The Multiple Apps and Devices of Swiss Freshmen University Students

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ABSTRACT
Over the past decade mobile learning has dramatically changed with the widespread acceptance and ownership of smartphones. Given the speed of these changes and the lack of data, the scale of the mobile devices' impact on educational institutions is hard to estimate. As topics such as multimodal learning appear in the scientific discourse, universities continue to struggle in understanding the changing digital landscape of digital natives. Different to previous research and market studies, this paper focuses not only on smartphone ownership, but includes the parallel use of different devices. The analysis grounds on surveying five consecutive cohorts in the same study program of a Swiss university. The paper provides an overview on surveying five consecutive cohorts in the same study program of a Swiss university. The paper provides an overview on the changing device ecologies as new technologies reach the mass markets. The observations show the broad role of digital technologies for students and that the parallel use of several devices is not science fiction for many of them: A majority of students reported to own and use several mobile devices at the same time. However, over the years we can observe subtle changes in this device ecology as new device types enter the mass market and become affordable to students. Although the scope of this study is limited and one cannot generalise the findings to other study programs or institutions, the findings provide valuable insights for further research on leveraging bring-your-own-device strategies in higher education.

Author Keywords
Mobile learning, device ecologies, multimodal computing, bring your own device (BYOD), long-term observation, student perspective, organisational strategy

INTRODUCTION
The development of consumer technologies has transformed the relation to information of entire societies. Smart phones play an important role in these developments, but the mobile revolution is not limited to them. Besides conventional PCs, other technologies, such as tablets, smart watches, smart TVs, augmented reality glasses, or fitness trackers, also have become convenience products for many citizens industrialised countries. As a whole these technologies create an environment, in which users interact with data and information. These developments seem to be unnoticed within educational systems, as many discussions still focus on the usefulness or dangers of individual technologies for student performance and supportive technologies follow largely the one to one interaction paradigm. This is particularly the case in higher education, in which many institutions struggle with the core digital transformation from analogue campus teaching to online blended learning. We found that equal access to information technologies of students is among the key concerns of lecturers and management. Yet, little data is presently available that can inform researchers and faculty in higher education institutions about the students' digital habitat. This lack of understanding becomes increasingly problematic as consumer-available technologies allows for technological enriched and continuous experiences across environments and devices (Glahn & Specht, 2010). This broader perspective of mobile learning in terms of multimodal learning paves the way for new complex learning experiences (Moreno, & Mayer, 2007; Schneider, Börner, van Rosmalen, & Specht; 2017; Di Mitri, Schneider, Specht, & Drachsler, 2018). This paper addresses the gap in research on understanding how these new experiences connect meaningfully to the learners’ technological practices and settings. Such understanding is particularly important for educational institutions as many rely on Bring Your Own Device (BYOD) strategies for including technological advancements of consumer electronics into their educational practices. Also the design of multimodal mobile learning solutions depends on such understanding in order to survive the diversity of the educational practice. Therefore, we need qualitative and quantitative data for understanding the conditions for investments of new educational infrastructures in higher education.

BACKGROUND
The present study is grounded on a previous survey in the context of professionalisation in the Swiss security and defence context (Glahn, 2012). The related research introduced the idea of multimodality through interactions on multiple devices. Therefore, the survey included a number of mobile digital devices that were commercially available at the time. The results of the survey indicated an almost complete adoption of smart phones among more than 500 participants in basic and further training of the Swiss military service. Moreover, the findings showed that a large proportion of the participants are frequently using different mobile technologies. In the meantime, very few studies were published with focus on mobile device adoption among students in higher education. These studies are outlined in the following paragraphs.
As a result of a literature review on the use of mobile devices in higher education, Crompton and Burke (2018) identify a gap between the portability of mobile devices and the how mobile devices impact learning experiences in higher education settings. Part of this gap appears to be related to the apparent lack of notion for the students’ digital habitat and their use of mobile devices as means for digital delivery of non-mobile educational practices. A 2014 study found that mobile devices are an important part of US undergraduate students’ digital ecosystem with adoption rates for laptops at 90%, smartphones at 86%, and tablets at 47%, but many institutions discourage and even ban particular smart technologies such as smartphones and tablets for educational purposes (Dahlstrom & Bichsel, 2014).

Ally & Wark (2018) recently reported in their study on the use of mobile devices among distance learners at a Canadian distance learning university. The study focussed on the use of mobile devices for learning, but included elements regarding the digital habitat of the students. The majority of the target audience of that study was 34 and 45 years old. The key findings indicated that 75% own at least one mobile device and out of those only three quarters use the mobile device frequently. These devices are used in wide range of contexts, for which the authors identified diverging usage frequencies. The authors’ findings suggest a more complex digital habitat, but their analysis focused on single device learning experiences and considered all mobile devices equally. One of the key findings of the study indicates that a key barrier for using mobile devices for learning is the devices’ screen size.

QUESTION FOR RESEARCH
Most of the prior research addresses mobile technologies as single device interactions. However, several studies also indicate that today’s students perform in a device ecology, in which multiple devices are simultaneously available to the students. Very few studies recognise this technological diversity. In addition to the device ecology, we differentiate the digital habitat of learners. This concept focuses on how the device owners embody the device ecology through different practices.

In order to develop mobile learning strategies in higher education it is important to understand both, the students’ device ecology and their digital habitat. This becomes increasingly important as the technological advances shift from single device interactions to multimodal and multi-device experiences. We find a lack of supportive research that helps to understand the students’ technological realities. This makes it very hard to make informed decisions regarding mobile learning and even multimodal learning experiences in higher education. From the present body of research, we also find in different countries widely varying values for similar attributes and factors. This situation demands also more targeted research and more continuous monitoring on the national as well as on the organisational level regarding the question: What comprises the digital habitat of contemporary students?

This question refers to a continuous development among the students’ digital habitat and lifestyle, because different types of consumer-available mobile technologies and services are rapidly developing. Educational providers need to monitor these developments in order to adjust educational approaches as well as infrastructure strategies.

METHOD
The presented data has been collected by five questionnaire surveys between 2014 and 2018 as part of evaluating a tool for mobile learning support in an introductory course in communication science at the University of Zurich in Switzerland (Glahn & Gruber, 2018; 2019 in press). The course is part of the first semester’s curriculum and typically reaches all students who are enrolled into the communication sciences study program. In total 1745 students were enrolled into the cohorts, combined. The majority of students is between 19 and 24 years old and predominantly female.
(3:1 over male students). The repetition rate for the course is below 2.5%. No student was enrolled in the analysed course more than twice. The survey was timed after the course’s final exam. The course participants used a mobile app for learning during that course. This timing led to a reduced participation, but was chosen to be aligned to the official course evaluation. This alignment ensured representative data for each cohort and avoids skewed data from perceived influence on the examination. All data was anonymised. Therefore, it was impossible to detect whether repeating students contributed twice to the survey.

The present study analyses 17 survey items that address device ownership, apps usage, and contextual usages. 3 items target device ownership focused only on the students’ mobile devices, out of which 2 focus on the students’ primary smart phone in order to determine the devices’ brands and the operating systems. The third item asked for additional mobile devices that the students frequently use. The students could indicate the ownership of multiple devices, but did not require to provide data on the usage frequency of their devices. These device categories are: “laptop”, “iPad”, “Windows tablet”, “Android tablet”, “media player”, “smart watch”, “camera”, and “eBook-Reader”. While this is a limitation for the present study, this decision is related to the overall context of the survey (Glahn & Gruber, 2018; 2019 in press).

The students were asked to indicate their perceived mobile phone use in five settings: “Home”, “university”, “work”, “commuting”, and “leisure time/with friends”. For each settings the usage frequency followed the following scale: “Never” (1), “Rarely (less than once a month)” (2), “Monthly” (3), “Weekly” (4), “Daily” (5). This provides insights into the students’ technology-related activities based on the mean and the standard deviation of the related Likert scales it is possible to deduce the level of relevance and agreement for each app-category: the mean indicates how frequently an application category is used, where 5 refers to daily use (high frequency) and 1 to no usage (no frequency). A standard deviation below 1 indicates agreement within a cohort towards the adjacent frequency levels, while a standard deviation above 1 indicates greater disagreement within a cohort. Disagreement indicates that students use an app category more variably and common usage patterns are rare.

The items that focus on the app usage addressed 11 application categories. Instead of asking for specific products, the survey focusses on categories to account for the students’ changing preferences within each category. The categories were broadly chosen based on categories of major app stores and include: “telephony”, “texting”, “e-mail”, “social networking”, “news and information”, “productivity”, “photo (consuming)”, “audio and video (consuming)”, “camera”, “navigation and public transport”, and “games”. The usage frequency for each category is the same as in the device usage items.

**RESULTS**

The 332 student responses to the survey represent 19% of all 1745 students. The participation ranged between 12.2% (2014) and 27.1% (2015). Table 1 shows the cohort size, participation, and response rate for each year. The surveys indicate a 100% smartphone adoption among the participants and show daily usage of mobile apps in various contexts. The data indicate that the students use these devices irrespective of the context. (Glahn & Gruber, 2019)

The smartphone is apparently central to the students’ life, because all participants agree to the daily use of their smart phone in all settings. This result is consistent across cohorts and suggests that smart phones are used in all contexts.

<table>
<thead>
<tr>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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</thead>
<tbody>
<tr>
<td>Cohort Size</td>
<td>410</td>
<td>343</td>
<td>323</td>
<td>342</td>
</tr>
<tr>
<td>Participants</td>
<td>50</td>
<td>93</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>Response rate</td>
<td>12.2%</td>
<td>27.1%</td>
<td>18.6%</td>
<td>17.3%</td>
</tr>
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Table 1. Cohort size and participation.

<table>
<thead>
<tr>
<th>2014</th>
<th>2015</th>
<th>2016</th>
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<th>2018</th>
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</thead>
<tbody>
<tr>
<td>iOS and iPhone</td>
<td>72</td>
<td>76.3</td>
<td>68.3</td>
<td>69.5</td>
</tr>
<tr>
<td>Android (combined)</td>
<td>26</td>
<td>23.7</td>
<td>31.7</td>
<td>28.8</td>
</tr>
<tr>
<td>Samsung</td>
<td>12</td>
<td>14</td>
<td>20</td>
<td>13.6</td>
</tr>
<tr>
<td>HTC</td>
<td>6</td>
<td>2.2</td>
<td>3.3</td>
<td>6.8</td>
</tr>
<tr>
<td>LG</td>
<td>2</td>
<td>0</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Sony</td>
<td>4</td>
<td>2.2</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>5.6</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Windows and Nokia</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>unknown</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

Table 2. Relative smartphone ownership and mobile OS distribution in percent (%), differences due to rounding.
Smart phone brands and operating systems
When asked about their device brands, the majority respond to own an iPhone. The follow-up brand among the students is Samsung as the market leader for Android phones. However, the Android market gets increasingly fragmented, as the rising number of “other” brands. Previously popular smartphone brands, such as Nokia, Sony, and Blackberry are no longer used by the respondents. The detailed development of smart phone ownership is outlined in table 2.

Multi-device ownership
Besides the smart phones, the students report to own additional mobile and portable devices. Almost all students own a laptop. Those who don’t have a laptop tend to have either an iPad or a Windows tablet as a replacement. Only four participants across all cohorts reported not to own a mobile “big-screen” device in combination with their mobile. Regarding the wider digital habitat, we analysed the size of the student’s mobile device ecosystem. The first indicator for the mobile device eco system are the number of mobile devices students possess and use. The data shows that a large proportion of the responses indicate 3 or more devices (Figure 1). While the device ownership for multiple devices was very high in the first sample, it dropped in three following years. This trend to fewer devices inverted only in the last sample, when again the more than half of the students reported to possess 3 or more devices (Figure 1).

![Figure 1. Number of personal devices per cohort](image)

The reason for multiple device ownership appears to be influenced by changes in consumer products. The second indicator for device ownership is related to the different device classes. Each device class stands for functional and interaction requirements. When comparing the ownership reports for the different devices, the data indicates three main trends. These trends are depicted in Figure 2.

The first trend shows that Apple’s iPad became increasingly unpopular among newly enrolled students until 2017. This was not related to an increased uptake of similar products of other vendors as the popularity of Android tablets was also dropping, and the relative increase of Windows tablets in 2015 and 2016 did not compensate for the other vendors, and has been followed by a drop to a level of reported ownership below Android devices (Figure 2). In 2018, Apple’s iPad was again popular among the students, while devices of the other tablet vendors were reported only by a few participants. The second trend that influenced multi-device ownership is related to reduced adoption of media players. The data shows that students owned media players less often with every cohort. As media players were the third most often owned device among the students in 2014, since 2016 these devices are hardly found among students.

The third trend of device ownership is related to smart watches and fitness trackers. Smart watches became only available relatively recently. In the first cohort of 2014, no student reported to possess such devices. While between 2015 and 2017 only single students reported ownership, these devices were the third most popular device class among the students in 2018. This development compensates for the decline of the media players.

Among the studied devices, cameras and e-book readers remain relatively constant. This suggests that for the time being, these devices offer unique functions to the students in the investigated cohorts.
Besides the device ecology of the students we analysed the students use of mobile apps and services along the application categories listed in the method section. All app categories are used by the different cohorts within the respective standard deviation (Table 3). This indicates that the relevance of the categories changed little between the cohorts.

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<tbody>
<tr>
<td>Audio and video</td>
<td>4.0</td>
<td>4.3</td>
<td>4.3</td>
<td>4.4</td>
<td>4.4</td>
<td>7</td>
</tr>
<tr>
<td>Camera</td>
<td>4.3</td>
<td>4.5</td>
<td>4.4</td>
<td>4.3</td>
<td>4.3</td>
<td>8</td>
</tr>
<tr>
<td>E-mail</td>
<td>4.3</td>
<td>4.4</td>
<td>4.5</td>
<td>4.1</td>
<td>4.3</td>
<td>6</td>
</tr>
<tr>
<td>Games</td>
<td>2.9</td>
<td>2.6</td>
<td>2.5</td>
<td>2.3</td>
<td>2.4</td>
<td>11</td>
</tr>
<tr>
<td>Navigation and public transport</td>
<td>4.3</td>
<td>4.3</td>
<td>4.4</td>
<td>4.3</td>
<td>4.3</td>
<td>9</td>
</tr>
<tr>
<td>News and information</td>
<td>4.6</td>
<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td>4.5</td>
<td>3</td>
</tr>
<tr>
<td>Photo</td>
<td>4.2</td>
<td>4.5</td>
<td>4.6</td>
<td>4.6</td>
<td>4.5</td>
<td>4</td>
</tr>
<tr>
<td>Productivity</td>
<td>4.7</td>
<td>4.7</td>
<td>4.8</td>
<td>4.7</td>
<td>4.7</td>
<td>2</td>
</tr>
<tr>
<td>Social networking</td>
<td>4.4</td>
<td>4.2</td>
<td>4.5</td>
<td>4.4</td>
<td>4.3</td>
<td>5</td>
</tr>
<tr>
<td>Telephony</td>
<td>4.2</td>
<td>4.0</td>
<td>4.0</td>
<td>3.8</td>
<td>4.1</td>
<td>10</td>
</tr>
<tr>
<td>Texting</td>
<td>4.9</td>
<td>5.0</td>
<td>5.0</td>
<td>4.9</td>
<td>5.0</td>
<td>1</td>
</tr>
</tbody>
</table>

The responses indicate that the participants primarily use texting and productivity features, including search. Both functions have high means and narrow standard deviations. Most of the respondents indicated daily use. This relevance is shared across the cohorts.

The two lowest ranking categories are telephony and gaming. Most respondents state that the use the telephony features of their phone about weekly, as both the mean and a standard deviation below 1 indicates. We found it particularly...
interesting that most participants report casual or no gaming on their smart phone. The high standard deviation suggests no common mobile gaming behaviour within the cohorts, while the low mean indicates only casual gaming. Within the investigated group of students, hard-core gamers are the exception. The findings are depicted in Figure 3.

**Figure 3. Mean usage frequency by application class per cohort**

DISCUSSION

The results show that freshmen students are heavy equipped with mobile technologies. The full adoption of smartphones for five years reflects the high market penetration of smartphones and broadband connectivity in Switzerland (ITU, 2019). This level of device adoption has implications for Bring Your Own Device strategies in lesson planning and learning support. Different to other device categories, it can be assumed that the students now only own an appropriate device, but also have it within reach most of the time.

Our data replicates the market consolidation for smartphone operating systems in the specific higher education setting. This development further reduced barriers for access to learning through these devices, because only two remaining smartphone operating systems were observed over the past four years. This makes it easier for educational providers to choose apps for learning support or to build tailored solutions.

Smartphones are a commodity for the participating students that connects them to information services and their peers in any context. These ubiquitous devices are essential for the students’ productivity and social connections on a day to day base. The app usage data indicates that within the studied cohorts the smartphone is a communication and information hub. However, conventional communication forms are atypical for young students. This is particularly the case for telephony and e-mail services, which have been largely replaced by texting services for immediate asynchronous communication.

The evidence for a device ecology

Our key findings from this study goes beyond smartphones and is related to other mobile devices. In combination with smartphones these devices create a digital ecosystem that shapes the student’s learning experiences. Our data shows that almost all students report a combined use of at least a “small screen” and a “big screen” device. Although the vast majority of the respondents uses conventional laptops, some students replace these devices with more recent tablet computers running either Android or iOS.

The digital ecosystem of about a half of the students in a cohort includes more than two devices. However, we observed large differences between the cohorts. The reason for these differences appears to be rooted in product innovations. For example, the increased uptake of iPads in the 2018 cohort takes place in the same year as the wider support for Apple’s pen-interface “Pencil” for lower-tier iPads. This innovation allows students to use the device for a wider range of tasks, such as handwritten notetaking, sketching or drawing. Similarly, the decline of media players seems to be connected to
increased storage on smartphones as well as the uptake of streaming services on smartphones over the past 5 years. With this respect function that were separated between two devices seems to have converged into one device. A new development are smartwatches. These devices gained increasing popularity in Switzerland with the introduction of the Apple Watch. After 3 years of marginal relevance, the 2018 cohort showed increased uptake of this device class. This seems to be supported by the relation between smartwatch ownership to the students’ smartphone operating system, because smartwatches are often tightly integrated with a primary smart phone (Table 4).

<table>
<thead>
<tr>
<th>2014</th>
<th>2015</th>
<th>2016</th>
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<th>2018</th>
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</thead>
<tbody>
<tr>
<td>Android</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>iOS</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
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</table>

Table 4. Absolute smartwatch ownership in relation to the users’ smartphone OS by cohort

It appears that the ownership of smartwatches is tied to specific smartphone products. This is justified by similar separation between iPads and Android tablets (Table 5) across cohorts. Other technologies are not vendor specific, such as e-book reading devices and digital cameras. For these devices the relation to smartphone ownership is not visible within cohorts. The findings suggest that vendors are not only proclaiming to build an integrated device ecology for their customers, but also succeed at the level of the observed student cohorts. This has implications for designing multi-modal experiences that leverage on the students’ devices. Therefore, it is important to observe the developments related to vendor-specific integrated device ecosystems.

**Smartphone specific functions**

Contrary to the dynamic changes of the students’ device ecology, our findings indicate that the smartphone specific functions remained relatively stable across the cohorts – at least for the students’ smartphone usage. The interesting finding is the low relevance of games on the smartphone for this particular audience. This indicates that gaming is not equally relevant for all audiences, which has implications for mobile educational designs that rely on gamification and playful learning.

The observations show a slight relative increase of the relevance of audio-visual media on smartphones as well as a decrease in mobile gaming. When comparing the developments for these app classes across the cohorts via ANOVA, the p-value for videos is 0.0186, for photos is 0.0679, and for gaming is 0.0515. This suggests that these developments do not refer to significant changes in the smart phone usage because the respective p-values are greater than 0.01. However, greater confidence would be required given the sample size for each cohort and the type of scale. The ANOVA for all other app classes yielded p-values > 0.1, which indicates that all differences between the cohorts are due to random effects. These findings suggest that the smartphone use remained largely consistent across the cohorts in the study program.

**CONCLUSIONS**

Our study showed that the digital habitat of freshmen university students can be more complex than one might expect. It indicates a significant relevance of the ICT ecosystem for contemporary students, which has been largely ignored by present research on multi-modal learning experiences. Our long-term observations lead to two important conclusions. Firstly, Swiss students live in a dynamic mobile device ecosystem. Almost all students combine a smartphone with a big-display-device, which is in most cases a laptop but is sometimes replaced by a tablet computer. Our findings further indicate that a large proportion of the students in the cohorts uses more than two devices. Over the past five years this proportion varied, which appears to be the result of “convergence” of old digital technologies into smartphones or laptops, on the one hand, and new more integrated technologies such as smart watches or better pen-interfaces, on the other hand. With respect to more integrated technologies we observe first signs of vendor-centric demarcation lines between the students. This may pose challenges for creating multi-modal learning experiences on the grounds of BYOD strategies. This is similar to the situation of smartphone operating systems.

Secondly, our findings indicate that the usage frequency of major app categories on the students’ smartphones remains largely constant. Particularly, the games category was surprisingly unpopular among the participating students, and the first cohort responded very negatively towards gamification elements in learning settings (Gruber, Glahn & Tartakovsky, 2015). The constancy of the app usage frequency across cohorts indicates that the students attribute a given social and communicative practice with their smartphone. Because we identified and analysed these app categories only on smartphones, this raises the question whether this attribution can be also observed for other device classes such as tablet computers. Moreover, we suspect that such attribution might be specific to students of certain academic disciplines.

While our study is limited to the use of mobile devices in one study program, the findings clearly suggest more research on the full digital ecosystem in order to understand its full implications for educational design, service development, and learning experiences. This is necessary for scaling new concepts such as multi-modal learning into the educational practice of universities, as well as for advancing our understanding about the nature of mobile learning as a whole.
ACKNOWLEDGEMENTS
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REFERENCES


