Comparisons between three disciplines regarding device usage in a lecture theatre, academic performance and learning

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ABSTRACT
This investigation explored students’ learning behaviour from three different disciplines in relation to the student personal device usage in a lecture theatre environment and its impact on learning and academic performance. 163 Psychology, 253 Life Sciences and 83 Veterinary Science students participated in this study by completing a questionnaire. Differences between the three disciplines have been identified regarding the device usage, (non)/learning activities and multitasking in a lecture theatre. The findings of this investigation contradict previously published literature regarding the student academic performance and the use of their own devices in a lecture theatre, as there was no difference amongst the students from the same discipline. Student learning experience is linked to their individual learning characteristics which may be connected to course characteristics and teaching approach. This study raises questions about the students’ behaviour to bring their own devices in a lecture theatre and its implication on multitasking and teaching approaches.

Introduction

The ubiquity of smartphone devices has increased to 95% for 16–24 year olds, approximately 60% for tablet devices and 68% for laptops in the UK in 2018 (https://www.statista.com/). Students are allowed to bring their own devices to Universities for administrative, teaching and learning activities. There is a debate in the literature regarding student satisfaction and engagement in learning, linking the use of devices to low level of constructivist activities and/or distraction from the primary learning task (Marzouki, Idrissi, & Bennani, 2017). This might allow students to follow non-learning activities in class, such as instant messages and playing games, alongside the teaching process (Zhang, 2015).

This article discusses how the learning process in a lecture theatre environment may be influenced by students’ actions to bring and use their own personal devices during the lecture time. In order to study how learning is affected by their behaviour (e.g., actions on
how to use their own devices), the learning environment (e.g., interactions with their devices, material and distractions from others) and their individual characteristics (e.g., self-efficacy, background knowledge and surface strategy), a connection to academic performance and Social-Cognitive Theory has been explored. The dynamic relationship between behaviour, environment and individual characteristics has been discussed in Social-Cognitive Theory (SCT) explaining the process of ‘reciprocal determinism’ (Bandura, 1986). Social-Cognitive Theory may offer an explanation on how knowledge is constructed through the interactions between personal cognition (e.g., self-efficacy) and offline and/or online behaviours through the use of digital devices (e.g., sending/receiving messages with others inside or outside class and/or interacting with the online learning material) (Chiu, Hsu, & Wang, 2006). Additionally, Bandura (2001) has pointed out that students can learn by observing the actions of others; for example, students may imitate the actions of others depicted in a lecture theatre with their own digital devices (e.g., use their own devices to keep notes and/or check social media). However, students may increase the capacity of multitasking through their interaction with their own digital devices becoming distracted from their devices and/or from others’ actions in a lecture theatre. In order to provide an effective introduction to this complicate topic, an overview of multitasking process in learning has been provided and then a context for the Social-Cognitive Theory framework linking to the factors that may influence learning through the use of digital devices in a lecture theatre is followed.

**Multitasking process**

As students use their own devices (smartphone and/or laptop) in a lecture theatre, they may shift between two or more tasks (e.g., attend the lecture and check social media account); thus ‘attention to one task is disrupted by switching to another task’ (Parsons, 2017, p. 124). Specifically, students may follow a task switching process in which they are alternating attention and effort between tasks mainly using one single device or they accomplish multiple tasks concurrently using multiple devices (dual tasking process). University students often engage in media-based activities during lectures, such as searching the Internet, online chatting and instant texting (Yeykelis, Cummings, & Reeves, 2014). According to Tindell and Bohlander (2012) 91% of students texted during their classes and 62% of students believed that texting was acceptable as long as it did not disturb their peers.

Researchers have studied how young people engage with media and the role of multitasking in their learning process. Their work is mainly based on the limited capacity and motivated cognition theoretical framework which describes multitasking process in-class (students attempting to process auditory and visual learning material at the same time that they are processing information from their own devices). This framework assumes that each person has only a limited number of cognitive resources to complete the process of perceiving, encoding, understanding and remembering information. The limited capacity model is influenced by the environmental stimulus which activate two motivational (appetitive and aversive) systems and the cognitive process of encoding, storing and retrieving information which is influenced by attention and media exposure (Yeykelis et al., 2014). Based on this model, the amount of required perceived mental effort to accomplish a multitasking task increases cognitive load which has a negative
impact on learning. For example, by following the traditional way of teaching in a lecture theatre, students are processing information through listening and taking notes. Their cognitive effort to store information into their long-term memory is dependent on the topic complexity, lecture clarity and their familiarity with the learning tasks. When students bring their own device in a physical learning environment, their attention may be distracted by notifications and messages which may interrupt their primary task (i.e. to attend the lecture) and switch to another task (e.g., answer email, check social media). Other than generating distractions for themselves, students may interrupt other students’ learning process by using their own device in class through involuntary shifts in attention (Sana, Weston, & Cepeda, 2013).

The majority of the previous studies has advocated the negative effect of multitasking on student learning, particularly in relationship with student grades and self-efficacy (their individual belief that they have capability to perform behaviours that will produce a desired outcome) (Kates, Wu, & Coryn, 2018; May & Elder, 2018). However, other researchers pointed out the importance of multitasking process under the employability perspective, as potential employees may shift between tasks every three minutes (Coulter-Smith, 2018).

Zhang (2011) explored the needs of students to multitask with new media during their lecture time and categorised them into four major areas: instrumental needs, social needs, cognitive adjustment and habitual use. Students mainly stated that their intention for multitasking in the lecture time is to find information related to the course and to accomplish relevant tasks (Zhang & Zhang, 2012). Hamid, Waycott, Kurnia, and Chang (2015) suggested that social network integration into lectures increased perceived ability and students’ confidence in their abilities due to the interaction among themselves, with their lecturers, and with the content of the course. Additionally, Sung, Chang, and Liu (2015) advocated that the use of mobile devices in a lecture theatre can enhance the effects of certain pedagogies such as self-directed learning, collaboration, assessment and game-based learning. The non-learning activities during the lecture time (e.g., instant messaging, updating Facebook profile or reading social media news feed) had a significant negative impact on academic performance, whereas social media used for academic purposes did not have this effect (Demirbilek & Talan, 2018).

**Social-cognitive theory (SCT)**

In summary, students’ attention and working memory through multitasking process along with their self-efficacy are influenced by whether they bring their own device and how they use it in class. However, learning cannot be considered a purely individual activity, as it takes place in social learning environment in which social interactions and social roles should be considered (Jordan, Carlile, & Stack, 2008). By applying Social-Cognitive Theory (SCT) (Bandura, 1986, 1997) to a lecture theatre environment, learning may be described as a dynamic relationship between individual characteristics (e.g., self-factors), environment (e.g., influenced by their peers) and behaviour (e.g., actions to bring their own device in a lecture theatre and use it for learning activities) modelling learners’ behaviour through the observations of what happens to others within the context of social interactions, experiences and media influences. Thus, following SCT learning has a dynamic bond together in a process of ‘reciprocal determinism’ with individuals, their behaviours and
environment. For example, the interaction between learners and the environment involves beliefs and cognitive competencies developed and modified by social influence. The interaction between the environment and their behaviour determining their environment, which in turn, affects their behaviour. The interactions between learners and their behaviour are influenced by their thoughts and actions (Bandura, 1993). Therefore, the social and cognitive interactions which take place in a physical learning environment (lecture theatre) may influence students’ academic performance and their own learning process. Apart from student self-efficacy, other individual variables that may influence learning could be students’ previous knowledge background (e.g., University entry qualification) (Ferrão & Almeida, 2018), their perceptions about the importance of the course in relation to their future career (course utility) (Kirk-Kuwaye & Sano-Franchini, 2015), test anxiety (Zwettler et al., 2018), surface strategy (Rozgonjuk, Elhai, Ryan, & Scott, 2019), digital source diversity and negative study habits (e.g., poor time and planning management, procrastination) (Goda et al., 2015).

**Study aim**

The aim of this investigation was to explore students’ behaviours from three distinct disciplines (Psychology, Life Sciences and Veterinary Science) with respect to personal device usage in a lecture environment and the connections of such use to learning, multitasking and distraction following the SCT assumptions (dynamic and reciprocal interaction of learners’ individual characteristics, environment, and behaviour) (Appendix 1). Specifically, the objectives of this investigation are to determine whether there are any differences between the three disciplines in:

- the effects of the device usage, multitasking, distraction and participation in (non)/learning activities on student academic performance; and
- learning variables, such as self-efficacy, utility of course, test anxiety, surface strategy, negative study habits.

The rationale of this investigation is to expand on past findings by comparing student learning experience and behaviours in order to find out if multitasking through the device usage in a lecture theatre environment is more apparent in different disciplines and to then infer why. This links to the idea that environment and individual characteristics based on SCT may influence student behaviour through the use of their own personal device in a lecture theatre to support (non)/learning related activities.

**Methodology**

This investigation took place in three different disciplines (Psychology, Life Sciences and Veterinary Science), at a research-intensive University in the Northwest of England, during the 2018–2019 academic year. A total of 499 first year undergraduate students from the three different disciplines participated in this investigation. Table 1 provides information about the students per discipline (participants, gender and average grades). Typical to most UK undergraduate cohorts of relevant disciplines, the average age of the sample was 19 (±1.5) and the majority of the students who participated in this study were British (86%).
Data were simultaneously collected from all three disciplines via a 10-minute questionnaire which consisted of multiple answer questions, 7-point Likert scale statements and open-ended questions. Specifically, the questionnaire designed to explore the connections between behaviours, environments and individual learning characteristics when students bring their own device(s) to a lecture theatre (Appendix 2). The items related to activities with technology were inspired by Technology-Acceptance Model (TAM) (McGill & Klobas, 2009). The items related to test anxiety, course utility, self-efficacy, surface strategy, source diversity and negative study habits were inspired by Pintrich’s work (Pintrich, 1999). The questionnaire of this study is located at the ZENODO repository (http://www.zenodo.org/) under the community ‘PSYCH-TEL: Psychology-Technology Enhanced Learning and Teaching’ (https://zenodo.org/collection/user-psych-tel). Beyond the quantitative questions, participants had the opportunity to leave free text comments about their behaviour/attitudes towards bringing their own device to lectures.

There is a difference between the entry requirements across the disciplines (Appendix 3). Psychology and Life Sciences have similar curriculum structure based on research-teaching nexus, whilst Veterinary Science has an integrated spiral curriculum in which learning activities are linked to different disciplines and topics allowing students to apply their knowledge to different contexts. The final assessments for Veterinary Science students are conducted only once at the end of the year, while there are many formative opportunities for students to assess their knowledge during the academic year. However, the final types of assessments for all the disciplines are quite similar (multiple choice and short answer questions). The blended learning approach, which supports all the three curricula, uses online material outside the lecture theatre (e.g., lecture videos, recommended additional learning sources, online quizzes, discussions) and integrates different digital tools inside the lecture theatre (e.g., online voting platforms, game-based online platforms and collaborative tools). From all the three disciplines, only Psychology students were highly encouraged to bring their own devices in order to reduce paper-based administrative, teaching and research activities.

**Results**

By using ANOVA statistical analysis to compare the first year student academic performance across the three disciplines (Table 1), a significant difference was identified between them (F(2, 496) = 10.672, p < .000, η2 = .041). Simple main effects analysis showed that Psychology students had significantly lower grades than Life Sciences (p < 0.001) and Veterinary Science (p < 0.001) students, but there was no significant difference between Life Sciences and Veterinary Science students (p = 0.420).

The aim of the first part of the questionnaire was to study how students from different disciplines use their devices during lectures (Table 2). Device usage was more ubiquitous amongst Psychology students who tended to bring multiple devices to a lecture theatre.
Table 2. Students’ responses on questions related to their behaviour in a lecture theatre.

| Behavioural variable                        | Psychology (%) | Life Science (%) | Veterinary science (%) | Chi-square results ($\chi^2 = 499$) |
|--------------------------------------------|----------------|------------------|------------------------|-------------------------------------|
| The device(s) that students mostly bring into a lecture theatre. |                |                  |                        |                                    |
| No device                                  | 2.4%           | 7.5%             | 10.8%                  |                                    |
| Smartphone                                 | 31.9%          | 56.9%            | 53.0%                  |                                    |
| Laptop                                     | 25.2%          | 15.4%            | 18.1%                  |                                    |
| Both devices                               | 40.5%          | 20.2%            | 18.1%                  |                                    |
| The applications that students usually use during the lecture time. |                |                  |                        |                                    |
| Microsoft Word                            | 59.5%          | 33.6%            | 27.7%                  | $\chi^2(2, 499) = 34.854, p = .000$ |
| Microsoft PowerPoint                       | 72.4%          | 43.9%            | 44.6%                  | $\chi^2(2, 499) = 35.440, p = .000$ |
| VLE                                        | 60.1%          | 56.1%            | 61.4%                  | $\chi^2(2, 499) = .881, p = .644$  |
| Facebook                                   | 23.3%          | 9.9%             | 8.4%                   | $\chi^2(2, 499) = 17.412, p = .000$ |
| Twitter                                    | 12.3%          | 6.3%             | 0.0%                   | $\chi^2(2, 499) = 12.977, p = .002$ |
| Chat applications                          | 40.5%          | 23.3%            | 12.0%                  | $\chi^2(2, 499) = 26.170, p = .000$ |
| Google                                     | 40.5%          | 39.1%            | 18.1%                  | $\chi^2(2, 499) = 14.068, p = .001$ |
| The behaviour(s) that students usually exhibit during the lecture time. |                |                  |                        |                                    |
| Just pay attention to the lecture          | 31.9%          | 25.7%            | 16.9%                  | $\chi^2(2, 499) = 5.604, p = .039$  |
| Keep notes by hand                         | 46.0%          | 59.7%            | 69.9%                  | $\chi^2(2, 499) = 14.381, p = .001$ |
| Read PowerPoint slides on your devices     | 56.4%          | 28.5%            | 43.4%                  | $\chi^2(2, 499) = 32.773, p = .000$ |
| Type notes on your devices                 | 53.4%          | 33.6%            | 30.1%                  | $\chi^2(2, 499) = 19.878, p = .000$ |
| Receive and send messages                  | 41.7%          | 14.2%            | 13.3%                  | $\chi^2(2, 499) = 47.621, p = .000$ |
| Check social media                         | 38.7%          | 11.9%            | 6.0%                   | $\chi^2(2, 499) = 56.783, p = .000$ |

$\alpha$ is the limit of significance level, $\chi^2(a, b)$ is the variance between groups, $p$ is significance level.

Furthermore, Psychology students more frequently used several different applications, including social media and chat applications. The majority of Psychology students also followed the lecture using PowerPoint slides and type notes on their personal devices. In the free-texted responses submitted, many students from Life Sciences appreciated the functionality of the different notes storage in one place, for example ‘bring laptop helps as it allows me to take notes, use PowerPoint slides and keep a lecture audio all in one place which helps me with my learning’. Veterinary students mentioned the importance of keeping notes in different ways in order to be focused on their lecture, ‘bringing my device is very useful for back to back lectures (especially 4 hours) as I can alternate between typing notes, writing by hand or using software to make mind maps which keep me focused as I am changing the way that I make notes for each lecture’. Psychology students seemed that they used their own devices during their lectures due to lecture delivery process, ‘bringing a device can be very helpful when the lecturer is going too fast as you can read the slides from the devices’. Many other students from all the three disciplines mentioned their needs to use their own devices during lecture time due to their disability issues (e.g., dyslexia, reading and hearing issues) or their lack of English language skills (no native speakers needed slide translation, grammar and spelling corrections as keeping notes). On the other hand, numerous students from Life Sciences and Veterinary Science preferred to keep hand-written notes. A very well-described comment that arose from the free text area of the distributed questionnaire provides details about students’ actions: ‘I find it more effective to hand-write my notes and I prefer writing by hand as I feel this helps me take information better although I do sometimes miss information as writing is slower than typing. This is where post-lecture notes, lecture recordings and PowerPoint slides are useful’.

A two-way ANOVA was conducted to examine the effect of different devices, applications and behaviours in a lecture theatre on students’ performance. Table 3 presents the ANOVA outputs between and within the disciplines. Regarding the effect of total
Table 3. Students’ performance on questions related to their behaviour in a lecture theatre.

| Behavioural variable | Psychology grade (M, SD) | Life sciences grade (M, SD) | Veterinary science grade (M, SD) | ANOVA between disciplines and within each discipline (α =.05) |
|----------------------|--------------------------|----------------------------|----------------------------------|----------------------------------------------------------------|
| No device            | 59.2±(8.4)               | 61.8±(16.96)               | 66.2±(10.26)                     | F (3, 491) =.123, p =.947 psychology: F (1, 161) =.953, p =.330 |
| One device (laptop/  | 59.8±(8.5)               | 63.3±(10.03)               | 64.6±(7.34)                      | Life Science: F (2, 250) =.371, p =.691 psychology: F (2, 80) =.271, p =.764 |
| smartphone)          |                          |                            |                                  |                                                                |
| Both devices (laptop | 58.5±(8.5)               | 62.0±(10.93)               | 63.6±(7.45)                      |                                                                |
| and smartphone)      |                          |                            |                                  |                                                                |

Total number of applications which are used during the lecture time.

| No application       | 69.0±(7.21)               | 63.2±(11.19)               | 64.2±(7.31)                      | F (10, 480) =.928, p =.507 psychology: F (38, 124) =.879, p =.669 |
| One application      | 60.8±(12.12)              | 61.3±(11.97)               | 66.9±(8.09)                      | Life Science: F (48, 204) = 1.042, p =.410 |
| Two applications     | 59.4±(8.57)               | 65.1±(9.27)                | 62.3±(6.26)                      | Veterinary Science: F (31, 51) = 1.484, p =.104 |
| Three applications   | 60.0±(7.45)               | 64.1±(10.73)               | 64.1±(7.20)                      |                                                                |
| Four applications    | 57.6±(8.15)               | 60.5±(10.04)               | 61.1±(7.24)                      |                                                                |
| Five applications    | 58.1±(8.14)               | 60.4±(7.70)                |                                  |                                                                |
| Six applications     | 57.8±(5.12)               | 60.8±(9.02)                |                                  |                                                                |

Total numbers of different types of behaviours which are exhibited during the lecture time.

| One type             | 55.3±(11.45)              | 63.0±(11.70)               | 65.2±(7.49)                      | F (7, 485) =.876, p =.525 psychology: F (38, 124) =.941, p =.573 |
| Two different types  | 61.5±(7.45)               | 63.9±(9.55)                | 64.8±(8.08)                      | Life Science: F (48, 204) =.764, p =.865 veterinary science: F (31, 51) =.944, p =.560 |
| Three different types| 59.3±(7.27)               | 60.8±(10.13)               | 62.6±(6.28)                      |                                                                |
| Four different types | 58.5±(9.94)               | 63.4±(9.14)                | 62.0±(7.79)                      |                                                                |
| Five different types | 58.9±(7.82)               | 61.2±(8.87)                |                                  |                                                                |

α: the limit of the significant level, M: Mean, SD: Standard Deviation, F(a,b) is the variance value, p: significant value.

number of devices that students bring in a lecture theatre, it seems that there was no significant difference between the three groups of students. However, simple main effects analysis shows that Psychology students had significantly lower performance than Life Sciences (p < 0.001) and Veterinary Science (p < 0.001) students, but there was no difference between Life Sciences and Veterinary Science students (p = 0.422). Additionally, there was no significant difference in students’ performance from within the same discipline. A two-way ANOVA statistical analysis of the total number of applications and students’ performances demonstrated that there were no significant differences between and within the three disciplines. However, the simple main effects analysis showed a significant difference between Psychology and Life Science students (p < 0.001) and Psychology and Veterinary Science (p < 0.001), but no difference between Life Sciences and Veterinary Science. Similar are the findings by comparing students’ performance from the different disciplines when they exhibited different behaviours in the lecture theatre. However, in all the cases there were no significant differences in students’ performance from the within each discipline statistical analysis.

The comparisons provide differences between the three disciplines regarding the (non)learning purposed activities and distractions in a lecture theatre based on the students’ responses. Psychology students were more actively engaged in using their devices for both learning and non-learning purposed activities during the lecture time rather than the students from the other two disciplines as the simple main effects analysis shows (Table 4). More in-depth details about the use of devices in a lecture theatre immersed from the qualitative data gathered by the open-ended questions of the distributed questionnaire. Specifically, psychology students mentioned that the use of
Table 4. Comparisons between the students’ responses per discipline related to the use of devices for (non)learning purposed activities and distractions in a lecture theatre.

| Behavioural and environment variable | Discipline (M, SD) | ANOVA between disciplines (α = .05) |
|--------------------------------------|--------------------|-------------------------------------|
| Non-learning purposed activities     |                    |                                     |
| (unproductive)                       | Psychology: 3.4 (± 1.56) | F (2, 496) = 48.61, p < .001, η² = .164 |
| (3- Itmes, α = .878)                 | Life Science: 2.4 (± 1.21) | Simple main effects analysis: a significant difference between Psychology and Life Science (p < .001), Veterinary Science and Life Science (p = .04) |
|                                     | Veterinary Science: 1.9 (± 1.07) | Psychology and Veterinary Science (p < .001) and Life Science and Veterinary Science (p = .04) |
| Learning purposed activities (productive) | Psychology: 4.0 (± 1.5) | F (2, 496) = 14.69, p < .001, η² = .056 |
| (13- Itmes, α = .897)                | Life Science: 3.3 (± 1.27) | Simple main effects analysis: a significant difference between Psychology and Life Science (p < .001), Veterinary Science and Life Science (p = .04) |
|                                     | Veterinary Science: 3.4 (± 1.28) | Psychology and Veterinary Science (p < .001) and no difference between Life Science and Veterinary Science (p almost equals to 1) |
| Distractions                         | Psychology: 3.2 (± 1.28) | F (2, 496) = 4.01, p = .019, η² = .016 |
| (3- Itmes, α = .706)                 | Life Science: 2.8 (± 1.38) | Simple main effects analysis: no difference between Psychology and Life Science (p = .086), Psychology and Veterinary Science (p almost equals to 1) and Life Science and Veterinary Science (p < .005) |
|                                     | Veterinary Science: 3.3 (± 1.48) | |

α = Cronbach’s Alpha, α: the limit of the significant level, M: Mean, SD: Standard Deviation, F(a,b) is the variance value, p: significant value, η²: effect size.
devices for (non)/learning purposes activities is dependent on their engagement in the lecture. For example, the following free-texted comments clear describe the reasons of their actions: ‘I like the online interactive activities set up by some lecturers where we all send an answer for example, as it livens up lectures and makes me use my brain rather than listening and writing’ and ‘when I find a lecture boring, I tend to check social media on my phone which negatively impacts on my studies as then I miss important points in the lecture’. On the other hand, although the distractions from the use of devices inside the lecture theatre were limited (small extent for all disciplines based on students’ quantitative responses) (Table 4), three interesting points have come of analysing the free-texted comments (a thematic analysis of the qualitative student comments has been conducted):

(1) Distractions related to lecture: Students from all the disciplines mentioned that if a lecture topic is interesting, they do not use their devices. The following comment clearly describes their views, ‘I am not distracted by my own device, but if I am interested in the lecture or find it unnecessary, so turn to my device to pass the time without distracting anyone else by talking or fidgeting or rudely making noises and fuss by leaving the theatre. As students we are not slaves to our devices, those using them for activities unrelated to the lecture simply don’t want to listen the lecturer or have given up listening, but the School insists on taking attendance so we have to turn up’.

(2) Distractions related to when other students use their devices for non-learning purposes: Students from all disciplines have experienced distraction from other students’ interactions with digital devices through unrelated to lecture activities. The following student comments well describes the distractions from other peoples’ actions, ‘when other people in front are on social media (e.g. Facebook)’ or ‘when others in front of me watching short highlights or laughing at cat picture – it’s a bit distracting and I end up losing the flow of the lecture’.

(3) Distractions related to the use of smartphones: Students from the three disciplines mentioned that the use of smartphones in a lecture theatre is more distracting than laptops mainly due to opportunities for being in online on their social media account.

The last point regarding the smartphone led many students to stow their devices into their bags and put them on silent to avoid distractions. The following student comment presents clearly how students’ actions could reduce distractions from their smartphones, “I find it distracting, if I have my phone on my desk because I am tempted to use it to go on social media, because of this I put my phone in my bag and only use it when the lecturer asks us to use it, for example, to do a poll”.

Finally, in the last section of the questionnaire students expressed their views on different variables related to their own learning experience and study behaviours. Table 5 presents all the relevant comparisons between the three discipline students’ responses for individual learning characteristics. By analysing students’ responses regarding self-efficacy, it seems that all students believed that they had the capability to achieve high academic performance in their studies. However, the simple main effects analysis for self-efficacy shows that Psychology (p = .036) and Veterinary Science (p = .058) students had a slightly less confidence in their abilities compared to Life Sciences. All the students experienced stress and anxiety before or during their test situations and the simple main effects
### Table 5. Comparisons between the disciplines and individual learning characteristics.

| Individual learning variable | Discipline (M, SD) | ANOVA between disciplines (α = 0.05) |
|------------------------------|-------------------|-------------------------------------|
| Self-efficacy (4-items, α = 0.730) | Psychology: 4.7 (±1.07) | F(2, 496) = 4.549, p = 0.011, η² = 0.018 |
|                              | Life Science: 5.0 (±0.85) Veterinary Science: 4.7 (±0.81) | Simple main effects analysis: a significant difference between Psychology and Life Science (p = 0.036), but no significant difference between Psychology and Veterinary Science (p almost equals to 1) and Life Science and Veterinary Science (p = 0.058). |
| Course utility (3-items, α = 0.786) | Psychology: 5.8 (±0.82) | F(2, 496) = 47.009, p < 0.001, η² = 0.159 |
|                              | Life Science: 5.5 (±0.85) Veterinary Science: 6.5 (±0.51) | Simple main effects analysis: significant differences between all the disciplines (Psychology and Veterinary Science: p < 0.001 and Veterinary Science and Life Science: p < 0.001 and Psychology and Life Science: p = 0.035). |
| Test anxiety (4-items, α = 0.842) | Psychology: 5.5 (±1.23) | F(2, 496) = 0.618, p = 0.539, η² = 0.002 |
|                              | Life Science: 5.4 (±1.24) Veterinary Science: 5.3 (±1.13) | Simple main effects analysis: no significant differences between all the disciplines (p almost equals to 1). |
| Surface Strategy (3-items, α = 0.801) | Psychology: 5.3 (±1.21) | F(2, 496) = 7.672, p < 0.001, η² = 0.030 |
|                              | Life Science: 5.3 (±0.96) Veterinary Science: 5.7 (±0.96) | Simple main effects analysis: a significant difference between Psychology and Veterinary Science (p = 0.002) and Veterinary Science and Life Sciences (p < 0.001), but no significant difference between Psychology and Life Sciences (p almost equals to 1). |
| Source Diversity (3-items, α = 0.819) | Psychology: 5.0 (±1.03) | F(2, 496) = 8.943, p < 0.001, η² = 0.035 |
|                              | Life Science: 5.3 (±0.86) Veterinary Science: 5.6 (±0.94) | Simple main effects analysis: a significant difference between Psychology and Veterinary Science (p < 0.001) and Veterinary Science and Life Science (p = 0.015), but no significant difference between Psychology and Life Science (p = 0.069). |
| Negative habits (e.g., procrastination, time and planning management) (7-items, α = 0.835) | Psychology: 4.7 (±1.18) | F(2, 496) = 11.111, p < 0.001, η² = 0.043 |
|                              | Life Science: 4.2 (±1.04) Veterinary Science: 4.2 (±1.09) | Simple main effects analysis: a significant difference between Psychology and Life Science (p < 0.001) and Psychology and Veterinary Science (p < 0.001), but no significant difference between Veterinary Science and Life Science (p almost equals to 1). |

a = Cronbach’s Alpha, α: the limit of the significant level, M: Mean, SD: Standard Deviation, F(a,b) is the variance value, p: significant value, η²: effect size.
analysis shows that there is no difference between the three disciplines (p almost equals to 1). However, a difference has been identified regarding the surface learning approach with the Veterinary Science students to exhibit more of this type of learning strategy (the simple effects analysis showed that there is a significant difference between Psychology and Veterinary Science students (p = .002) and Veterinary Science and Life Sciences students (p < .001) and no difference between Psychology and Life Sciences). Regarding the course utility, it seems that there is a significant difference between the three disciplines with the Veterinary Sciences students perceiving their course to be important in their future lives (e.g., employability opportunities, academic performance/career). Specifically, the simple size effects analysis for course utility shows a significant difference between Psychology and Veterinary Science (p < .001), Veterinary Science and Life Science (p < .001) and Psychology and Life Science (p = .035)., Regarding students’ negative study habits, there is a significant difference between the three Schools and specifically the simple size effects analysis shows that Psychology students exhibited poor time and planning management skills procrastinating their work compared to Life Sciences (p < .001) and Veterinary Science (p < .001), while there is no difference between Life Science and Veterinary Science (p almost equal to 1). Finally, there is a significant difference between the three disciplines regarding the use of the digital diversity learning sources. The simple main effects analysis for learning source diversity shows that there is a significant difference between Veterinary Science students with Psychology (p < .001) and Life Science students (p = .015) but no difference between the disciplines of Psychology and Life Science (p = .069).

Discussion

The aim of this study was to explore student behaviours from three distinct disciplines with respect to their personal device usage in a lecture environment and to explore the connections of such use to learning, multitasking and distraction. The difference of this study to the current literature is that three different disciplines were examined under the same circumstances (first year students, same questionnaire and learning environment). The assumption of study is that the learning environment and individual learning characteristics influence student behaviours regarding the use of their own devices in a lecture theatre (and vice versa) following the aspects of Social-Cognitive Theory. The proposed model (Appendix 1) describes students’ behaviour in a lecture theatre when they bring their own devices providing a visual reference of the reciprocal determinism for a lecture environment in order to answer questions regarding the effects of the device usage, multitasking, distraction and participation in (non)/learning activities on student academic performance in respect on student individual characteristics. By analysing students’ responses, it has been found that the number of devices that the first-year students bring to their lectures is not linked to their academic performance within any of the discipline. Similar results have been found regarding the number of applications accessed by the students during the lecture theatre and their academic performance. Overall, there was no significant difference between the disciplines regarding the distractions from the use of devices in a lecture theatre. However, this study revealed that the use of smartphone in a lecture environment was more distracting than that of a laptop. Additionally, students
have mentioned that the use of their smartphones over the lecture time was related to their perceptions of teaching process (e.g., interesting vs boring lecture time).

Furthermore, this study shows that there is a significant difference between Psychology student performance and Life Sciences and Veterinary Science students. This finding may be related to Psychology students’ engagement in two types of activities during lecture (learning and non-learning related activities). As Psychology students were more involved in both types of activities, they split their attention between different tasks increasing the multitasking level of engagement (frequency that students used their own devices in a lecture theatre to support their learning or to use applications such as online chats and social media for non-learning purposes). Thus, Psychology students increased their mental effort to accomplish the multitasking tasks and their academic performance might be negatively affected (Glass & Kang, 2018).

When students keep notes, they are more selective, as they cannot write as fast as they type and they are processing the learning information which is more important for their understanding (Mueller & Oppenheimer, 2014). As Psychology students extensively used their own devices to type their own notes during lectures, they relied on their own notes without using the diversity of digital sources that were available to them during their study period. However, as the multitasking process split their attention into different tasks, it might raise a question on how accurate their notes were for their revision (Morehead, Dunlosky, & Rawson, 2019), which might be also related to lower performance of Psychology students’ academic performance compared to the students from the other two disciplines. The Life Sciences and Veterinary Science students made an extensive use of the variety of digital sources during their study period and their academic performance was higher than Psychology students. The fact that psychology students were choosing to type notes on their device might further impact the frequency with which they engaged in non-learning activities in a lecture theatre, simply because the Internet and social media were more accessible to them using their device.

This expands the findings of multitasking and the use of devices in a lecture theatre by making a connection to how teachers expect students to use their own devices for the in-class learning purposes through their own teaching approaches. Although psychology students did not multitask significantly more than the students from the other two disciplines, a difference in their academic performance was detected which might be related to learning activities that were followed in-class. From one perspective, teachers could explain to students the problematic use of their own devices in relation to multitasking process increasing students’ learning self-regulations. This might be an important point for the 21st-century undergraduate students who belong to ‘the Net Generation’ and should learn to work in a multitasking environment using digital technologies for learning purposes (Lai & Hong, 2015). From the other perspective, based on students’ comments, teachers should include more constructive learning activities making the learning process more engaging, interactive and enjoyable for students reducing their desire to ‘play with social media’ during lecture time. To do so, teachers should follow a teaching approach which integrated digital technologies into their teaching enhancing students’ curiosity, engagement and personal needs in respect to students’ learning characteristics and not only to allow students to follow their learning process through the variety of digital resources (e.g., PowerPoint slides, lecture capture videos and reading material).

The rationale of this investigation is to expand on past findings by comparing student learning experience and behaviours in order to find out if multitasking and distractions
from technology is more apparent in different disciplines and to then infer why. This links to Social-Cognitive Theory (SCT) that whether environment and individual characteristics are linked to student behaviour to use their own personal device in a lecture theatre following the proposed model (Appendix 1). Regarding individual characteristics it seems that student background, self-efficacy and negative study habits were related to Psychology student academic performance. For example, the student background based on each discipline requirements was different, Psychology has the lowest level of entry qualifications. Although each course has been designed to meet the needs of a Higher Education degree, it seems that the entry requirements where psychology has the lowest tariff might be linked to student self-efficacy leading Psychology students to exhibit less confidence in their abilities for a successful course completion. Although the aim of this investigation was to study student behaviours when they bring their own devices to a lecture theatre in respect to multitasking and distractions from their peers’ actions and from the use of devices, the link to SCT raise another issue related to students’ individual characteristics and their academic performance (Honick, Broadbent, & Fuller-Tyszkiwicz, 2019). For example, both these two factors could be connected to students’ behaviours using their own digital devices outside a lecture theatre environment to support their own independent learning. A potential connection between students’ behaviour inside and outside a lecture theatre will be a future work of this study in order to provide a complete framework for teachers who embed technology into their teaching.

There are a number of limitations to this study. Firstly, the study provides only a snapshot of the student learning experience over a specific year of studies. A future investigation could examine longitudinal development to ascertain how students may change their behaviour over time and how this may influence their learning. Secondly, SCT could explain how learning can be constructed through the shared experiences including sociocultural understandings. The proposed model (Appendix 1) supported by this study evidence does not extensively discuss the sociocultural perspective of SCT regarding the connection to social norms and peer group behaviour. This study aim was mainly to explore how multitasking and distractions from others’ actions with their digital devices and distractions from digital device itself in a lecture theatre environment might influence student learning process. This investigation was only an initial study in this area exploring the reciprocal relationship in which a lecture theatre (multitasking and distractions from their peers and from their own digital devices), action and individual interact. However, future investigation on this topic will further explore the social perspective of learning (e.g., peers, community and class affect learning in comparison to teacher’s influence) alongside with the individual characteristics (e.g., age). This may allow teachers to gain an insight understanding of students’ learning process and potentially reconsider their teaching approaches inside a lecture theatre.

Studying the topic of the device usage in a lecture theatre applying SCT for three disciplines reveals interesting findings regarding the complexity of Higher Education, the connection to learners’ characteristics, the way that a blended learning approach supports teaching allowing students to be involved in non-learning activities and the disciplines’ difference in academic performance. This study may explain why there is still a debate whether or not the use of devices in a lecture theatre is linked to low academic performance. The learning experience in Higher Education should be gradually moved away from the traditional way of teaching where digital technologies are used for supporting
supplementary material providing students only the opportunity to follow the teaching material inside and/or outside classes. Teachers should take the advance that their students are used to work online and enhance their teaching approach increasing their student curiosity and engagement. Thus, they could provide other than that opportunity of typing notes on their devices. Combining students’ individual characteristics and their behaviours in a lecture learning environment, it would be challenging for teachers and students to walk the line between embracing technology in a constructive way to enhance engagement in learning and allowing technology to be used without putting students in the way of temptation to be engaged in non-learning activities. Teachers should take into their account that although students are used to work in online environments, their behaviours in class are linked to other variables such as course utility and self-efficacy. These factors should be considered by teachers in order to support a technology rich, flexible and enjoyable learning environment for their students. Future investigation should consider student behaviours from the three levels of studies within the same discipline in order to explore whether their device usage would be linked to the demands of each year of studies.

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Statements on potential conflicts of interest, open data and describing the ethical guidelines and approval for reports of empirical research

The data were handled in accordance with the Ethics policy as it stated by the University of Liverpool, ensuring the protection of participants’ privacy. Data collection and use is conformed to the BERA ethical guidelines for educational research. The data used in this study were anonymised and original data are being deleted at the end of the project period following the University of Liverpool regulations.

No conflict of interest exists in the submission of this manuscript. The authors declare that the work described in this paper is an original research that has not been published in any other journal previously and is not under consideration for publication elsewhere, in whole or in part. All the authors listed have read and approved the enclosed manuscript for publication.

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