BYOD strategies in higher education: current knowledge, students' perspectives, and challenges

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Introduction

Over the last decade, the use of mobile computing devices has become an integral part of virtually every aspect of our personal and professional life, and education is no exception to this paradigm (Traxler 2009). The expression "Bring Your Own Device" ('BYOD'), originally coined by Ballagas et al. in 2004 (Ballagas et al. 2004), has since gained widespread use and is currently defined in the Oxford English Dictionary as "the policy or practice of allowing employees, customers, etc., to connect to an organization's network using their own smartphones, computers, etc.". While there are governmental guidelines regulating the use of BYOD strategies in work environments in the public sector, a consistent framework has yet to be put in place to standardise their use as education tools in schools and universities ('BYOD Guidance: Executive Summary', 'Bring Your Own Device (BYOD)'). A plethora of arguments has been raised both in favour of and against the educational use of electronic devices in what appears to be a yet unsolved debate (Motiwalla 2007; Corbeil & Valdes-Corbeil 2007). In 2015, an Ofsted spokesperson declared that "Pupils bringing personal devices such as laptops or tablets into school can be extremely disruptive and make it difficult for teachers to teach. It is up to schools to decide whether they have rules about personal devices, but Ofsted would be supportive of heads who took tough action to make the learning environment better for children" (Vaughan 2015). Shortly after, however, Ofsted clarified their stance on the issue by specifying that their former statement referred to the unregulated use of personal electronic devices for non-didactic purposes, whereas "Ofsted is clear that technology can of course have a positive impact on a pupil's learning experience (as noted in many of our reports) and we are not against the use of tablets, laptops or other devices in school when part of planned lessons" (Cameron 2015). The above controversy clearly embodies the main conundrum related to the use of BYOD strategies in education: although their game-changing potential in teaching, learning and assessment is undeniable, caution should be exercised in their practical implementation.

While there is a burgeoning amount of literature on the evaluation of BYOD in primary and secondary schools (Parsons & Adhikar 2016; McLean 2016; Hamilton et al. 2016; Cristol & Gimbert 2013), this paper seeks to focus on the critical evaluation of the current knowledge on the implementation of BYOD strategies in higher education (HE), highlighting potential *caveats* arising from their use with specific regards to the issue of digital divide within the learning group. The first part of the paper will explore and discuss relevant recent literature to provide some key views on the effectiveness and limitations of the use of BYOD strategies in teaching, learning and assessment. The critical evaluation of the advantages and pitfalls of BYOD will be used as a theoretical scaffold for the second part of

the paper, which will outline the results of a recent case study giving a practical account of the implementation of BYOD-based formative assessment in higher education.

BYOD strategies in HE teaching and learning

As concisely stated by Vavoula et al. in 2004, "Mobile learning is an emergent paradigm in a state of intense development fuelled by the confluence of three technological streams: ambient computing power, ambient communication and intelligent user interfaces. The pedagogy of mobile learning, however, has yet to become clearly established" (Vavoula et al. 2004). While the use of mobile learning in higher education has since been widely investigated and is gaining an increasingly complex philosophical and pedagogical framework, the extent of its practical implementation is still largely inconsistent between (and in most cases within) different universities (Afreen 2014). Mobile devices have been used in higher education for a wide array of purposes, which Patten et al. have classified into seven main functional areas, namely administration, collaborative, interactive, referential, location aware, data collection, microworld (Patten et al. 2006). As the main focus of the present paper is the implementation of BYOD strategies in teaching, learning and assessment, particular emphasis will be given to the impact and potential setbacks of the strategies described as interactive and collaborative in Patten's functional framework. The reasons behind the choice of narrowing down the scope of this paper to the interactive and collaborative use of mobile learning resonates with Herrington's observation that "Despite the significant potential of mobile technologies to be employed as powerful learning tools in higher education, their current use appears to be predominantly within a didactic, teacher-centred paradigm, rather than a more constructivist environment. It can be argued that the current use of mobile devices in higher education (essentially content delivery) is pedagogically conservative and regressive" (Herrington et al. 2009). In apparent disaccord with Herrington's remarks, it has been observed that mobile learning in higher education only has a positive impact on students' achievement if integrated or "blended" in the context of traditional teaching strategies. Al-Qahtani and Higgins reported that e-learning, defined in the study as "asynchronous online classroom […] where students could interact with learning materials and with each other, but without the physical presence of the instructor" resulted in similar achievement to traditional classroom-based learning (Al-Qahtani & Higgins 2013). In the same study, the "blended learning" cohort, which had access to mobile learning in the context of traditional face-to-face sessions, significantly outperformed both the traditional and e-learning groups, corroborating previous observations on the positive emerging qualities of the integration of mobile learning within the framework of traditional pedagogical strategies (Gould 2003; Akkoyunlu & Soylu 2006; López-Pérez et al. 2011; Garrison & Kanuka 2004). Despite the vast number of positive reports surrounding the implementation of blended learning in higher education, it has been argued that a significant proportion of the studies on the topic are highly heterogeneous from both a theoretical and methodological standpoint, and in many cases present wide discrepancies on the definition of the expression "blended learning" itself (Bliuc et al. 2007). This observation indicates that the evaluation of the effectiveness of blended learning in higher education must take into account the specific context in which each study has been carried out, and caution must be taken when transferring and applying research outcomes to a different sociological and educational reality. As remarked by Cochrane, "there are yet few well-developed theoretical frameworks for supporting creative pedagogies via BYOD" (Cochrane et al. 2014). According to Cochrane and colleagues, an effective framework for creative pedagogies should aim to meet three key goals: "model a community of practice (COP), focus upon redefining pedagogy and provide an appropriate technology support infrastructure". Recent studies indicate that Cochrane's framework could successfully be implemented to provide a consistent structure for mobile learning in higher education (Mac Callum et al. 2015; Cronin et al. 2016).

Tossell et al. proposed a "naturalistic approach" to investigate the effects of

unstructured use of mobile computing devices in a higher education context (Tossell et al. 2015). The participants (undergraduate students who did not own, nor had previously used smartphones) were given a smartphone but received no instruction on how to use it. The participants' use of smartphones was logged over the course of a year, and they were asked to complete a survey prior to the start of the experiment and after its conclusion. Interestingly, despite not receiving any guidance towards the educational use of the smartphones, 63% of the participants used the device for course-related purposes. Prior to the beginning of the study, the majority of students had a positive outlook on the effect of the use of smartphones on their academic attainment. However, the students' perception of the effectiveness of smartphones changed dramatically over the course of the study, whereby most participants reported that "their iPhones were more of a distraction than a help, and they had noticed large changes in habitual behaviours associated with the need to continuously check their iPhone".

The dramatic importance of providing appropriate structure and guidance towards the implementation of ICT-based strategies in education had already been clearly recognised by educators before the turn of the millennium. David Mioduser, who famously described the assimilation of new technologies in education as "One step ahead for the technology, two steps back for the pedagogy", stressed that the implementation of ICT in education is futile (and, arguably, deleterious) unless backed up by a concomitant overhaul of the pedagogical dimension (Mioduser et al. 2000).

Does BYOD bridge or aggravate digital divide?

It cannot be ignored that teaching and learning strategies based on the use of personal mobile computing devices may pose a significant risk to aggravate the digital divide between students who have access to (and operational mastery of) such devices, and students who do not. While this the link between BYOD strategies and the digital divide has been extensively investigated in a primary and secondary school context, there is relatively little research on its extent in higher education. Hence, this section will discuss relevant examples from the literature tackling the issue of digital divide across all age groups. When evaluating the issue of the digital divide in mobile learning, one must not forget the widely different socio-economic and geographical contexts in which the teaching and learning take place. Although it has been argued that mobile learning poses the risk of *de facto* excluding demographic groups with limited digital access and skills (Gulati 2008), this approach has shown an enormous potential in developing countries where physical access to education is only available to a small fraction of the population (Motlik 2008). However, how beneficial and justifiable is a transition to mobile learning in western societies where physical access to educational institutions is considered an established right for the vast majority of the population? Adhikari et al. sought to elucidate the challenges and implications brought about by the use of BYOD in education. In a pilot study published in 2012, the authors reported that almost every student who participated in the survey had access to internet-connected devices both at school and at home (Adhikari et al. 2012). However the data on the ICT skills level revealed a wide spread in the participants' digital skills, indicating that mere ownership of mobile computing device is not sufficient to allow their effective use as learning tools. The public perception of the use of mobile devices in education was also investigated in the same study. Worries were expressed by 20% of the participants that BYOD would aggravate any existing socio-economic disparities within the classroom environment, as the ownership or quality of digital devices may be regarded as a status symbol. A key aspect identified by the authors is that providing access to mobile devices and the appropriate technical know-how is not sufficient to grant equity effectively in the learning process, as "To address the issue of digital divide in learning, there must also be equality in learning outcomes beyond just access and skills". The three-tiered nature of the digital divide in the learning process (namely digital access, digital capability, digital outcome) was further investigated in a longitudinal study carried out in a secondary school in New Zealand over the course of three years (Adhikari et al. 2016). Access to digital devices did not appear to be a major hurdle, as

the vast majority of the students who participated to the study owned, or had easy access to, internet-connected mobile devices. The implementation of BYOD resulted in a general improvement in self-assessed digital capabilities of the cohort, and did not appear to widen the gap in ICT skills initially observed within the participants. In terms of digital outcome, Adikhari's study seems to indicate that while the majority of the participants commended the usefulness of BYOD to promote learning, a small proportion of students and parents described the use of mobile computing devices as detrimental to the learning process. Although the results of the study did not identify any aggravating effects on digital divide, the implementation of BYOD unearthed significant concerns, including the potential loss of handwriting skills (identified as a likely problem by half of the participants) and the disruptive effect of device compatibility issues.

BYOD strategies for formative assessment

It is widely acknowledged that formative assessment is a cornerstone of every meaningful teaching and learning effort across all age groups (Sadler 1989). By allowing students to monitor their own progress without the pressure and anxiety typically associated with summative assessment, formative assessment fosters the development of critical evaluation skills, which can feed back into the learning process in a virtuous learning circle (Boston 2002). While the cognitive and metacognitive value of formative assessment is widely recognised, the extent and modalities of its use (especially in higher education) vary broadly between different learning environments (Yorke 2003). It has been argued that "conceptions of assessment have lagged behind conceptions of learning in higher education. While students have been given more responsibility for learning in recent years, there has been far greater reluctance to give them increased responsibility for assessment processes" (Nicol & Macfarlane-Dick 2006). The present study seeks to evaluate the potential of Electronic Interactive Formative Assessment as a tool to bridge the existing gap between self-directed learning and assessment and consolidate the perception of formative assessment as a metacognitive moment in higher education.

Cowie and Bell have defined "Interactive Formative Assessment" as formative assessment which "took place during student-teacher interaction" and "involved the teachers noticing, recognising and responding to student thinking" as opposed to "Planned Formative Assessment", which is "characterised by the teachers eliciting, interpreting and acting on assessment information" (Cowie & Bell 1999). It is worth pointing out that, for the present case study, formative assessment was carried out in a planned fashion, either as a minor part (e.g. at the start or at the end) of a lecture, or as a stand-alone revision session. However, despite their "non-spontaneous" nature, all formative assessment episodes on which the present study is based involved a strong dialogic component, as every question and its outcomes were discussed in real time with the students. For the sake of simplicity, and in order to adapt Cowie and Bell's definition of Interactive Formative Assessment to the scope of this paper, the expression "Electronic Interactive Formative Assessment" (EIFA) will be used to describe the use of electronic devices (smartphones, tablets, laptops) and appropriate software (in this case, Nearpod) as formative assessment tools to aid the students' understanding of scientific topics and consolidate their learning. This definition ties in with the "interactive" category described in Patten's functional framework of mobile learning, which encompasses applications that "transcend information management and content delivery by focusing on engaging users through a 'response and feedback' approach" (Patten et al. 2006).

Case study design

The 54 participants were a subset of level 4 students enrolled in Biology, Biochemistry, and Marine Biology courses at the University of Portsmouth (UK). All participants had routinely used Nearpod as an interactive formative assessment tool for a whole term prior to the start of the present study. The whole cohort participated in regular revision sessions in the context of the "Introduction to Cell Biology and Biochemistry" level 4 unit. At the beginning of each session, the students were informed that they could participate by either using Nearpod

or reading the questions on the lecture theatre screen and answering using pen and paper. Each question was shown simultaneously on the lecture theatre screen and on the students' handheld devices, therefore allowing students who did not have an internet-connected device to participate in real time. Students were encouraged to collaborate with each other and discuss the questions in small groups before attempting an answer.

Each revision session included pre-prepared questions on the last topic that the students had been taught. Three questions styles were used, namely multiple choice, open-ended, and "draw it" questions, the latter type requiring the students to sketch a diagram or structure (e.g. "Sketch an example of symmetric or asymmetric division of a stem cell" or "Draw the structure of a generic amino acid").

To avoid influencing the students via the "bandwagon effect", the outcome of each individual multiple choice question was displayed using pie charts on the lecture theatre screen only after the group had answered. Each question was followed by a short whole-group discussion: for multiple choice questions, specific emphasis was given to topics in which the students' responses were more evenly split between two or more answers, i.e. if a high proportion of the students had not chosen the correct answer. In such case, each answer was discussed and evaluated as a whole group, and the students given direction on appropriate revision strategies. The students' answers to open and "draw it" questions were anonymously shown on the lecture theatre screen and used to guide a whole group discussion. Typically, some incorrect answers were chosen to highlight and correct common misconceptions before showing one or more correct answers to the question.

After the end of the teaching block, the students were informed of the possibility to participate in the present survey. The study was designed and carried out in accordance with the University of Portsmouth Ethics Policy. The online survey was voluntary and anonymous, and no personal information about the participants was collected. All participants were notified of the purpose and modalities of the study, as well as of their right to withdraw from it.
It is worth pointing out that all participants were clearly informed of the meaning of the expression "Electronic Interactive Formative Assessment", which was defined in the introduction to the survey as "the use of electronic devices (smartphones, tablets, laptops) and appropriate software (in our case, Nearpod) as tools to aid your understanding of scientific topics and consolidate your learning".

The participants were asked to complete an anonymous online questionnaire composed of two main sections:

- Eight Likert-type questions, in which participants are asked to rate their agreement with a given statement on a scale from 1 (completely disagree) to 5 (completely agree):
    - EIFA is helpful to consolidate my understanding of a topic.
    - I find EIFA more useful than conventional formative assessment methods (e.g. worksheets, tests)
    - Formative assessment software (e.g. AllTheVotes, Kahoot, Nearpod, Socrative, etc.) was used in my high school or college.
    - When revising, I prefer using electronic learning materials (e.g. lecture slides, videos, animation) than textbooks.
    - I am more likely to attend a revision session if it involves the use of EIFA
    - I would find it beneficial if lecturers implemented short EIFA sessions during most lectures.
    - The use of EIFA is unfair because not all students may have access to electronic devices (laptop, tablet, smartphone).

- Three open questions to obtain qualitative results with the aim of corroborating the quantitative results of the Likert-type questions and allow the participants to expand on their answers:
    - Which feature(s) of EIFA did you find more helpful and why?
    - Do you think EIFA should be routinely used in education? Motivate your answer.

- Can you think of any pros and cons of using EIFA rather than traditional assessment methods?
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Results

Our results indicate that only a minority (35%) of the participants had used EIFA in an educational context before enrolling into university (figure 1A). This finding, in apparent disaccord with a recent BESA survey in which 67% of UK secondary schools showed interest in the adoption of BYOD (British Educational Suppliers Association 2013), may in fact reflect the existing lag between the expression of interest and the practical implementation of BYOD strategies in the classroom context.

Despite (or, arguably, because of) the novelty of BYOD-based formative assessment strategies, the students' account of their efficacy appears overwhelmingly positive. Most students (96%) commended the helpfulness of interactive formative assessment to consolidate their learning (figure 1C), and over 70% of the participants expressed a clear preference for electronic formative assessment compared to traditional formative assessment methods (figure 1B), with 54% of the participants claiming to be "more likely to attend a revision session if it involves the use of EIFA" (figure 1D). While the students' enthusiasm should be viewed as an encouraging factor towards the implementation of BYOD strategies in education, it is important to stress that students' engagement does not necessarily result in improved attainment. Follow-up studies will be required to investigate whether the students' overwhelmingly positive outlook on EIFA will persist once its novelty wears off, and how it will translate in terms of learning outcomes.

The vast majority of the participants (over 90%) did not perceive EIFA as potentially aggravating the digital divide among their peers (figure 1H), nor did they express worries that the use of electronic devices could have a detrimental effect on student/teacher communication (figure 1G).

When evaluating the overwhelmingly positive students' accounts of the use of EIFA, and the limited concerns expressed over its potential drawbacks, it is important to take into account the modality of the study. As participation in the online questionnaire was voluntary, one cannot rule out a selection bias whereby the students who chose to participate may arguably be more confident with the use of electronic devices than the rest of their peers, and may therefore not be entirely representative of the whole cohort.

The quantitative data obtained via the questionnaire are corroborated by the students' responses to the open-ended questions, which identified the most commonly perceived benefits of the use of EIFA. Although anecdotal in nature, the following statements are representative of key elements frequently mentioned by the students:

"The immediate feedback is definitely very helpful as allows me to see how much I know, and also fix gaps in my knowledge whilst I'm still focused on the topic in question"

"The feedback being on the entire group, so common misunderstandings can be explained to eliminate the confusion"

"Helps pinpoint areas of struggle which I can go on to revise in depth. Often when using Nearpod, the lecturer is able to pick up on areas of difficulty and explain these concepts in a different way"

"The anonymity means we can learn without others knowing if we didn't know something before"

"The lecturer can give feedback about the answer straight away if people don't understand it whereas with a worksheet you have to sit in silence and can't help friends understand."

"Yes, a short interactive session at the beginning of the lecture on the previous lecture would be helpful and not to destructive on the lecture structure"

It is important to mention that, while the vast majority of the statements highlighted a positive outlook on the use of EIFA, several students also pointed out potential drawbacks

stemming from its excessive or unstructured use:

"The occasional use is ok, however too much electronic assessment could detract from the importance of exams, allowing students to get used to a form of assessment totally different to the conditions of their final exams."

"People may use their electronic devices to go on social media rather than the interactive assessment."

"Perhaps there is a danger that these assessments could limit how much a student questions something and pushes to learn more, as I find satisfaction in seeing that I answered something correctly and then am less motivated to learn more as I feel I have achieved my goal here."

"The occasional use of interactive electronic assessment may be beneficial, either at the end of a lecture to see how much students have learnt, or at the beginning of the following lecture as a reminder of the previous one. However, too much use could get students out of the habit of going over lecture content, and may make it harder/ more stressful to sit final exams as they are such a different environment"

Graph reference	Statement	Strongly disagree	Partially disagree	Neither agree nor disagree	Partially agree	Strongly agree
1A	Formative assessment software (e.g. AllTheVotes, Kahoot, Nearpod, Socrative, etc.) was used in my high school or college.	31 (57.4%)	4 (7.4%)	3 (5.6%)	6 (11.1%)	10 (18.5%)
1B	I find EIFA more useful than conventional formative assessment methods (e.g. worksheets, tests).	0 (0.0%)	9 (16.7%)	7 (13.0%)	27 (50.0%)	11 (20.4%)
1C	EIFA is helpful to consolidate my understanding of a topic.	0 (0.0%)	1 (1.9%)	1 (1.9%)	18 (33.3%)	34 (63.0%)
1D	I am more likely to attend a revision session if it involves the use of EIFA.	1 (1.9%)	8 (14.8%)	15 (27.8%)	22 (40.7%)	8 (14.8%)
1E	When revising, I prefer using electronic learning materials (e.g. lecture slides, videos, animation) than textbooks.	1 (1.9%)	8 (14.8%)	8 (14.8%)	24 (44.4%)	13 (24.1%)
1F	I would find it beneficial if lecturers implemented short EIFA sessions during most lectures.	0 (0.0%)	7 (13.0%)	6 (11.1%)	25 (46.3%)	16 (29.6%)
1G	The use of EIFA is unfair because not all students may have access to electronic devices (laptop, tablet, smartphone).	7 (13.0%)	23 (42.6%)	20 (37.0%)	4 (7.4%)	0 (0.0%)
1H	The use of electronic devices in education should be minimised because it can have a negative impact on student/teacher communication.	14 (25.9%)	19 (35.2%)	15 (27.8%)	4 (7.4%)	2 (3.7%)

Table 1 Outcome of the Likert-type questionnaire

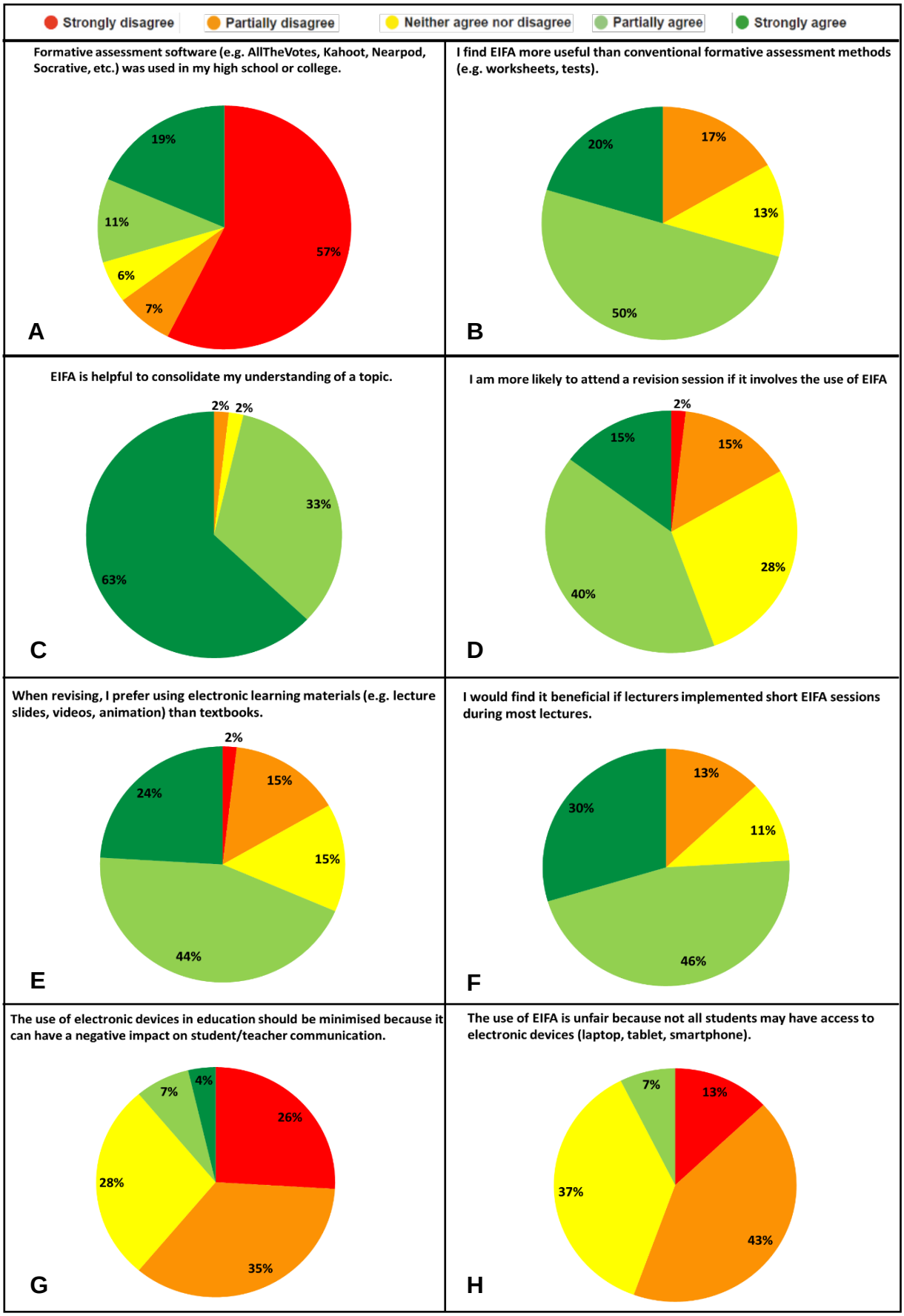

Figure 1 graphic representation of the participants' responses to the Likert-type questions.

Conclusions

The necessity of innovating pedagogy prior to (or alongside with) the introduction of BYOD strategies appears to be a leitmotif that can be identified in most studies on the topic and is confirmed by the outcome of the present case study. The use of personal computing devices should be seen by educators as a long overdue opportunity to improve upon (rather than replace) traditional pedagogic approaches. There is abundant evidence that the implementation of BYOD strategies without a concomitant overhaul of the underpinning pedagogical dimension would have a detrimental effect on the learning process (Mioduser et al. 2000; Tossell et al. 2015). Hence, it is of paramount importance that educators engage in continuing professional development activities to acquire the theoretical framework and technical competence required for an effective modernisation of their teaching practice (Beckingham & Nerantzi 2015).

In addition to the pedagogical considerations discussed in this paper, the use of personal mobile computing devices in education has deep socio-economic ramifications. For example, BYOD strategies may play a key role in an institution's effort to "go paperless", which poses significant ecological and economic advantages (Altena 2015; Cornwell 2015). Moreover, with budget cuts increasingly affecting many Universities' didactic provisions, BYOD strategies could relieve some of the tension by making an efficient use of resources that are already widely available to students (Shumate & Ketel 2014). BYOD strategies also bring about a plethora of security and privacy concerns (Gordon 2015), and institutions wishing to implement them should provide appropriate infrastructures and staff training. Although an extensive discussion of such ramifications would fall outside the scope of this paper, educators and policymakers should be aware that the use of personal computing devices in education comes with a wide range of implications that often transcend the classroom context.

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