12) were perceived as major barriers by a small percentage of students (about 12%), and as moderate barriers by about one fifth of the sample; this finding is associated with student training and is discussed in implications.

3.2 Factorial structure of the questionnaire

In order to investigate the factorial validity of the questionnaire, an exploratory factor analysis was applied, and three factors were revealed. Factor number one (F1), labelled "Student skills, confidence, attitudes, and concerns", was associated with seven items/statements: S12, S11, S13, S17, S10, S16, S18. Factor number two (F2), labelled "Lack of support/apps and tutor knowledge, attitudes", was associated with seven items: S8, S9, S14, S5, S15, S7, S6. Factor number three (F3), named "Technological (barriers)", was associated with four items: S1, S2, S3, S4. Table 3 indicates the loadings, mean, and standard deviation per item, as well as Cronbach's alpha coefficient for each factor/dimension (F1 to F3). An acceptable internal consistency was shown for all factors: the range for Cronbach's alpha coefficient is from 0.601 to 0.809; typical threshold for acceptable value is considered 0.6 [36]. The structure of three groups/factors of barriers, as revealed by factor analysis, is characterized by discriminant validity; which means these obstacles are perceived by students as separate/distinct.

In order to test how well the measured variables, represent the number of factors, a Confirmatory Factor Analysis (CFA) was conducted. The results are shown in Table 4.

Table 3 Factor loadings, mean, and standard deviation per item (18 items)

Statements	F1	F2	F3	Mean	SD
S12	0.78			2.071	1.007
S11	0.70			2.184	0.992
S13	0.69			2.132	0.994
S17	0.52			2.580	0.992
S10	0.45			2.377	0.988
S16	0.43			2.613	0.969
S18	0.38			2.962	0.837
S08		0.72		2.840	0.925
S09		0.61		2.665	0.967
S14		0.57		2.844	0.988
S05		0.52		2.774	0.852
S15		0.42		2.967	0.990
S07		0.39		2.896	0.913
S06		0.30		3.373	0.831
S01			0.64	3.033	1.073
S02			0.61	2.844	0.876
S03			0.42	2.255	0.882
S04			0.34	3.278	0.833
Cronbach's alpha	0.809	0.761	0.601		

All responses ranged from 1 (not a barrier) to 4 (major barrier). Factor 1 (F1): "Student skills, confidence, attitudes, and concerns", Factor 2 (F2): "Lack of support/apps and tutor knowledge, attitudes", Factor 3 (F3): "Technological (barriers)"

Table 4 Results of Confirmatory Factor Analysis

Parameter	Value
Chi-square (P-value)	535.88 ($p < 0.001$)
Comparative Fit Index (CFI)	0.935
Tucker-Lewis Index (TLI)	0.865
Root Mean Square Error of Approximation (RMSEA)	0.063
Standardized Root Mean Square Residual (SRMR)	0.047

Table 5 Pearson correlations among factors

	Student skills, confidence, attitudes, and concerns (F1)	Lack of support/apps and tutor knowledge, attitudes (F2)
Lack of support/apps and tutor knowledge, attitudes (F2)	0.5238**	–
Technological (barriers) (F3)	0.3711**	0.3475**

** Correlation is significant at the 0.01 level (2-tailed)

In some approaches the CFI cut off score is considered to be 0.9, while in others 0.95. In this study the value is 0.935 which is considered a good fit index. Regarding the RMSEA, the value is 0.063, which a little above the cut off score of 0.05, while SRMR is under this score. Values of CFI and TLI close to 0.95 and RMSEA under 0.08 imply an acceptable fit [37, 38]. Moreover, all of the estimate coefficients loadings are significant and all are positive. Final, all variances have a positive sign. Overall, it is considered that the factor model fits the data derived from the questionnaire.

The three-factor distribution did not indicate serious decline from normal distribution, neither extreme values for factor scores were observed. Therefore, Pearson correlations were used. Moderately and highly positive correlations were detected among the factors (Table 5). "Moderate degree" of correlation [39] was identified between "Student skills, confidence, attitudes, and concerns" (F1) and "Technological (barriers)" (F3) ($r = 0.3711$, $p < 0.01$), as well as between "Lack of support/apps and tutor knowledge, attitudes" (F2) and F3 ($r = 0.3475$, $p < 0.01$). "High degree" of correlation [39] was identified between "Student skills, confidence, attitudes, and concerns" (F1) and "Lack of support/apps and tutor knowledge, attitudes" (F2) ($r = 0.5238$, $p < 0.01$).

4 Discussion—implications

This study identified the barriers to the use of mobile technology-learning in academic studies, as perceived by undergraduate students. Different barriers may prevent students from utilizing mobile devices for learning purposes/activities, even though they have positive views of mobile learning. Additionally, mobile learning is an underexplored topic in Greece. The present research provides an added value to an increasing number of international research studies, and the findings are expected to be of interest to researchers, educators and educational policy makers, in the post-pandemic era.

Student perceived mobile technology-learning barriers include both external and internal barriers. The strongest agreement for major barriers regards external-technological (internet connectivity issues, high cost of mobile devices, outdated operating systems) and internal tutor-related barriers (tutors' negative attitudes and insufficient knowledge for mobile technology-learning integration). Major barriers, were initially technological barriers regarding problems with internet connection (item S06, $M = 3.373$), high cost of mobile devices (item S04, $M = 3.278$), and outdated operating system (item S01, $M = 3.033$); these were perceived as major barriers by around half of the sample. In parallel, about half of the sample perceive as moderate barriers the lack of good educational apps for mobile devices and the limited storage space (or battery life) of some devices. These findings are in agreement with recent research which reported on student perceived technological barriers: unstable internet, device design, hardware/software usability, operating systems' compatibility, as well as inappropriate content for use on mobile devices [13, 14, 22, 30]. Following the technological barriers, our findings also revealed major perceived barriers regarding tutors' negative attitudes (S15, $M = 2.967$), and tutors' insufficient knowledge for mobile technology-learning integration (item S14, $M = 2.844$); such perspectives are expressed by about one third of the sample. This finding is in agreement with a recent study [28] which identified as student perceived challenges their tutors' attitudinal and technical limitations. Earlier research [40] indicated that

teachers' limited technological/pedagogical knowledge of mobile applications may be a hindering factor in applying mobile learning in higher education contexts. Regarding university tutors' digital skills, research indicated that higher education institutions tend to give consideration to technical issues, and not pedagogical support [41]. Teachers' knowledge, confidence and skills are likely to affect the implementation of mobile pedagogies in university courses, thus it has implications for educators' training and support.

Other perceived important barriers were associated with student concerns about distraction when using mobile devices for educational purposes (item S18, M = 2.962), and inadequate training opportunities to use mobile technology in their studies (item S07, M = 2.896). In line with earlier research studies [13, 23, 27, 30] student concerns about distraction in mobile learning environments constitute a barrier. In parallel, the lowest agreement for barriers was detected for individual student-related barriers. It was indicated that lack of student confidence in mobile technology use (item S12, M = 2.071), negative student attitudes for mobile learning (item S13, M = 2.132) and lack of students' digital technology skills (item S11, M = 2.184) constitute minor (or not at all) barriers. This means that today's undergraduate students perceive themselves as confident and willing to use mobile technology in their studies. It seems that student related barriers are diminishing throughout the years, and it can be attributed to that students increasingly utilize their mobile devices for educational-academic purposes.

4.1 Implications

Mobile learning in higher education has an increasingly essential role [42] and, in particular, after the pandemic [4, 13]. Identifying and understanding which barriers are perceived by students, may facilitate in how to tackle them. The findings of this study have implications for students, university educators, and university policy makers. Student training is expected to facilitate them in the proper use of mobile devices in university classrooms and, in particular, of their smartphones. For example, a study in Canada [43] indicated that students apply different strategies to eliminate the dangers of smartphone use; e.g., installing apps that manage time on various platforms, and turning off notifications. Organized workshops or seminars are suggested to provide training in accessing electronic databases. Appropriate student training may assist in some barriers to be overcome (e.g., student concerns about distraction). Organizing awareness sessions with stakeholders/specialists and students may also be helpful in order to strengthen student confidence on mobile device use for educational purposes.

University tutors and university stakeholders (e.g., policy makers) need to be aware of students' major perceived mobile technology-learning barriers. Higher education tutors could design appropriate teaching interventions that include mobile devices as learning and supportive tools; the educational and pedagogical potential of mobile devices' usage arises under conditions; one of them regards educators' practices. Mobile pedagogies for innovative teaching–learning incorporate the affordances of mobile devices to enhance learning [44]. Appropriate mobile-mediated educational activities, utilization of mobile technology features, as well as organization and management of the mobile learning environment are likely to affect student perspectives and performance. Educators' professional development (training) may aid towards the improvement of their knowledge, skills and confidence, as well as of positive perceptions towards the integration of mobile technology in their courses. For example, research suggested professional development programs for faculty members to develop teachers' technological, pedagogical knowledge for integrating digital technology in the pedagogical practices [45]. Tutors' skills and confidence affect their mobile pedagogical practices (within the context of both in-person and online/blended education modes), as well as students' experiences.

University policy and practice should support students in order the mobile technology-learning barriers to be eliminated (e.g., by investing in appropriate re-sources and infrastructure). Cooperation among stakeholders (educational policy makers, educators, administration personnel) is needed in order to assist mobile technology utilization for academic purposes. We suggest provision of technical, educational and administrative support, and of clear policy/guidelines on personal data protection and security issues. For example, educational support may aid on how to integrate mobile-mediated learning in university context, thus eliminating barriers. Universities could also plan for the adoption of hybrid approaches of education that utilize mobile learning. Blended learning emerges as a 'new' and popular post-pandemic trend in higher education, and mobile technology has the potential to facilitate blended learning approaches to increase students' autonomy [46]. Additionally, the design of appropriate mobile technology/phone applications could target different academic subjects; mobile applications are a potentially valuable resource influencing educational interactions [47]. Also, the design of flexible, digital platforms that are accessible via mobile devices/phones may facilitate student mobile practices.

5 Conclusion

Mobile technology usage and integration in higher education is linked to both advantages (mobility, flexibility, autonomy, etc.) and challenges. The current study explored undergraduate students' perceived mobile technology-learning barriers in their academic studies, and the findings supplement prior research on students' perceptions. Major perceived barriers regard external-technological (internet connectivity issues, high cost of mobile devices, outdated operating systems) and internal tutor-related barriers (tutors' negative attitudes and insufficient knowledge for mobile technology-learning integration). Other obstacles are associated with student concerns about distraction, and inadequate training opportunities to use mobile technology in their studies. It was shown that internal student-related obstacles such as confidence, attitudes and digital skills regarding mobile technology adoption/use, are perceived as minor barriers (or not at all barriers). This exploration is important because when students associate mobile learning with barriers, it is less likely to implement it in their academic activities and, consequently, it may prevent mobile-mediated learning adoption in higher education institutions. Since research on mobile learning/technology in higher education constitutes an ongoing research topic, this study's findings contribute to the rising body of relevant evidence, in the post-pandemic era. The findings have implications for students, university tutors and university stakeholders.

6 Limitations and future prospects

Main limitations of this study regard the sample and the use of a quantitative inquiry only. The sample derives from one country, and it is not representative enough to make the findings generalizable. Students' views could be further investigated with larger and more diverse samples. The Cronbach-a value for factor 3 (F3) was lower in comparison to the values of the other two factors (F1 and F2). We suggest for the questionnaire to be expanded with other items in order to strengthen the reliability of the questionnaire, and increase the Cronbach-a values. Since there is not a single accepted classification for grouping different barriers [17], it is considered useful to add new items (e.g., items related to university mobile resources/infrastructure) and explore possible redistribution in grouping; e.g., across similar and different contexts such as undergraduate and postgraduate levels. Also, the administration of a quantitative instrument is suggested to be combined with interviews. Responses to interview questions will allow students to express their thoughts and may indicate, for example, how perceived barriers change over time.

We suggest that future research explores student perceived mobile learning barriers in relation to their academic discipline. The rapid adoption of affordable personal mobile devices (e.g., smartphones) should be exploited for access to quality educational material. Flexible modes/formats of teaching–learning such as blended learning are suggested; e.g., investment in mobile technology may lead to a more flexible educational system. During the recent pandemic, mobile learning enabled learners to continue their education from any location, while students and tutors communicated via mobile technology [13, 18]. Mobile technology has the potential to support the educational process post-pandemic (e.g., to support educational goals in different academic disciplines). As mobile devices' usage facilitates university students' self-regulation learning [48], we suggest mobile technology-supported learning within online or blended learning contexts. Future research could also compare, within the same institution, students' and tutors' perceived barriers to mobile technology adoption; for example, barriers such as institutional support have also been reported by university lecturers [49]. Mobile devices are now essential components of undergraduate students' everyday life, and each new generation of devices incorporates more advanced features/capabilities [50]; for example, enhanced features and tools that facilitate collaboration or editing. As a result, exploring students' perceived mobile learning-technology barriers (and enablers) for their academic studies is an open research field.

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Declarations

Competing interests The authors declare no competing interests.

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