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A longitudinal study to understand students' acceptance of technological reform. When experiences exceed expectations

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Abstract
This study investigates technology acceptance over time of two specific technologies in a university setting, namely interactive quizzes and screen sharing. This topic is investigated in the framework of the Technology Acceptance Model (TAM) that includes the perceived usefulness, perceived ease of use and behavioural intention as main concepts. This study also add experience or actual use to this framework. Although previous research investigated the relation between technology acceptance and actual use, no longitudinal study of TAM variables has been previously conducted in the context of interactive quizzes and screen sharing from a student perspective. This study aims to meet this research gap and investigated students' expectations towards educational technology at the start of the project and students' experiences with educational technology throughout the academic year. Results reveal that students started out with a positive predisposition to the usefulness, ease of use, and behavioural intention of using educational technology in university settings. The TAM perceptions after experiencing the technology were significantly higher than before using the technology. This was the case for both interactive quizzes and screen sharing technology. The longitudinal results even counter a novelty effect. Although educational reform is also related to organizational processes, students' acceptance is critical to make sure that technologies might contribute to improve learning and teaching.

Keywords Technology integration · Technology acceptance model · Higher education · Longitudinal study · Interactive & collaborative learning

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1 Introduction: How technology can support educational change

Over the last 50 years, technology has become more and more present in all areas of human society. The field of education has not escaped from this evolution and an important shift towards increased digitalisation has occurred (Laurillard 2002; Yang et al. 2015). Spanjers et al. (2015) see the increased digitalisation as an opportunity to enhance education and support the current shift towards a more (inter)active and student-centred approach on learning and instruction. As the profile of the modern student changes, it is important to understand the role that technology now plays in students' lives and to capitalise on new technology in order to engage with students on the kind of learning platforms that they regularly utilise. Instead of shunning these devices, Dobbins and Denton (2017) stated that the higher education teaching community needs to embrace the moving tides of technology to benefit from this growing phenomenon.

The TECOL project, a Living Lab University project focusing on Technology-enhanced Collaborative Learning, can be situated in this shift and started in March 2016 at the University KU Leuven in collaboration with two industry partners, i.e. Barco and Televic Education (for more information see https://www.kuleuven-kulak.be/tecol?lang=en). More specifically, the project questions how technology can support two important shifts in education.

1. From receptive to (inter)active learning

It is generally assumed that learning is an active process in which students are not perceived as passive consumers of new information. Rather, they only learn when they integrate this new information in their existing knowledge structures. As a consequence, effective teaching methods should promote students' cognitive activation of prior knowledge and aim for a deep understanding of what has to be learned (Linn and Eylon 2011; Mayer et al. 2009). Formative evaluation is seen as one of the cornerstones of effective interactive teaching and learning (Hattie 2009). As elaborated below (see section 2.3) assessment in general and formative assessment more specifically can be organized more efficiently and more effectively by using specific Information and Communication Technologies in education (Jahnke 2016).

2. From individual to collaborative learning

In the last decennia both educators and researchers have begun to highly stress the importance of integrating collaborative learning within classroom practice (Roschelle et al. 2010). Recent curriculum and instruction reforms have focused to a greater extent on the teaching and assessment of twenty-first century skills of which collaboration and communication skills are central to (Griffin et al. 2011). Nowadays, building and maintaining a shared understanding of the task and its solutions is seen as a core activity in education. As described below (see section 2.4), specific technology has been developed to support these collaborative processes.

To deal with these shifts in education, the TECOL project invested in the design of new learning spaces equipped with innovative educational technology as displayed in Fig. 1. The redesigned learning spaces function as a living lab, called Edulab. The picture on the left

Interactive lecture with quizzes or polls | **Collaborative learning space with screen sharing functionality**

Fig. 1 Different learning settings at the university living lab project

displays the interactive lecture, in which quizzes or polls can be launched through the TECOL-platform [specific name omitted for blind review] to increase interactivity and formative assessment during lectures. The picture on the right shows the collaborative learning space which is characterized by flexible work stations with bidirectional screen sharing between students and teachers. Up to four screens can be shared on the group screens.

Although technology implementation can offer great opportunities for innovative teaching and learning, No form of technology has the capacity to change practice (Stahl et al. 2006; p. 9) and cause educational change. Successfully facilitating technology adoption must address cognitive, emotional, and contextual concerns including both an individualistic and organizational or systemic approach (Straub, 2017). As indicated by Fullan (2007) - taken a systemic approach - educational change occurs in three phases over time, i.e. initiation, implementation and institutionalization. The goal of any change, technology reform included, is institutionalization, yet institutionalization will not occur if the change has not been successfully initiated and fully implemented by the different stakeholders. Next to that, Jaffee (1998) stated that adoption does not equal acceptance, and understanding and facilitating the process of acceptance may be more important than adoption itself. That is why this study aims to focus on the individualistic approach from the students' perspective as they are the end users. To support successful educational change within our institution, it was decided to longitudinally monitor students' technology acceptance, including both the acceptance prior to intervention (i.e. expectations) and post intervention (i.e. after experiences with the technology). In the following theoretical framework, the Technology Acceptance Model and its relation to action use will be outlined. After that, previous research about the two educational technologies will be presented.

2 Theoretical framework

2.1 Technology acceptance

Among other theories, the theory of planned behavior (TPB) and the technology acceptance model (TAM) have been widely adopted to study the intention and behavior of using technologies (Cheng 2018). The Technology Acceptance Model (TAM) is proposed by Davis (1989) and is originally based on the Theory of Reasoned Action (TRA) by Fishbein and Ajzen (1975) that has proven to be successful in predicting and explaining psychological determinants of behavior from a social psychological perspective, including a broad range of information technologies. TAM has been empirically tested in many contexts and fields (e.g. Lust et al. 2013; Venkatesh and Davis 2000). According to the study of Šumak et al. (2011) who systematically reviewed existing knowledge in the field of e-learning acceptance, TAM is the most common ground theory in literature.

Davis (1989) claims that two cognitive constructs, i.e. *perceived usefulness* (PU) and *perceived ease of use* (PEU) are of primary relevance for technology acceptance. PU is defined as the degree to which the user believes that using the technology will improve his or her learning performance, whereas PEU is the degree to which the user believes that using the technology will be user-friendly. According to TAM, PEU has an important influence on PU and both PU and PEU are major influences of an individual's attitude towards using technology (ATT) and a person's Behavioural Intention (BI) (Hu et al. 2003). However, prior research also found that the role of attitude as mediating factor between PU and PEU on BI has not always been confirmed (Burton-Jones and Hubona 2006; Venkatesh and Davis 2000) For instance, Teo (2009) compared two versions of TAM: with attitude and without attitude and found that attitude towards using technology does not contribute to the total variance in usage. Also Islam (2013) studied the direct relationship of both constructs (i.e., PU and PEU) on use, and found that both PU and PEU had a direct effect on self-reported usage. This study supported previous studies which found the attitude construct in TAM to be unnecessary (Turner et al. 2010). Based on these findings, as displayed in Fig. 2, the current study only includes PU and PEU as predictors of BI and actual use.

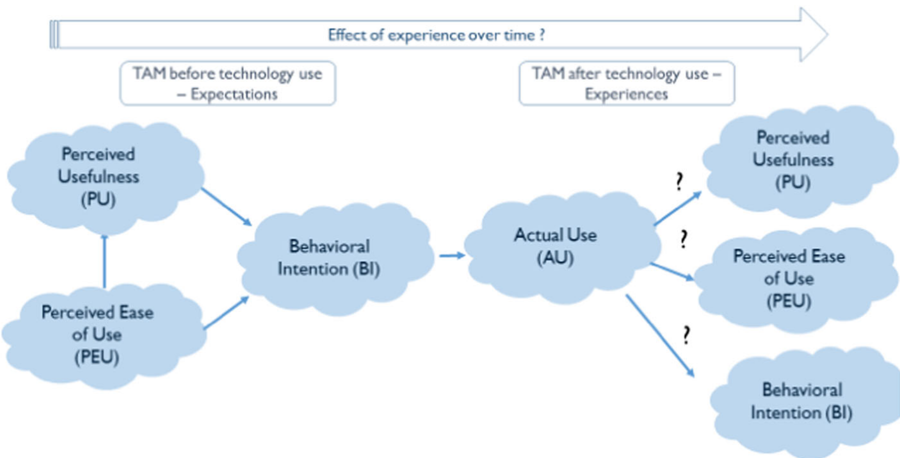


Fig. 2 The Technology Acceptance Model (TAM) from a longitudinal perspective (based on Davis 1989)

2.2 Technology acceptance from a longitudinal perspective in relation to actual use

Next to studying TAM variables related to the two specific information technology (IT) contexts, this study aimed to investigate how technology acceptance changes over time and how this is influenced by experience. Longitudinal research in relation to actual use is important for three reasons: (1) Although many studies are built on the assumption that intention is the most immediate and important predictor of a person's behaviour, it is notable that there is a gap between intentions and behaviour which is not negligible (Sheeran 2002). As noticed by Venkatesh et al. (2002), prior longitudinal studies have demonstrated that the primary predictor of future behaviour is past behaviour, not necessarily mediated by intentions (Ajzen and Madden 1986). (2) When technology acceptance is only measured at one moment, the causal relationship between independent and dependent variables should be questioned (Legris et al. 2003; Turner et al. 2010). (3) User beliefs and attitudes are key perceptions driving IT usage, yet, these perceptions may change over time as users gain first-hand experience with IT usage, which, in turn, may change their subsequent IT usage behaviour (Bhattacherjee 2001; Bhattacherjee and Premkumar 2004; Hu et al. 2003).

Prior research (e.g. Venkatesh et al. 2000; Venkatesh and Davis 2000) provides empirical evidence that user beliefs and attitudes can change over time. Venkatesh and Davis (2000) more concretely conducted a longitudinal study with three measurement points (pre-implementation, one month post-implementation, and three months post-implementation) and found that although PU and BI were quite stable over this three-month horizon, PEU, increased over time. Studies that examine or validate potential reasons for such change are limited. The work of Bhattacherjee (2001) and Bhattacherjee and Premkumar (2004) attempted to fill this gap. Bhattacherjee (2001) found that users' level of satisfaction with initial technology use is positively associated with intention for continuing use of the technology. This study even found that satisfaction with the technology use is the strongest predictor of users' continuance intention, followed by perceived usefulness as a significant but weaker predictor. In same vein, the study by Bhattacherjee and Premkumar (2004) investigated disconfirmation and satisfaction as emergent and critical factors to understand temporal changes in IT users' beliefs and attitudes, and proposed the Expectance-Disconfirmation Theory (EDT)-based process model. The empirical findings of Bhattacherjee and Premkumar (2004) showed that IT users' usefulness sand attitude perceptions tend to fluctuate over time across technological and usage contexts, and that such change tend to be more prevalent during the initial phases of IT usage than in the later phases. These findings confirm the role of disconfirmation and satisfaction in driving usefulness and belief change.

Given the need for longitudinal studies, our study aims to add value on previous literature by studying temporal changes in the TAM constructs PU, PEU and BI in two contexts of IT usage which have not been studied before, i.e. using polling & quizzing and using screen sharing. Next to that, in line with Bhattacherjee and Premkumar (2004) we investigated the effect of experience with IT usage by comparing a group of users with a group of non-users. What differs our study from previous studies, is our focus on students' technology acceptance, instead of studying teachers' attitudes and beliefs.

As depicted in Fig. 2, the current study will investigate both students' expectations of emergent technologies and students' technology acceptance over time as function of experience with the implemented educational technology. In other words, the effect of Actual Use will be investigated on the PU, PEU and BI as further explained under the section 'Research Questions'.

2.3 The interactive lecture supported by quizzes or polls

Although lecture-style teaching has remained the favored teaching method for millennia, an increasing number of scientists question its efficacy due to low levels of engagement. Student engagement is an important topic in education as engagement is associated with positive outcomes along academic, social, and emotional lines (Klem and Connell 2004). Moreover, engagement is a very good predictor of students' learning, grades, achievement test scores, retention, and graduation (Fredricks et al. 2004).

One specific technology application which can be used to increase student engagement within lectures is launching interactive quizzes by means of Classroom Response Technology (CRT), also known as clickers. Yet, the rise in usage and ownership of mobile devices (i.e. smartphone, tablet and laptop) and internet access in educational institutions has also let to the development of innovative software solutions (e.g. Socrative, Mentimeter, Kahoot) which make the clickers redundant as most students bring their own device (Pegrum 2015). By using CRT, a teacher can collect students votes on multiple choice questions or polls, facilitating dynamic formative assessments during lectures.

As visualized in Fig. 3, within the current project, the opportunity to launch quizzes during lectures and show the results to students is integrated within the project

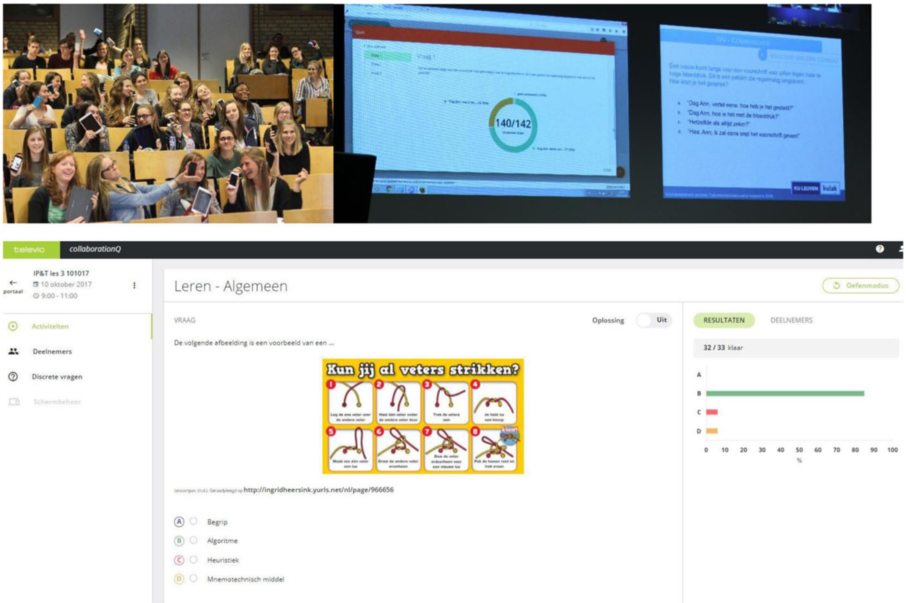


Fig. 3 The TECOL project platform for launching interactive quizzes and polls. Upper left: students responding by using their own device. Upper right: Interface of the teacher's portal to show students' results on the multiple choice question. Below: Teacher interface with participants, questions and answers

platform. Students can participate in the quizzes by using their own device when connected to WIFI.

An extensive literature review by Kay and LeSage (2009) shows that CRT has been proven to be an effective educational tool when used during classes in higher education as students attended more classes, paid more attention, and were more engaged. Moreover, there even seemed to be a positive effect of CRT on students' cognitive learning outcomes. For instance, Mayer et al. (2009) concluded that using student response systems are more effective than paper and pencil questions with regard to short-term effects on cognitive engagement and learning outcomes. However, Lantz and Stawiski (2014) indicated that the effectiveness of clickers also depends on the way they are used within the classroom. Launching interactive quizzes during or at the end of a lecture can increase performance at a later date, especially when used as review with immediate feedback about the correct answer. Next to this, a study conducted by Raes et al. (2013) found that students typically report that it is the anonymous nature of the response that encourages them to participate. This is in line with research done by Dobbins and Denton (2017) indicating that students were unequivocal that the use of mobile technology presented a good way for them to become more involved and interact within lectures. They also reveal that this solution is particularly great for students who are rather shy and would not usually vocally participate during lectures, in front of everyone or fear their question being perceived as 'stupid'.

2.4 Screen sharing for collaborative learning

One of the current trends in collaborative learning is using mobile devices for supporting the process and products of collaboration, which has been forming the field of mobile Computer-Supported Collaborative Learning (mCSCL) (Sung et al. 2017). It has been found that mobile devices can support face-to-face collaborative learning as these technologies have the potential to improve coordination, communication, organization, negotiation and mobility during learning activities (Zurita and Nussbaum 2007). Also the world wide web has become an important learning resource as it enables students to experience cognitive restructuring and develop new ideas (Kerne et al. 2007) during collaborative problem solving.

Traditionally, there were two ways of CSCL. On the one hand, in the shared approach students share a single computer. This approach can realize a high interaction and joint collaboration, yet it limits equal participation. On the other hand, in the parallel approach students each work on their individual device, yet this approach also has possible pitfalls. One pitfall is the fragmented interaction pattern (Chung et al. 2013). As students concentrate only on their own mobile computer, the level of activity awareness decreases (Scott et al. 2003). Based on these findings, it has been stressed that a common focus is critical for achieving a positive physical interdependence that stimulates discussion and continuous verbal exchange. Within this context a multi-shared visual workspace - in which up to four individual screens can be shared wireless via MirrorOp Sender - can be seen as a possible solution as this shared display groupware should lead to increased level of partner action (e.g., eye contact and hand-pointing behaviour) and smooth transitions between individual and group activities can be achieved (Chung et al. 2013) (Fig. 4).

Fig. 4 The collaboration room with screen sharing technology

3 Research questions and hypotheses of the current study

The current study aims to investigate students' initial expectations about the implementation of both technologies and how actual use over time influences students' technology acceptance. To meet these objectives, the following research questions and corresponding hypotheses were put forth:

> RQ 1. What are students' ***initial expectations*** about the usefulness (PU), ease of use (PEU) and behavioural intention (BI) to use interactive quizzes and screen sharing in university setting and does this differ across both technological contexts?
>
> H1: Because of the difference in innovativeness between the two technological contexts, we hypothesize more positive initial expectations regarding interactive quizzes compared to screen sharing technology based on the known role of previous experience in forming beliefs (Venkatesh and Davis 2000; Venkatesh et al., 2002).
>
> RQ 2. Do students' ***Perceived Usefulness (PU) and Perceived Ease of Use (PEU) change over time as function of experience*** with the implemented technologies? In other words, what is the difference between TAM variables PU and PEU prior to implementation, one semester post-implementation and one year post-implementation.
>
> H2: Based on the empirical findings of Bhattacherjee and Premkumar (2004), we hypothesize based on the expectance-disconfirmation theory that IT users' perceived usefulness will fluctuate over time and that the change will be more prevalent during the initial phases of IT usage than in the later phases.
>
> RQ3. Is the ***behavioural intention (BI) to use the technology in the future influenced by experience*** with the technology? In other words, does the BI differ between users and non-users of interactive quizzes during lectures and screen sharing during collaborative learning?
>
> H3: As mentioned above, based on the known role of actual on TAM variables (e.g. Venkatesh and Davis 2000; Venkatesh et al., 2002), we hypothesize that students who had the chance to experience interactive quizzes and screen sharing technology during their courses (i.e. the users) will have a higher BI to use the technology in the future compared to students who could not experience the technology during the courses or group sessions (i.e. the non-users).

4 Methodology

As mentioned previously, this study is based on the two year campus-wide TECOL project which was implemented from July 2016 and ended in July 2018. This means that this study was conducted in a highly ecologically valid context compared to studies in lab settings. Data collection within the overall project included focus group interviews with all stakeholders including teachers, policy staff member and industry partners, individual interviews with students and teachers, and repeated online student surveys. The data source used within the current study are the student surveys which collected mainly quantitative data based on the TAM framework. The student-survey is described more detailed in the section below.

To have a better view on the overall context of the project and get insight in the challenges and opportunities from a pedagogical, technological policy, and societal perspective, we advise to have a look at the following video reports: 1) 9 min video including interviews with students and teachers reflecting about their experiences with the technology integration (See: https://www.youtube.com/watch?v=Swa9YTp7yNw); 2) 7,5 min video including interviews with leading university staff (rector, vice rector, and financial manager of the university) and the managers of the industry partners (See: https://www.youtube.com/watch?v=GXapRGcFaWY).

4.1 Student survey & data collection

The survey was conducted online via the Websurvey service of the University based on the Limesurvey Software. At the start of the project all students were invited by email on the address generated by the university to participate in the study by filling in the questionnaire. Participation in the survey was voluntary, no prizes or money were offered to encourage completion. The survey consisted of three main parts. A first part was used to collect students' active informed consent and students' demographic information, including age, gender, student status (regular student versus working student), student year (Bachelor 1 to 3), Faculty, and ownership of mobile technology.

The second part included the TAM variables to gauge participants perceptions about both technologies. In line with the study of Venkatesh and Davis (2000) the TAM scales of perceived usefulness, perceived ease of use, and behavioural intention were measured using items adapted from Davis (1989). The original TAM variables were measured with more items (see Davis 1989, Table 3, p. 326 for the 10 item scale for perceived usefulness. As we aimed to investigate TAM related to two technological contexts in a longitudinal way, we wanted to beware of respondent fatigue (Lavrakas 2008) by reducing the original scales. Table 1 presents the adapted measurement scales. All TAM-related items were measured on a 6 point Likert scale (1 totally disagree - 6 totally agree). Each construct was based on three items. Cronbach's alpha coefficients were calculated for all constructs for all data collections (6 in total) and all measurement scales showed high reliability indicated by alpha scores above .70.

4.2 Participants & procedure

As depicted in Table 2, the procedure and participants in year 1 and year 2 were somewhat different based on the changed focus throughout the project, namely the

Table 1 Measured items regarding the different constructs included in this study adopted from the original scales of the Technology Acceptance Model (TAM) of Davis (1989) and based on Venkatesh and Davis (2000)

Variables in dataset	Regarding interactive quizzes during lectures	Regarding screen sharing during collaborative work
Perceived usefulness (PU)		
Interactive quizzes/ screen sharing will enhance[1] /enhances[2] the effectiveness of my learning process.	IAQUIPU1	COLSSPU1
Using the system will improve[1] / improves[2] my learning performance.	IAQUIPU2	COLSSPU2
I think that[1] / find[2] the interactive quizzes/ screen sharing will be[1] useful in my studies.	IAQUIPU3	COLSSPU3
Perceived ease of use (PEU)		
I think that[1] /find[2] interactive quizzes/ screen sharing: will be[1]/ flexible to use.	IAQUIPEU1	COLSSPEU1
I think that[1] /find[2] interactive quizzes/ screen sharing: will be[1]/ clear and understandable to use.	IAQUIPEU2	COLSSPEU2
Interacting with the system will[1] /does[2] not require a lot of my mental effort.	IAQUIPEU3	COLSSPEU3
Behavioral Intention (BI)		
Assuming that in future I would be able to use Interactive quizzes/ screen sharing, I intend to use it.	IAQUIBI1	COLSSBI1
Given that I have access to the system, I predict that I would use it.	IAQUIBI2	COLSSBI2
I would use the system, if I have access to it.	IAQUIBI3	COLSSBI3

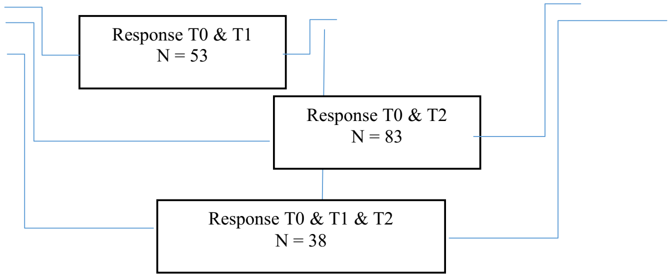
[1] In Time 0 items were formulated as expectations; [2] In Time 1 and Time 2 items formulated in the past tense to gauge students' experiences with the technology

main interest in the longitudinal effect on Technology Acceptance as function of the experience with the technology. In year 1 (starting October 2016–July 2017), all students on campus ($N = 1264$) had been invited to fill in the survey three times (T0, T1 and T2). Within the very first data collection (academic year 2016–2017, T0), the data was collected anonymously, yet from the second survey (academic year 2016–2017, T1) names were asked to be able to link students responses over time and examine possible fluctuations in technology acceptance. Once the repeated measures had been merged, the dataset was anonymised as we were not interested in identifiable information from participants.

In year 2 (starting October 2017 – July 2018), it was decided to only interrogate the first year students ($N = 534$) as these were the students without prior experiences with the technologies under investigation in the project. Next to this, the university did not want to overload the other students (second and third year bachelors) with surveys and protect them from respondent fatigue. Within year 2, the main focus became the longitudinal effect over time as function of experience with the technology. Because of that reason, the T1 and T2 survey were only sent to students who responded in T0. The amount of students who filled in at least two surveys are indicated in the rectangles displayed in Table 2.

Table 2 Procedure of the data collection and participants involved in the different measurements

	Prior to intervention Time 0: Sept. – Oct.	1 semester post intervention Time 1: Dec. – Jan.	1 year post intervention Time 2: May-June
Year 1: **Oct 2016 – June 2017** All students on campus (N = 1264)	Response of N = 278 Response rate: 21.9%	Response of N = 278 Response rate: 21.9%	Response of N = 262 Response rate: 20.7%
Year 2: **Oct 2017 – June 2018** Time 0: All first bachelor students on campus (N = 534) Time 1 & 2: students who responded Time 0 measurement (N = 188)	Response of N = 188 Response rate: 35.2%	Response of N= 56 Response rate: 29.7%	Response of N= 100 Response rate: 53.2%



4.3 Response rate

Survey response rates should be calculated as the number of returned questionnaires divided by the total sample who were sent the survey initially. It is indicated that response rates approximating 60% for most research should be the goal of researchers, yet, it has been stated that e-mail response rates may only approximate 25% to 30% without follow-up e-mail and reinforcements (Yun and Trumbo 2006). In line with these findings, Nulty (2008) indicated that online surveys achieved response rates that were much lower (on average 33%) compared with the paper-based ones (on average 56%). As shown in Table 2, the response rate for our online surveys was between 20.7% and 53.2% which is in line with the response rate expected for online surveys without reinforcement and without using extra modes (e.g. contact via telephone). Our response rate is even rather high compared to similar recently published research investigating the use of Mobile Technology in Higher Education based on a response rate of 8% (29 responses, 347 participants) (Dobbins and Denton 2017).

4.4 Data analysis

To answer **research question 1** focusing on students expectations, the quantitative data that were received via the Likert Scale responses on the TAM scales prior to intervention (T0) were analysed by means of the statistical package for social sciences, i.e. SPSS statistics 25. First, one-sample t-tests were conducted to investigate if students' mean scores differed significantly from the neutral score (3.5). Second, to test our first hypothesis, paired sample t-tests were conducted to test if the PU, PEU and BI regarding interactive quizzes prior to intervention were more positive compared to TAM regarding screen sharing technology.

In our **second research question** we aimed to capture possible fluctuations in technology acceptance as function of experience. To do that, the paired sample t-test was used on the student samples who met two criteria. First, students had to have experienced the quizzes and/or the screen sharing during the last semester or academic year as only after experience students were invited to rate the usefulness and ease of use of the specific technology. Second, the students had to have completed at least two surveys including the baseline measurement which captured student' expectations to make comparisons possible. Subsequently, these expectations prior to intervention (T0) were compared with T1 or T2 measurements which captured students' perceptions based on their experience with the technology. As visible on Table 2, 53 students filled in both the survey prior to intervention (T0) and one semester post-intervention (T1), 41 of them had experienced quizzes during lectures in the past semester and 39 had experienced screen sharing during collaborative learning. A sample of 83 students filled in both the survey prior to intervention (T0) and one year post-intervention (T2), 38 students of them had experienced quizzes during the last academic year and 50 had experienced screen sharing during collaborative learning. In addition, Related-Samples Friedman's Two Way Analysis of Variance by Ranks (3 samples) was conducted on the sample that completed the survey at T0, T1 and T2 ($N = 38$) as the assumptions for parametric testing were not met to conduct repeated measures analysis on this sample. This longitudinal analysis is needed to test our hypothesis stating that PU and PEU will fluctuate over time and that the change will be more prevalent during the initial phases of IT usage than in the later phases.

To answer **research question 3** aiming to investigate if the behavioural intention (BI) to use the technology in the future is influenced by experience with the technology independent sample t-tests for two independent samples were conducted. We investigated the effect of the factor experience (operationalized as a dichotomous variable: users = 1 versus non-users = 0) on the dependent variable BI. In this context, users were students who had the chance to experience interactive quizzes and screen sharing technology during their courses or group work. Non-users were students who could not experience the technology during the courses or did not take the opportunity to use the screen sharing technology in the group sessions. We tested the hypothesis that students who had the chance to experience interactive quizzes and screen sharing technology during their courses (i.e. the users) would have a higher BI to use the technology in the future by means of the responses in year 1.

Although the PU and the PEU in the Time 1 and Time 2 was only evaluated by students with experience, the intention to use the technology in the future (BI) was gauged both by students with and without experience which are indicated as users versus non-users in this study. The T1 sample included 278 students. With regard to interactive quizzes there were 192 users vs. 86 non-users; regarding screen sharing there were 121 users vs. 157 non-users. T2 sample included 262 students, regarding interactive quizzes there were 120 users vs. 142 non-users; regarding screen sharing 151 there were users vs. 111 non-users.

5 Results

5.1 RQ 1: Students' expectations towards interactive quizzes and screen sharing technology

Figure 5 depicts the mean values of **students' expectations** regarding both using quizzes during lectures and regarding using the screen sharing technology during

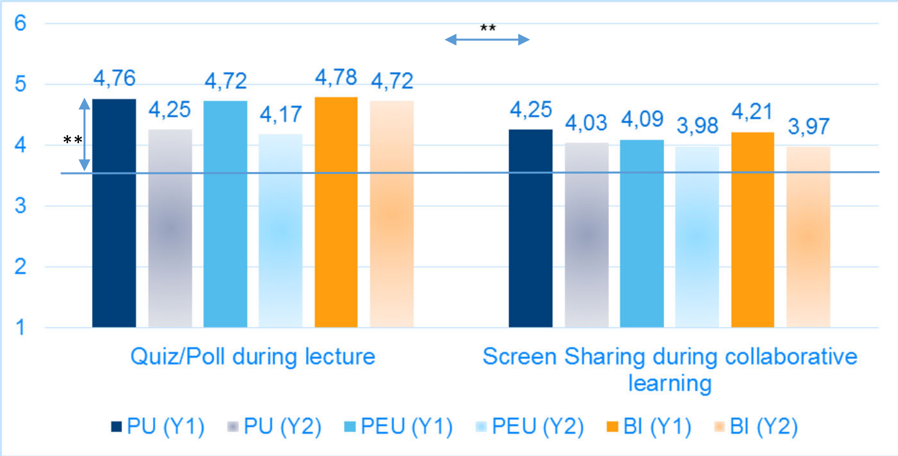


Fig. 5 Students' expectations regarding the Perceived Usefulness (PU), Perceived Ease of Use (PEU), and Behavioural Intention (BI) of the technology. ** Indicates significance with p-level < 0.01

collaborative learning. First, based on the one-sample t-tests, we found that all means differed significantly from the neutral score (3.5) which indicates ***positive expectations towards both technologies***. Yet, based on paired sample t-tests, we found that students' expectations of quizzes during lectures were significantly higher than students' expectations of the screen sharing technology. This result held both for year 1 and year 2 and for all TAM constructs, i.e. PU, PEU, and BI. These findings confirm our first hypothesis. We further elaborate on this finding in the discussion section.

5.2 RQ 2: Fluctuations in technology acceptance as function of experience

Table 3 summarizes the mean values of both students' expectations towards and experiences with the technology. If we compare PU and PEU prior to

Table 3 Differences between expectations towards and experiences with interactive quizzes

Technology acceptance of interactive quizzes during lectures						
	Comparison between pre intervention and one semester post intervention (N = 41)			Comparison between pre intervention and one year post intervention (N = 38)		
	M (SD) Expectations (T0)	*M (SD)* Experiences one semester post intervention (T1)	Sign. level	*M (SD)* Expectations (T0)	*M (SD)* Experiences one year post intervention (T2)	Sign. level
PU	4.41 (.71)	4.49 (.72)	p = .49	4.42 (.72)	4.50 (.78)	p = .63
PEU	4.34 (.66)	4.89 (.58)	p < .001	4.26 (.59)	4.93 (.64)	p < .001

PU = Perceived usefulness, PEU = Perceived Ease of Use. Significance levels are based on the paired sample t-test

Table 4 Differences between expectations towards and experiences with screen sharing

Technology acceptance of screen sharing during collaborative learning						
	Comparison between pre intervention and one semester post intervention ($N = 39$)		Sign. level	Comparison between pre intervention and one year post intervention ($N = 50$)		Sign. level
	M (SD) Expectations (T0)	*M (SD)* Experiences (T1)		*M (SD)* Expectations (T0)	*M (SD)* Experiences (T2)	
PU	4.14 (.75)	4.51 (.75)	$p < .05$	4.14 (.85)	4.51 (.99)	$p < .05$
PEU	4.25 (.76)	4.79 (.69)	$p < .001$	4.13 (.84)	4.60 (.93)	$p < .001$

PU = Perceived usefulness, PEU = Perceived Ease of Use. Significance levels are based on the paired sample t-test

intervention (T0) with PU and PEU post intervention (T1 or T2), we found no significant difference between the expected usefulness (PU) and the experienced usefulness of quizzes during lectures. Yet, a significant increase was found regarding the PEU after experiencing the interactive quizzes. As shown in Table 4, with regard to the screen sharing technology, both the PU and the PEU significantly increased after experience with the technology. This means that the initial difference in technology acceptance regarding both technologies decreased after experiencing the technology.

In addition, the related samples Friedman's Two Way Analysis of Variance by Ranks (3 samples) was conducted on the sample that completed the survey at T0, T1 and T2 ($N = 38$) to check for the longitudinal effect of experiencing the technology during Year2. Longitudinal mean values are presented in Fig. 6 and Table 5. In line with previous finding, regarding the PU for quizzes, no significant differences were found in the distributions of T0, T1 and T2 measurements ($p = 0.58$), yet the PEU of quizzes significantly changed over time ($p = 0.04$). Regarding the screen sharing technology, both the PU ($p < 0.01$)

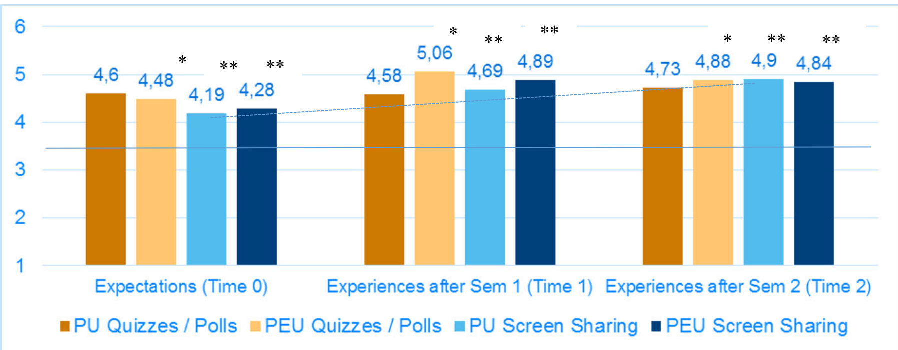


Fig. 6 Students' Perceived Usefulness (PU) and Perceived Ease of Use (PEU) over time. * Indicates significance with p-level < 0.05 ** Indicates significance with p-level < 0.01

Table 5 Evolution of PU and PEU from pre intervention till one year post intervention regarding interactive quizzes (N = 16) and screen sharing technology (N = 21)

	M (SD) Expectations (T0)	*M (SD)* Experiences, one semester post intervention (T1)	*M (SD)* Experiences, one year post intervention (T2)	Sign. level
PU quizzes/polls	4.60 (.71)	4.58 (.87)	4.73 (0.79)	$p = .58$
PEU quizzes/polls	4.48 (.40)	5.06 (.41)	4.88 (0.78)	$p < .05$
PU screen sharing	4.19 (.84)	4.69 (.84)	4.9 (0.71)	$p < .01$
PEU screen sharing	4.28 (.92)	4.89 (061)	4.84 (0.91)	$p < .01$

PU = Perceived usefulness, PEU = Perceived Ease of Use. Significance levels are based on the non-parametric test Related-Samples Friedman's Two Way Analysis of Variance by Ranks (3 samples)

and the PEU ($p < 0.01$) significantly changed over time and a positive trend line can be observed in Fig. 6. As hypothesized PU and PEU fluctuate over time and the change is more prevalent during the initial phases, in this case after one semester, than in the later phase, after one academic year.

5.3 RQ 3: Is the intention to use the technology in the future influenced by experience with the technology?

Results of the independent sample t-tests are displayed in Table 6.

Significant differences were found between users and non-users meaning that the intention and hope to use the technology during future courses is positively influenced by the experience with the technology. Yet, it is noteworthy that the difference between users and non-users is higher for screen sharing which is in line with the lower expectations for screen sharing compared to interactive quizzes presented under research question 1. Table 6 only displays the results of T1 and T2 in Year 1, but the same trend could be replicated in Year 2.

Table 6 Behavioral intention between users and non-users

Technology acceptance of screen sharing during collaborative learning						
	Comparison between users and non-users one semester post intervention ($N = 278$)			Comparison users and non-users one year post intervention ($N = 262$)		
	Users M (SD)	*Non-users M (SD)*	Sign. level	*Users M (SD)*	*Non-users M (SD)*	Sign. level
BI quizzes/polls	4.90 (0.79) ($N = 192$)	4.41 (1.18) ($N = 86$)	$p < .01$	4.48 (0.92) ($N = 120$)	4.33 (0.73) ($N = 142$)	$p < .05$
BI screen sharing	4.5 (1.04) ($N = 121$)	3.81 (1.17) ($N = 157$)	$p < .01$	4.72 (0.87) ($N = 151$)	3.89 (1.13) ($N = 111$)	$p < .01$

BI = Behavioural intention. Significance levels are based on the independent sample t-test for two independent samples

6 Discussion & conclusion

This study reports about students' technology acceptance within the TECOL project, a two-year campus-wide living lab project which aims at increasing the interaction and collaboration within university education by means of technology integration. The integration of learning technologies is increasing in educational contexts at all levels from primary to secondary and higher education; however, this integration is not always supported by applied research. This study zooms in on the use of technology-enhanced interactive quizzes during lectures and on the use of screen sharing technology during collaborative learning sessions. The Technology Acceptance Model (TAM) is used to investigate the perceived usefulness, the perceived ease of use and the behavioural intention towards these educational technologies. By investigating the longitudinal effect over time and by including the effect of actual use of interactive quizzes and screen sharing technology during courses, this study contributes to the research literature in which TAM variables were not yet measured longitudinally within these contexts taken into account the students' perspective and the effect of actual use. As our study integrates two technological contexts and includes different samples investigated over a two year project, our study provided empirical evidence for the generalizability of the findings across technologies (interactive quizzes and screen sharing) and usage contexts (interactive lectures and collaborative learning settings).

More specifically, our study revealed that all students have a positive predisposition to the usefulness, ease of use, and behavioural intention of using interactive quizzes and screen sharing technology in university settings. Yet, in line with previous research (Bhattacherjee and Premkumar 2004; Venkatesh and Davis 2000) a significant difference was found regarding both technologies. Students' expectations regarding the interactive quizzes were significantly higher compared to the screen sharing technology. This finding can probably be attributed to the known role of previous experience in forming this belief as Venkatesh et al. (2002) noticed that longitudinal studies have demonstrated that the primary predictor of future behaviour is past behaviour. As interactive software (e.g. Socrative, Mentimeter, Kahoot) have been on the market for several years, and probably more acknowledged and experienced by students in the past, this can have created a higher technology acceptance at the start of the project regarding the use of quizzes at university level. In contrast to this, screen sharing technology is a technology no student could have seen or used in advance as it was recently developed.

Whereas an initial difference in expectations was shown, this difference disappeared after experience with both screen sharing and interactive quizzes. Regarding both technologies, we found evidence that beliefs and attitudes towards technology use positively change over time after actual use. This means that the TAM results after experience exceeded the expectations. Our longitudinal results including prior expectations, experiences after one semester and experiences after one academic year moreover counter the possible novelty effect as no decrease in technology acceptance was found.

Although this study did not conduct Structural Equation Modelling which is frequently used within TAM research to understand the relationships between the different constructs, our results contributes to previous TAM research including a longitudinal dimension by providing new evidence that actual use of a particular technology significantly affects PU, PEU and the continued usage intention (BI) which, in turn, may change subsequent IT behaviour (Bhattacherjee 2001; Bhattacherjee and Premkumar 2004; Hu et al. 2003). This means that actual use should not only be seen as an outcome in the TAM model, but also as an explaining variable when investigating technology acceptance from a longitudinal perspective. Yet, we should also be careful when drawing conclusions as this study is based on self-reporting data regarding use and the usage variable is only operationalized as a dichotomous variable (use versus non-use). More research is needed taking into account a more fine-grained measurement of actual use.

These positive findings regarding the specific technologies, i.e. interactive quizzes and screen sharing, are in line with previous research and reinforce the idea that introducing technology into university settings presents the potential for positive learning experiences meeting the need for interactive and collaborative learning in the twenty-first Century (Spanjers et al. 2015). Although interactive quizzes have been studies in the past (e.g. Kay and LeSage 2009; Dobbins & Denton, 2017) no previous research was found focusing on screen sharing technology. Our study met the research gap as indicated by Sung and colleagues (Sung et al. 2017) by showing evaluative evidence for the substantial contribution of screen sharing to collaborative learning. To the best of our knowledge, this is the first study exploring the acceptance and user experience of this screen sharing technology for collaborative learning. There are previous studies investigating a shared group screen, but this group screen could only display one individual display at once. The screen sharing functionality that is investigated in this study is innovative compared to previous application studied in research as the screen sharing technology is characterized by a multi-shared visual workspace meaning that up to four individual screens can be shared.

This study also contributes to the idea that technology adoption is a complex, inherently developmental process in which individuals can construct unique yet malleable perceptions of technology (Straub, 20017). Yet, although this study presents evidence that students' technology acceptance increased based on experience with interactive quizzes during classes and using screen sharing during collaborative learning, it is important to realize that the technology itself will not cause educational change (Stahl et al. 2006). We have to realize that although these technologies can improve the learning experience, this study cannot provide any evidence of the impact of these technologies on actual learning outcomes. More research is needed to fully elucidate the process, products and conditions of technology implementation and to include the specific way of using the technology as a determining factor. By means of quasi-experimental design studies within the same project, we are investigating the effect of using these technologies on learning outcomes (see Raes et al. 2018; Raes et al. 2019).

Next to this, follow-up research should also focus on teacher's perceptions and look into organizational processes to further support the gradual adoption of technological tools in education as suitable method not only for engaging students, but also for supporting more effective learning and teaching.

This study shows that there is no need to convince the student population, yet, as indicated by other research, a more challenging task in educational reform is to motivate the teaching staff as institutionalization of technology reform means that the new practices are embraced by everyone responsible for teaching and learning and that the practices lead to the intended results (Fullan, 2007). As well, as indicated by Hu et al. (2003), as a group, teachers may subtly differ from end-users in ordinary business settings. For instance, teachers are relatively independent and have considerable autonomy over their teaching activities, including technology choice and use. This suggests a professional orientation that might lead to differences in teachers' technology acceptance compared to that of business users. User training has been found to have an important impact on user acceptance and use (Venkatesh et al. 2002). As stated by Venkatesh and Davis (2000), empirically demonstrating to users the effectiveness of a new system (conceptualized as result demonstrability) may provide important leverage for increasing user acceptance. These research findings can be used in training settings as evidence to encourage more teachers to invest in new ways of teaching and to show that these technologies are a worthwhile, pedagogical tool, and not only an amusing novelty.

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Compliance with ethical standards

Conflict of interest The authors of this manuscript, i.e. Annelies Raes and Fien Depaepe, declare no to have any conflict of interest.

Ethical approval & informed consent This research involves human participants, but this research project has been reviewed and approved by the Social and Societal Ethics Committee (https://ppw.kuleuven.be/home/onderzoek/SMEC). Informed consent was obtained from all individual participants included in the study.

References

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology, 22*(5), 453–474.

Bhattacherjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly, 25*, 351–370.

Bhattacherjee, A., & Premkumar, G. (2004). Understanding changes in belief and attitude toward information technology usage: A theoretical model and longitudinal test. *MIS Quarterly, 28*, 229–254.

Burton-Jones, A., & Hubona, G. S. (2006). The mediation of external variables in the technology acceptance model. *Information & Management, 43*(6), 706–717.

Cheng, E. W. L. (2018). Choosing between the theory of planned behavior (TPB) and the technology acceptance model (TAM). *Educational Technology Research and Development., 67*, 21–37. https://doi.org/10.1007/s11423-018-9598-6.

Chung, C. W., Lee, C. C., & Liu, C. C. (2013). Investigating face-to-face peer interaction patterns in a collaborative web discovery task: The benefits of a shared display. *Journal of Computer Assisted Learning, 29*(2), 188–206. https://doi.org/10.1111/j.1365-2729.2012.00493.x.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(1), 319–340.

Dobbins, C., & Denton, P. (2017). MyWallMate: An investigation into the use of Mobile Technology in Enhancing Student Engagement. *TechTrends, 61*(6), 541–549. https://doi.org/10.1007/s11528-017-0188-y.

Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: And introduction to theory and research*. MA: Addsion-Wesley Reading.

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research, 74*(1), 59–109. https://doi.org/10.3102/00346543074001059.

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). New York: Teachers College Press.

Griffin, P., Care, E., & McGaw, B. (2011). The changing role of education and schools. In P. Griffin, B. McGaw, & E. Care (Eds.), *Assessment and teaching 21st century skills*. Heidelberg: Springer.

Hattie, J. (2009). Visible learning. A synthesis of over 800 meta-analyses relating to achievement. Taylor & Francis.

Hu, P. J. H., Clark, T. H., & Ma, W. W. (2003). Examining technology acceptance by school teachers: A longitudinal study. *Information & Management, 41*(2), 227–241.

Islam, A. K. M. N. (2013). Investigating e-learning system usage outcomes in the university context. *Computers and Education, 69*, 387–399. https://doi.org/10.1016/j.compedu.2013.07.037.

Jaffee, D. (1998). Institutionalized resistance to asychronous learning networks. *Journal of Asychronous Learning Networks, 2*(2), 21–32.

Jahnke, I. (2016). Digital didactical designs: Teaching and learning in CrossActionSpaces. Routledge.

Kay, R. H., & LeSage, A. (2009). A strategic assessment of audience response systems used in higher education. *Australasian Journal of Educational Technology, 25*(2), 235–249. https://doi.org/10.1016/j.compedu.2009.05.001.

Kerne, A., Koh, E., Smith, S., Choi, H., Graeber, R., & Webb, A. (2007). Promoting emergence in information discovery by representing collections with composition. In *Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition - C&C '07* (p. 117). New York, New York, USA: ACM Press. https://doi.org/10.1145/1254960.1254977.

Klem, A. M., & Connell, J. P. (2004). Relationships matter: Linking teacher support to student engagement and achievement. *Journal of School Health, 74*(7), 262–273. https://doi.org/10.1111/j.1746-1561.2004.tb08283.x.

Lantz, M. E., & Stawiski, A. (2014). Effectiveness of clickers: Effect of feedback and the timing of questions on learning. *Computers in Human Behavior, 31*, 280–286. https://doi.org/10.1016/J.CHB.2013.10.009.

Laurillard, D. (2002). *Rethinking University teaching. A conversational framework for the effective use of learning technologies*. London: Routledge.

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Thousand Oaks: Sage Publications, Inc.. https://doi.org/10.4135/9781412963947.

Legris, P., Ingham, J., & Collerette, P. (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information and Management, 40*(3), 191–204. https://doi.org/10.1016/S0378-7206(01)00143-4.

Linn, M. C., & Eylon, B.-S. (2011). *Science learning and instruction. Taking advantage of technology to promote knowledge integration*. New York: Routledge.

Lust, G., Elen, J., & Clarebout, G. (2013). Students' tool-use within a web enhanced course: Explanatory mechanisms of students' tool-use pattern. *Computers in Human Behavior, 29*(5), 2013–2021. https://doi.org/10.1016/j.chb.2013.03.014.

Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., Bulger, M., Campbell, J., Knight, A., & Zhang, H. (2009). Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology, 34*(1), 51–57. https://doi.org/10.1016/j.cedpsych.2008.04.002.

Nulty, D. D. (2008). The adequacy of response rates to online and paper surveys: What can be done? *Assessment and Evaluation in Higher Education, 33*(3), 301–314. https://doi.org/10.1080/02602930701293231.

Pegrum, M. (2015). *Mobile learning: What is it and what are its possibilities* (p. 142). Teaching and Digital Technologies: Big Issues and Critical Questions.

Raes A., Vens C., Vanneste P., Depaepe F. (2018). Teaching for versus through problem solving: Impact on teaching and learning. In: Rethinking learning in the digital age: Making the learning sciences count: vol. 1 (408-415). Presented at the International Conference of the Learning Sciences (ICLS) 2018, London, UK. ISBN: 978-1-7324672-0-0.

Raes, A., Vanderhoven, E., & Schellens, T. (2013). Increasing anonymity in peer assessment by using classroom response technology within face-to-face higher education. *Studies in Higher Education, 40*(1), 178–193. https://doi.org/10.1080/03075079.2013.823930.

Raes, A., Vanneste, P., Windey, I., Van den Noortgate, W. & Depaepe, F. (2019). Monitoring student engagement through multimodal analytics to improve learning across spaces. To be presented at the Research Community W000519N – First meeting Workshop Leuven, October 16-18, 2019.

Roschelle, J., Rafanan, K., Bhanot, R., Estrella, G., Penuel, B., Nussbaum, M., & Claro, S. (2010). Scaffolding group explanation and feedback with handheld technology: Impact on students' mathematics learning. *Educational Technology Research and Development, 58*(4), 399–419.

Scott, S. D., Grant, K. D., & Mandryk, R. L. (2003). System guidelines for co-located, collaborative work on a tabletop display. In *ECSCW 2003* (pp. 159–178). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-010-0068-0_9.

Sheeran, P. (2002). Intention—Behavior relations: A conceptual and empirical review. *European Review of Social Psychology, 12*(1), 1–36. https://doi.org/10.1080/14792772143000003.

Spanjers, I. A. E., Könings, K. D., Leppink, J., Verstegen, D. M. L., de Jong, N., Czabanowska, K., & van Merriënboer, J. J. G. (2015). The promised land of blended learning: Quizzes as a moderator. *Educational Research Review, 15*, 59–74. https://doi.org/10.1016/j.edurev.2015.05.001.

Stahl, G., Koschmann, T., & Suthers, D. D. (2006). Computer-supported collaborative learning: An historical perspective. *Cambridge Handbook of the Learning Sciences*, 409–426. https://doi.org/10.1017/CBO9781139519526.029.

Straub, E. T. (2017). Understanding Technology Adoption: Theory and Future Directions for Informal Learning. Review of Educational Research 79 (2):625-649

Šumak, B., Hericko, M., & Pušnik, M. (2011). A meta-analysis of e-learning technology acceptance: The role of user types and e-learning technology types. *Computers in Human Behavior, 27*, 2067–2077. https://doi.org/10.1016/j.chb.2011.08.005.

Sung, Y.-T., Yang, J.-M., & Lee, H.-Y. (2017). The effects of Mobile-computer-supported collaborative learning: Meta-analysis and critical synthesis. *Review of Educational Research, 87*(4), 768–805. https://doi.org/10.3102/0034654317704307.

Teo, T. (2009). Is there an attitude problem? Reconsidering the role of attitude in the TAM. *British Journal of Educational Technology, 40*(6), 1139–1141. https://doi.org/10.1111/j.1467-8535.2008.00913.x.

Turner, M., Kitchenham, B., Brereton, P., Charters, S., & Budgen, D. (2010). Does the technology acceptance model predict actual use? A systematic literature review. *Information and Software Technology, 52*(5), 463–479. https://doi.org/10.1016/j.infsof.2009.11.005.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*, 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926.

Venkatesh, V., Morris, M. G., & Ackerman, P. L. (2000). A longitudinal field investigation of gender differences in individual technology adoption decision making processes. *Organizational Behavior and Human Decision Processes, 83*(1), 33–60.

Venkatesh, V., Speier, C., & Morris, M. G. (2002). User acceptance enablers in individual decision making about technology: Toward an integrated model. *Decision Sciences, 33*(2), 297–316.

Yang, J., Schneller, C., & Roche, S. (2015). *The Role of Higher Education in Promoting Lifelong Learning The Role of Higher Education in Promoting Lifelong Learning*. Retrieved January 2019 from http://unesdoc.unesco.org/images/0023/002335/233592e.pdf

Yun, G. W., & Trumbo, C. W. (2006). Comparative response to a survey executed by post, E-mail, & web form. *Journal of Computer-Mediated Communication, 6*(1). https://doi.org/10.1111/j.1083-6101.2000.tb00112.x.

Zurita, G., & Nussbaum, M. (2007). A conceptual framework based on activity theory for mobile CSCL. *British Journal of Educational Technology, 38*(2), 211–235. https://doi.org/10.1111/j.1467-8535.2006.00580.x.

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