Predictive Learning Analytics and University Teachers: Usage and perceptions three years post implementation

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ABSTRACT

Predictive learning analytics (PLA) dashboards have been used by teachers to identify students at risk of failing their studies and provide proactive support. Yet, very few of them have been deployed at a large scale or had their use studied at a mature level of implementation. In this study, we surveyed 366 distance learning university teachers across four faculties three years after PLA has been made available across university as business as usual. Informed by the Unified Theory of Acceptance and Use of Technology (UTAUT), we present a context-specific version of UTAUT that reflects teachers' perceptions of PLA in distance learning higher education. The adoption and use of PLA was shown to be positively influenced by less experience in teaching, performance expectancy, self-efficacy, positive attitudes, and low anxiety, while negatively influenced by a lack of facilitating conditions and low effort expectancy, indicating that the type of technology and context within which it is used are significant factors determining our understanding of technology usage and adoption. This study provides significant insights as to how to design, apply and implement PLA with teachers in higher education.

CCS CONCEPTS

• **Applied computing**; • **Education**; • **Distance learning**; • **Computer-assisted instruction**; • **Computing methodologies**; • **Machine learning**;

KEYWORDS

Predictive learning analytics, University teachers, Technology Adoption, UTAUT

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1 INTRODUCTION

The sudden shift to online learning following the Covid-19 pandemic has drawn increased and renewed interest in the use of Predictive Learning Analytics (PLA) in higher education. By visualising student journeys and predicting future performance, PLA has been viewed as an innovation that can enhance "the quality of online and distance higher education and offer learners personalised and responsive learning experiences" [7]. In particular, a review of eleven studies noted overall improvements in grades and course activity following interventions based on learning analytics, such as a 6% increase in overall grades, a 10% increase in As and Bs, and 11-25% higher student retention [22].

While several variables are used to predict students' future performance, the best predictors of student performance were shown to be (in order of significance): 1) students' previous grades and class performance, 2) e-learning activity, 3) students' demographics and 4) students' social information [8]. Despite promising outcomes, several challenges accompany the use of learning analytics such as small student samples used to produce predictions raising concerns about the generalisability of findings, a constrained view of engagement data that are only focused on Virtual Learning Environment (VLE) activity, and more accurate predictions for 'pass' than 'fail' students as the latter are typically considerably fewer in datasets analysed [28]. Issues of equity and social justice are increasingly highlighted. Data fed into predictive systems should not be seen as neutral or objective; it reconfigures existing societal relations, practices, and inequalities by communicating certain narratives while restricting others [17].

Several PLA approaches have been developed and tested with university students and teachers [12, 24], yet most of them are small-scale and focus on the early days of PLA adoption [13, 14]. Little is known about how teachers' perceptions and usage change or develop over time and after PLA reaches a level of maturity, that is, been integrated into the teaching practice for a period of time and viewed as 'business as usual'. In this paper, we focus on one of the few large-scale implementations of PLA in higher education at an online and distance learning university, The Open University UK. We examine teachers' perceptions and usage three years after PLA has been made available to teachers across all University Faculties (as an optional tool that can support online teaching and student retention). We built on our extensive body of work engaging with

university teachers since PLA inception and early adoption (e.g., [1-7]) to capture teachers' perceptions at a more mature stage of implementation. Our previous findings [3] showcased that the engagement of teachers with PLA varies across and within faculties with most teachers found to be randomly checking PLA. There is yet a need to understand how to systematically engage teachers with PLA, for systematic use was shown to relate to better student support and enhanced learning outcomes [7].

The aim of this study is to capture the perspectives of university teachers across four faculties about the Early Alert Indicators (EAI) dashboard, a PLA system that has been made available for use in teaching for the last three years. The Research Objectives (ROs) of this study are: RO1: To capture and explain perceived EAI usage by teachers, and RO2: To identify any differences in perceptions of EAI usage amongst (i) university Faculties and (ii) new and experienced teachers. In regard to RO2, in our interactions with teachers (to provide training and support), we observed two trends: a) an emerging interest by newcomer teachers in using EAI and b) Faculty members requesting information tailored to their Faculty courses and teachers. These observations motivated the formation of RO2. To inform our understanding of technology adoption and usage, we drew from an established theory in the field, the Unified Theory of Adoption and Use of Technology (UTAUT). UTAUT informed the design of the instrument for data collection and our subsequent interpretation of findings.

2 PLA DASHBOARDS AND TEACHERS

Student learning analytics such as engagement with VLE and future assignment performance are mainly presented to teachers in the form of dashboards with graphs and tables. One of the challenges teachers face is the interpretation of dashboard data. In response to this, other forms of representation, such as storytelling, are under exploration [15], while co-designing dashboards with teachers at the centre is proposed as the way forward [19]. An increasing number of studies point to positive effects from teachers' engagement with analytics; this refers to enhanced understanding of learning processes, provision of individualised and timely interventions, better course design [18], better student performance when accessing analytics than without [4], especially for disadvantaged students including those from low socio-economic backgrounds [6], and effective support to collaborative student work [10]. Yet, some teachers are found to be sceptical about the use of analytics in teaching, due to their data-driven nature [19] and due to concerns about the ethical implications of using student data without students being involved in a dialogue about it [20].

In this paper, we examined a specific PLA system, the Early Alerts Indicators (EAI) dashboard (Figure 1), designed at The Open university UK, an online and distance learning institution. EAI presents student data from two sources: a) a machine learning system producing short-term, weekly predictions about whether a student is going to submit their next Teacher Marked Assignment (TMA); a traffic light system is used to indicate whether a student will submit and pass their next assignment, with 'green' pointing to success, 'red' to non-submission or failing and 'amber' to submission but a borderline score (40-54), and b) a regression-based system showing long-term predictions of whether a student will

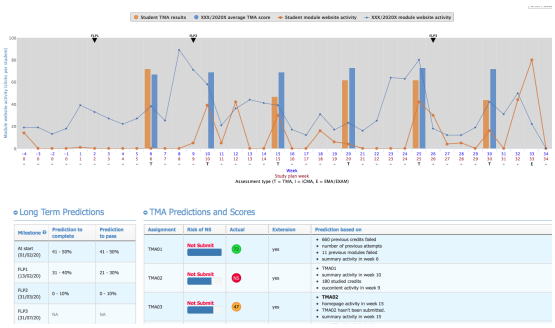

Figure 1: The EAI dashboard showing VLE engagement, assignment performance and predictions for an individual student

reach certain milestones such as complete and pass a course. In addition, a graph shows students' engagement with course material, their individual assignment performance and how this relates to students' performance the year before. Data are presented at both the group and individual student levels.

3 THEORETICAL FRAMEWORK

3.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a synthesis of a number of models, such as the Technology Acceptance Model (TAM) aiming to explain the intention to use and actual use of a technology. Four factors were found to explain 70% of the variance in people's intention and use of a technology: a) performance expectancy refers to perceived benefits emerging from using a technology, b) effort expectancy refers to how easy it is to use the technology, c) social influence refers to significant others and whether they think that the technology should be used, d) facilitating conditions refers to whether users think that there is a structure in place to support use at the organisation level and a technical one [30]. The model distinguishes between factors influencing behavioural intention to use technology - performance expectancy, effort expectancy and social influence - and actual use influenced by behavioural intention and facilitating conditions. These factors are moderated by individual user characteristics, including gender, age, experience, and voluntariness of technology use [30]. For example, it was found that the relationship between performance expectancy and behavioural intention is stronger for men and younger users [27].

UTAUT has been applied in 1,935 independent samples with 737,112 users in areas such as mobile banking, e-government and e-learning [11]. The model has been either used as it is or modified to include other models potentially explaining its use. In some studies, findings contradicted the original model with, for example, performance expectancy not affecting behaviour intention to accept mobile payments [26]. Other studies have found that UTAUT cannot explain the use of certain types of technologies [25]. A recent meta-analysis [11] concluded that it "remains unclear which higher-level contextual factors exert moderating influences on UTAUT in addition to its individual-level moderators (e.g., age, gender)" and proposes that cultural (e.g., individualism vs collectivism cultures)

and technology-specific characteristics should be considered in future studies. In terms of technology characteristics, three characteristics are proposed (p.21): "(1) transaction-based vs non- transaction-based technologies, (2) internet-based vs. non-internet-based technologies, and (3) mobile-based vs. non-mobile-based technologies". For example, internet-based technologies may require increased effort (effort expectancy) as they are not tangible, thus harder to understand, and require support. In this paper, PLA could be seen as a non-transaction, internet and mobile-based (if accessed via a mobile device) technology, which could potentially necessitate support to comprehend and use. Results of the above meta-analysis confirmed the influence of original UTAUT predictors that explained 63,2% of variance in behavioural intention. Weaker effects were noted for social influence and facilitating conditions. In terms of use, while habit and behaviour intention were strongly predicting technology use, facilitating conditions were a weak predictor.

3.2 Education studies using UTAUT

UTAUT has been applied in several education studies to explain technology adoption and usage by teachers and teaching-related staff. The theory was replicated in some of these studies, whereas in others unique insights contradicting UTAUT emerged. For example, the use of electronic document management systems by university academic and administrative staff showed that only performance expectancy and social influence positively affected behavioural intention. Contrary to the theory, effort expectancy did not have a positive effect [9]. In contrast, the acceptance and use of mobile technologies by academic staff verified UTAUT2 in a higher education context showing that academics' behavioural intention and usage were affected by performance expectancy, facilitating conditions, hedonic motivation and habit. Proposed moderating factors of age, gender, teaching experience and discipline were also verified [16].

In other educational contexts, high school teachers' intention to use whiteboards in teaching was positively influenced by performance expectancy, effort expectancy and social influence. Time using whiteboards was influenced by positive behavioural intention and facilitating conditions [27]. Adoption and use of MOOCs in teaching was influenced by performance expectancy. Yet, facilitating conditions were found to be a barrier of use. To adequately understand MOOC adoption, additional variables (not captured by UTAUT) should be examined, such as variables related to the learner and their language competencies [23].

In relation to the use of PLA in higher education, informed by UTAUT, eleven in-depth interviews with university teachers identified that teachers who used PLA did so due to performance expectancy, effort expectancy and social influence. Similarly, teachers who were less engaged with PLA presented decreased performance expectancy and reported a lack of facilitating conditions related to training and understanding of the predictive data [1]. In the case of PLA, performance expectancy was explained by: a) the provision of additional student insights on a regular basis (weekly) a teacher could not access otherwise, b) support that is proactive and timely to students who need it, c) making student monitoring systematic for teachers, d) confirming teachers' intuition about students who need extra support [1]. These dimensions of performance expectancy informed the creation of a set of items for measuring performance expectancy specific to PLA (Appendix 1). Drawing from the same study and teachers' reporting difficulties understanding PLA features, one new item was added to the effort expectancy subscale.

4 METHODOLOGY

4.1 Sample

We collected data from 366 self-selected teachers, the majority of whom were female (n=252), 103 male, and nine (n=9) preferred not to declare any gender information (2 missing values). In terms of years of teaching experience, 26% were teachers very new to the profession, 19.5% had 3-10 years of teaching, 39% had between 11 and 20 years of experience, and 15.6% had 21+ years of experience. Participants came from the four Faculties of the University under study: STEM: Science, Technology, Engineering and Maths (n=126, 7% of faculty); FASS: Faculty of Arts and Social Sciences (n=96, 6%); WELS: Wellbeing, Education, and Language Studies (n=88, 6%); FBL: Faculty of Business and Law) (n=37, 5%), multiple faculties (n=17) (2 missing). A significant number of teachers stated that they are currently using the EAI dashboard (42%) (Figure 2). The rest of the participants were rather equally split amongst the following three groups: those who had not previously heard about it (via the survey) (19%), those who had heard of it but had not used it to date (18%) and those who tried it in the past but were not using it at the moment (20%).

4.2 Methods of data collection

We used the central university's email service to circulate an email announcement to all teachers working at the university under study. We invited teachers who are using EAI as well as those who were not using it at the moment of email circulation, as this would provide us with insights about possible obstacles inhibiting EAI usage. Also, we encouraged teachers who heard about EAI for the first time (via the email announcement) to also follow the link to the study; those teachers were given a general overview of EAI and directions as to where they could find more information about it. This was seen as a mechanism to raise awareness about EAI via the email circulation of the study. Participating teachers were asked to complete an online questionnaire, the questions of which were customised depending on whether they were using or not the EAI dashboard. An email reminder was sent out 10 days after the first email circulation. The study received ethical approvals from the Open University's ethical body.

The questionnaire included the following sections: a) consent-related questions in accordance with the University's ethical requirements, b) background questions including faculty, years of teaching, and gender, c) a routing question determining whether a teacher is currently using or not the EAI dashboard (Figure 2), d) those who have heard of the EAI dashboard, yet they had not used it were asked the question: What are the reasons you have not tried the EAI dashboard yet?, e) participants who used EAI in the past or are currently using it were asked questions about (i) dashboard features they had used (an accompanying document was showing screenshots of each feature to help participants recall

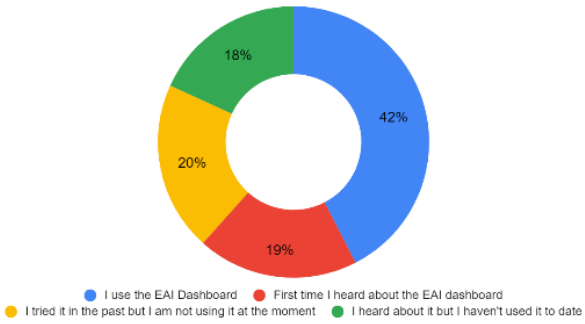

Figure 2: Usage of EAI across the University as captured by the study

what each feature looks like), (ii) when they checked on the EAI dashboard, (iii) their response to predictions (i.e., students flagged as red, amber and green) and (iv) a modified version of the UTAUT questionnaire (5 point Likert scale) (Appendix 1), (v) reasons they are not using the EAI any more (if applicable) and (vi) any other thoughts, comments and feedback.

4.3 Methods of data analysis

Open-ended questions were thematically analysed [21]. Data were first coded by assigning a code to each response or sections of a response. Similar codes were then grouped together and formed themes. Example quotes were selected to illuminate each emerging theme. Quantitative data related to the UTAUT questionnaire, gender, faculty and years of teaching were analysed using SPSS. Descriptive statistics provided information about the mean, standard deviation and numbers for each variable. Cronbach's alpha was used to assess the reliability of the UTAUT subscales. All subscales were equal to or larger than 0.7, indicating a good or excellent reliability rating [29]. In the next sections, we analyse questionnaire data in relation to the ROs of this paper.

5 FINDINGS

5.1 Perceived usage of EAI as measured by open-ended questions (RO1)

Teachers who had used or are currently using the EAI dashboard reported when they were checking on it. Key time points teachers were likely to check on the dashboard were: before (46.7%) and after (43.2%) an assignment submission deadline, and before a course starts (19.4%) (the latter is possible as predictions produced at this point of time consider for historic study data and student demographics). 14.5% checking on it every week suggests that EAI has been embedded in the daily teaching practice of some teachers, as a tool that accompanies online teaching. 34.4% noted 'other' time points for checking the dashboard. Follow-up responses showed that these teachers checked EAI when there was a need, such as *"When there has been or has not been contact from a student"* (n.6), *"If I hear from a student who is struggling; or if I can't reach ones I have emailed/phoned"* (n.290) or *"To check individual students progress"*. Others commented on the frequency they check on it, noting that they check it *"regular (monthly)"* (n.14), *"infrequently"* (n.54) or when *"[they] remember"* (n.44).

A follow-up question asked teachers to select the EAI features they are checking when visiting the EAI dashboard. While all features were checked by teachers, the three most popular ones were: the course engagement graph (82,5%), the student last login information (66,4%) and the assignment results and submission predictions (65,9%). Other features checked by teachers were the individual student engagement and assignment comparisons (47,2%), the assignment predictions (42,4%), the long-term predictions of completing and passing a course (41,5%) and assignment comparisons (36,7%) and tutorial attendance (34,9%) (see EAI features https://bit.ly/3LJPMQZ..

In the following paragraphs, we present the thematic analysis of teachers' responses to open-ended questions (Table 1). The analysis is organised around three groups, as shown in Figure 2. Each quote is followed by 'n' to denote 'number' and a unique identifier for each participant e.g. n.252.

5.1.1 "I heard about it but haven't used it to date" (18% of the sample). A number of reasons explained why, while participating teachers were aware of the EAI dashboard, they had not used it yet. Four overarching themes emerged from the analysis: a) a lack of training, b) a lack of awareness, c) other priorities, d) overlap with other approaches of monitoring student progress.

A lack of training: A lack of training about what the EAI dashboard is and how to use it was a core reason explaining non-use and one strongly supported by several participants: *"I have not been directed to it or received any training"* (n.227). Participants stated a lack of knowledge of how to interpret the EAI data: *"Unaware of its function and how to interact"*(n. 308), as they have not attended any training and any materials emailed to them were rather long to read and understand: *"I had not attended the training yet. I have looked at it, but it isn't immediately clear as to how it works"* (n.15). Another participant explained: *"All of the documents sent have been very long and so I haven't had the time to go through them and don't want to mess up using it without that understanding"* (n. 16). This lack of training, often related to clarity of what the dashboard features mean, is likely to explain perceptions of usefulness and added value of the EAI dashboard. As explained: *"I have had a look, but I don't know whether it has any value. I would need to be told how to interpret them, and also find out if they have been proved to be*

Table 1: Emerging themes from the thematic analysis of open-ended questions

Sample (see Figure 2)	Emerging themes & relation to UTAUT dimensions *themes not relevant to UTAUT dimensions
"I heard about it but haven't used it to date" **(18% of the sample)**	•lack of training (FC) •lack of awareness (FC) •other priorities* •overlap with other approaches of monitoring student progress (PE)
"I tried it in the past, but I am not using it at the moment" **(20% of the sample)**	•perceptions of usefulness (PE) •lack of training (FC) •technical difficulties (EE) •perceptions of extra workload (PE) •a need for a reminder (FC)
"I use the EAI dashboard" **(42% of the sample)**	•useful features (PE) •student interventions (PE) •need for training (FC) •changes to teaching practice (PE) •technical difficulties (EE) •ethics and students * •recommendations *

useful. I have seen other systems which automatically generate these metrics, but nobody pays any attention" (n.4). It is suggested that evidence showing whether a proposed innovation, in this case, the EAI dashboard, is effective and can support students' progression is shown to be a significant factor for teachers when choosing to use a new system in their teaching.

Amongst participants, there was also the perception that using EAI would add to their workload and current work pressures: "I looked at it when given initial information about it, but it seemed like extra work on top of increased pressure that has continued through the pandemic" (n.38) Also, they stated that predictive tools are needed when working with large student groups: "Don't see any reason; I have small student groups" (n.51). Overall, teachers were found to have varied perceptions about EAI and its use, yet these perceptions emerged from limited or no use of EAI and/or limited understanding of how EAI works. For example, perceptions about the added value of EAI could be discussed and clarified in training sessions where teachers are introduced to how the system works and why it has benefits over and above other approaches of monitoring students. Also, using a system for the first time requires time potentially seen as "extra workload".

A lack of awareness: A number of participants were unaware that EAI was rolled out across the university and that it could be accessed via their tutor home (the webpage through which teachers access course related information). In contrast, some others only recently found out about it and did not get a chance to use it yet: "*Just hadn't got around to it – I have been meaning to (Because of doing this questionnaire I have now checked it out on one of my groups! So hopefully I will make more use of it in future)"* (n.26). Such insights stress the need to raise awareness about EAI in the teaching community in order to use it systematically. Teachers should become aware about it but also be reminded at different points of time that the system is available and that they should use it.

Other priorities: The impact of Covid-19 alongside other challenging situations such as work strikes, lack of time and personal issues inhibited some teachers from trying out EAI: *"A difficult year personally has held me back from trying new ventures. It does seem [like] a great scheme"* (n. 86). Another teacher stated: *"I haven't had the time to investigate this tool so far, although it was mentioned by my mentor, so this is a good opportunity"* (n. 171).

Overlap with other approaches: Some teachers referred to other approaches they are using to monitor students and their progress that make EAI for them rather redundant. As explained: *"I am pro-active with all of my students. One to one tutorials are booked, and I am pro-active with individual and group emails"* (n.22). Another teacher noted: *"I don't see what it adds that I can't see through my usual tutor home pages & other contacts with the student"* (n. 54). Others mentioned their expertise as a factor for not using EAI: *"I have a long experience with the University and I feel I can easily recognise the students who are at risk from the limited data we have and after the first early assignment"* (n. 44). What research has shown is that while these approaches can be beneficial, they present shortcomings EAI overcomes such as providing insights before the submission of the first assignment that can help a student submit their work as opposed to finding out about students who are struggling after they have submitted and failed their first assignment. Such perceptions reinforce the need for training that could inform teachers about the unique added value of EAI over and above other approaches.

5.1.2 "I tried it in the past, but I am not using it at the moment" (20% of the sample). The following reasons explained why some teachers "dropped out" from using EAI: a) perceptions of usefulness, b) a lack of training, c) technical difficulties, d) perceptions of extra workload, e) a need for a reminder.

Perceptions of usefulness: Perceptions about the EAI usefulness were strongly linked to a lack of appropriate training and understanding of the tool. As explained: *"I've had a look in the past and didn't find it particularly useful. However, the questions above suggest it might have numerous additional features that I wasn't aware*

of before so I'll go back and have another look when I've got more time" (n.34). This suggests that the participant did not receive any training that could help them understand and use the various features of the tool. Also, teachers who engage with their students regularly and dedicate time to develop trust are likely to be aware of their progress and hence such tools are seen as not needed: *"It's complementary at best if you have the time to engage with it. It is not a game changer for me. It certainly doesn't replace building a trusting relationship with students, which is what tutors do best. No tool can replace that"* (n.101). Yet, not all teachers choose to develop trusted relationships with all of their students or have the time to do so, especially when managing a large cohort of students. Teachers are mostly found to rely on student information captured online to assess student progress and provide support: *"I find it doesn't give me any surprising information - last student logins can be seen from the student details. I use it most to compare assignment results to previous years. I don't find that the information I gain from it is novel and the predictions are not very reliable"* (n. 77). Another teacher explains: *"The dashboard tells me what the student has done but not why. I already know if they haven't submitted an assignment and can check their last login"* (n. 203). Such statements reveal that teachers mostly rely on historical/past data to assess student progress and not predictive data that would allow for interventions before a possible assignment failure.

Lack of training: For some teachers, EAI was seen as rather overwhelming due to the amount of data presented in it that they cannot understand or interpret: *"I don't really understand what it is telling me"* (n. 312). A simplified version of EAI would be preferable: *"There's a lot of data on it, and I'm not sure how many teachers want that much. Personally, I would prefer some kind of automated notification system (e.g. "We think Student X is at risk of not getting their assignment in, please do Y to support them")*" (n. 345). How to respond to students who are flagged as at risk was also discussed by teachers raising the need for a clear plan of actions in response to students who may be struggling with their studies: *"I wasn't sure how to respond if a student was marked at risk of not submitting an assignment"* (n. 262). Other teachers noted that they do not know how to access it. Those teachers are likely to have tried it in the pilot phases of development. Yet, they were not informed that EAI has been rolled across the university and can be accessed via their tutor home: *"I was not aware it was in use and available. I can't find a link to it on tutor home either, so I don't know how to access it!"* (n. 23). Lastly, teachers explicitly stressed the need for training, especially if they are new to the university: *"The EAI dashboard should be included in the new teacher training"* (n. 94). Another teacher explained: *"I have looked at the dashboard quite a few times, but not in a systematic way. I am not aware of any training. I [teach] mainly in nursing modules, and it has never been mentioned. However, it has been mentioned in a couple of the Level 1 modules I teach on, but I'm not aware of where to access the training [. . .] I would love to know how I can actually use it"* (n.144).

Technical difficulties: For some teachers, EAI was found to be slow and clunky, requiring considerable time to engage with. As explained: *"I found it very slow and time-consuming. [I] get a lot of information about students from checking logins, contact history and direct communication. Their situations are more nuanced than the dashboard. If the dashboard was quick and easy to use, I'd access it more"* (no. 15). The system's ease of use is shown to influence intentions to use it and frequency of use.

Perceptions of extra workload: Some teachers view the use of EAI as extra work for which they should be paid: *"This is extra work for which we receive no extra pay"* (n.68). Amongst teachers, there is the perception that workload would increase by checking EAI, the more students a teacher is managing: *"If I only had one group and sometimes had spare time in my contract, it would be a useful tool. With more than four groups it becomes too much additional work to check"* (n.244). Such perceptions raise questions as to whether (and how) teachers who manage multiple groups of students monitor their progress and provide timely support. Also, this contradicts other teachers' perceptions that EAI is particularly useful when you have a lot of students that you cannot effectively communicate with and monitor through other monitoring approaches.

Need for a reminder: Some teachers, while informed about EAI, forgot about it over time: *"Time, forget it's there"* (n.302). Others explained that they would use EAI if their manager prompted them: *"As a teacher, I simply had too many students to do additional checks unless directly prompted by my manager. It's a nice idea, but something I have at the bottom of my priority list, which goes a) assignment marking, b) pastoral support, c) tutorial quality, d) forums, e) extras like this. I usually forget it's available and sometimes worry it will create work for me that I have no time to do anyway"* (n. 155), suggesting that social influence from seniors could enable adoption. Responding to the study's questionnaire prompted action: *"I might now have another try with it"* (n.267).

5.1.3 "I use the EAI dashboard" (42% of the sample). Teachers who are currently using the EAI dashboard provided explanations as to why and how the EAI dashboard supports the teaching practice and their interactions with students. The themes emerging from the analysis were: a) useful features, b) student interventions, c) the need for training, d) changes to the teaching practice, e) technical difficulties, f) ethics and students, g) recommendations.

Useful features: Teachers perceived the dashboard as being *"very useful"* by *"giv[ing] insight into [the] level of student engagement and [...] changes in level of engagement"*(n.303), *"allowing [them] to see at a glance which students are progressing and which need [their] intervention"* (n.225) and accessing information they are not aware of within a single place: *"The thing I focus on most is checking when students have last visited the course website, and tutorial attendance, much of the rest I am usually aware of, although it is helpful to have all the information in one place rather than having to check individual student records"* (n. 255). What becomes evident is the varied EAI features used by teachers, including students' VLE engagement, student flagging system, tutorial information and last login. Teachers who were given access to only some of the features of EAI (due to a faculty decision) raised the need to alter their access rights: *"Very disappointed that the [Science Faculty] hasn't embraced its use and isn't supporting teachers to do a better job for students"* (n. 286), *"Functionality is limited in first presentation of a module, which is quite irritating!"* (n. 207).

Student interventions: Student insights provided teachers with information as to whether an intervention is needed that would help a student overcome any difficulties and submit their next assignment. As explained: "*[The] EAI dashboard is a great idea and*

should stay. It is a useful complement to other student engagement and support insights, such as the contact history and emails from students themselves. Together, they help provide useful insights into how students are getting on and provide a flag to indicate if an intervention might be needed, such as a referral to the Student Support Team. I don't feel that the EAI dashboard negatively biases my opinions." (n.307). Another teacher also commented on the potential influence of EAI data on personal judgement and marking decisions, and in particular, how their initial worries about the dashboard waved away after starting using it: *"I did worry about the dashboard adversely affecting my judgement or affecting my marking at first, but I have not found this to be so"* (n. 345). The idea that the EAI may influence teachers' views about students was described as a *'self-fulling prophecy'*, i.e., student predictions will eventually come true, yet a prophecy teachers have the power to revoke: *"I use the dashboard a lot, and have found it useful in identifying students that were not engaged. I have been a little worried about the self-fulfilling prophecy idea, but this has not stopped me using it, and I think I am more likely to contact students and offer support if they look like they need it, and so break any negative prophecy"* (n. 115).

Need for training of new and existing teachers: The EAI usefulness was particularly commented on by teachers who are new to their role and who suggested that EAI *"should be part of induction for all new teachers"* (n. 166), noting that the EAI dashboard was not one of the tools they were introduced to. As explained: *"Another new teacher found it by chance and mentioned it to me. I have found it invaluable since then. It is not something I have seen mentioned in my induction training or within my faculty"* (n. 198). The same teacher described how they used the system to help a student and the impact this had had on assignment submission: *"For the most recent assignment submission, I used it to help give me an indicator of who might be struggling to meet the deadline and contacted them directly in plenty of time to help them if needed - this seems to have had a positive effect on their assignment submission"* (n.198). The need for training was also mentioned by other teachers who after taking part in the study wondered whether the way they use EAI is appropriate: *"Seems hugely useful and I am using it but not sure if I am using it to full capacity"* (n. 87). A teacher found particularly useful the visual attachment accompanying one of the questionnaire questions showing different EAI features and suggested that some of these features may not have been known to teachers: *"The PowerPoint used in this questionnaire is very useful. Is it available to download?"* (n. 230). Another teacher was more explicit about their knowledge: *"I would like a short training session on how it could be used- I wasn't aware of the features listed above"* (n. 91).

Changing the teaching practice: By providing future insights about student performance, EAI helped some teachers become more proactive with their students: *"It has encouraged a more proactive approach to supporting my students, and I am better able to advise them on their studies"* (n. 38).

Technical difficulties: EAI use was often inhibited by technical issues teachers faced while interacting with the dashboard. In particular, the time needed to load individual student data: *"It takes an age for the details about particular students to load - that's the only thing that stops me from using it sometimes"* (n. 228) and move between sections: *"I use it infrequently. The main reason being that it takes too long to refresh and move between sections"* (n. 259) defined the frequency of using EAI. Other teachers reported that technical help cannot easily be accessed: *"It's not clear who to report technical issues to. There is an ongoing problem with the link for one group and after 8 week it still isn't fixed"* (n. 307).

Ethics and students: Teachers suggested that EAI data should be made available to students (in addition to teachers): *"Another important factor is if the students also see the early indicator data themselves, this transparency would help engage the learner with their own data"* (n. 320). Teachers raised concerns that students, although consented for their data to be used to improve their performance, they do not have a clear picture of how the University uses their data. Making data available to students could facilitate discussions between students and teachers as to how to improve performance which are based on the actual interactions of students with the course material: *"Although students give their permission for this data to be collected when they register, there is something unethical about them not knowing how this data is made available and used. Sometimes, I do share a screenshot of a student's individual engagement with them, for example, if they are telling me that the course is too difficult, but I can see that they haven't used the course website in months. This does facilitate some helpful conversations"* (n. 270). Another teacher raised issues about the ethical aspects of producing predictions the students are not aware of and the duty of care these come with: *"I have concerns about the morality and ethics of the university be[ing] aware of 'predictions' that a student might not succeed and not passing that on to a student"* (n. 309).

Recommendations: Teachers made recommendations as to how to improve the design of the EAI dashboard that related to: a) Accessibility: Some teachers noted that the accessibility of the EAI dashboard should be improved, giving as an example the colour scheme used to flag students at risk: *"The colour scheme used is not colour blind-friendly"* (n. 260). b) Material students engage with: Other teachers raised the need to associate student engagement data with the corresponding content a student is interacting with: *"I would like to know which sections of the course materials students are engaging with - study section, forum posts and quiz performance"* (n. 277). Such information would help contextualise engagement data and give indications of which content may be hard to understand or engage with. c) Support options for students at risk: *"It should give aggregated top-level indicators and also suggestions for what to do with certain situations. Some of these could be automated. If there is a lot of red, non-participation, the student should be contacted via phone to see what is happening"* (n. 336).

5.2 Perceived usage of EAI as measured by the UTAUT questionnaire

To further understand EAI usage, we analysed responses to the UTAUT questionnaire (Appendix 1), showing that teachers, overall, had positive perceptions about the dashboard in relation to performance expectancy (M=3,27, SD=.93), effort expectancy (M=3,21, SD=.94), self-efficacy (M=3,35, SD=.62), anxiety being low (M=2,01, SD=.88), and behavioural intention to use the system in the future and recommend it to others (M=3,66, SD=1.00). They were rather undecided in relation to attitudes towards using the dashboard (M=3,08, SD=.87) and had rather negative attitudes about social influence (M=2,72, SD=.70) and facilitating conditions (M=2,92,

SD=.84), indicating that influences by others and support conditions did not support them with the use of the dashboard.

To identify which UTAUT dimensions are likely to predict behaviour intention (BI), we conducted a multiple linear regression analysis with BI as the dependent variable (DV) and the rest of UTAUT dimensions as independent variables (IV). Prior to running the analysis, we ensured that the below assumptions were met in order for the findings of the regression to be valid: 1) Linear relationships: We inspected the scatterplots between each of the IVs and the DV (BI) and identified that there is a linear relationship between each pair of variables meeting the assumption of linearity, 2) Collinearity: Analysis of collinearity statistics showed that there was no multicollinearity in the data as VIF scores were well below 10 (max was 3.6), and tolerance scores were above 0.2 (lower value was 0,276), 3) Independency of residuals: The Durbin-Watson statistic was 2,23, which is close to 2, showing that this assumption was met, 4) Homoscedasticity: inspecting the plot of standardised residuals versus standardised predicted values, there were no signs of funnelling, suggesting the assumption of homoscedasticity was met, 5) The values of the residuals were normally distributed. The P-P plot for the model suggested that the assumption of normality of the residuals was met as nearly all of the data points attached the diagonal line, 6) Influential cases biasing the model: Cook's Distance values were all under 1 (higher value was 0.063), suggesting individual cases were not influencing the model. The multiple linear regression results were statistically significant (F=59,44, df=7, p<.001), explaining 66% (Adjusted R square=.66) of the variance in BI – a percentage very close to other UTAUT studies [11]. Only four of the proposed independent variables were found to predict BI: Performance expectancy (β =.55, p<001), Self-efficacy (β =.18, p=.010), Attitudes towards technology (β =.24, p=.006) and Anxiety (β =-.16, p=.002).

5.3 Comparisons between Faculties and years of teaching (RO2)

A one-way ANOVA with the Faculty teachers belonged to as the dependent variable showed no statistically significant differences in any of the UTAUT subscales indicating that teachers' perceptions of EAI do not differentiate depending on the faculty they are in (PE: p=.404; EE: p=.654; SI: p=.564, FC: p=.607, SE: p=.770; ATU: p=.298; ANX: p=.073; BI: p=.864; NS).

A t-test analysis was performed to identify any statistically significant differences between new (0-5 years of teaching) and experienced teachers (6+ years of teaching) in UTAUT dimensions. Levene's test of equality of variance determined whether equal variance could be assumed for each UTAUT dimension. Levene's test was significant for three dimensions: PE, SI and BI for which equal variances were not assumed and respective values for t-test were considered. A Bonferroni correction was applied due to the number of tests performed simultaneously; new level of significance p=0.05/8=0.006. Statistically significant differences were observed between new and experienced teachers in perceived expectancy (PE: t (162,01)=4,06, p<.001), attitudes towards using EAI (ATU: t (224)=3,88, p<.001) and behavioural intention (BI: t (181,66)=5,03, p<.001). No statistically significant differences were observed in social influence (SI: t (173, 37)=2,75, p=.007; NS), self-efficacy (SE: t (221)=2.03, p=.043, NS), effort expectancy (EE: t(226)=.75, p=.45, NS), facilitating conditions (FC: t(222)=-.506, p=.613, NS), and anxiety (ANX: t(223)=-.344, p=.732, NS) indicating similar perceptions in these dimensions between new and experienced teachers.

New teachers overall reported statistically significant more positive attitudes about using EAI than experienced teachers in three UTAUT dimensions. What is notable is the very positive perception of new teachers about using EAI in the future and recommending it to others (BI) (M=4,08, SD=.73) compared to experienced teachers who are positive but not to the same extent (M=3.4, SD=1.04) (p<.001). In terms of attitudes towards EAI (New: M=3.4, SD=.80; Experienced: M=2.9, SD=.86; p<.001) and perceived expectancy (New: M=3.6, SD=.7; Experienced: M=3.1, SD=.96; p<.001), new teachers are rather positive compared to experienced teachers who do not have a clear opinion yet about it.

6 DISCUSSION

In this study, we examined the perceptions of 366 online teachers from across four university faculties about the use of predictive learning analytics (PLA) in the teaching practice. This study was conducted at a point of time when PLA has been rolled out, for more than three years, across the university as an optional tool that can support student retention. While more than 40% of teachers reported accessing and using PLA, approx. 40% had not used it (they either heard of it for the very first time via the study or heard of it but did not use it). These insights stress the need to raise awareness about PLA and its potential to support students at risk of failing their studies across the university for the tool to reach its full potential. This group of teachers had not used PLA yet mainly due to a) a lack of training about how to use it and how to interpret data, b) a lack of awareness that the tool has moved from a 'pilot' to a 'business as usual' stage, c) other priorities some of which related to Covid-19 inhibiting experimentation with new teaching approaches, and d) the use of other approaches for monitoring students. In terms of the last factor, this was shown to relate to a lack of understanding of the added value of PLA and evidence showing that, compared to other approaches, PLA use by teachers can lead to better student performance [4]. The circulation of this study's questionnaire worked as a mechanism for raising awareness about the availability of the EAI dashboard and triggered some teachers to explore its use. Drawing from UTAUT, teachers' intention to use EAI has been influenced by two factors: a lack of facilitating conditions (FC) and low performance expectancy (PE). Facilitating conditions such as PLA training could alter negative perceptions about performance expectancy (Figure 3).

A 20% of teachers declared using it in the past yet not at the moment. Thematic analysis revealed that this group of teachers was not well informed about how to access the EAI dashboard, how to interpret and act on student data, including which interventions would help students at risk, and what its added value is. For example, there was the misconception that EAI only shows past student data, such as whether an assignment has been submitted or when a student was last logged in to the VLE. As such information is accessible via other resources, the EAI was viewed as redundant. Also, there was a concern that checking EAI would create additional workload that could not be managed. The added value of EAI lies in

the fact that all of student information is accessed within a single space and presented in a comprehensive way (through a traffic-light system), making it easy for teachers to quickly identify who needs support and when to intervene [2]. In addition, some teachers reported technical difficulties when accessing the dashboard that discouraged further interaction with it. Drawing from UTAUT, performance expectancy (PE) and effort expectancy (EE) were low within this group of teachers due to a lack of facilitating conditions (FC) that would help teachers understand how to effectively use EAI or remind them to use it in their practice (Figure 3).

Teachers currently using the EAI dashboard acknowledged its unique added value in monitoring and supporting students at risk of failing, implementing support interventions if and when needed and a more proactive approach to teaching from a distance. These findings align well with existing studies [1, 3] and evidence showing how tools such as EAI could promote educational opportunity, especially amongst students from underserved communities such as black students and those from low socio-economic backgrounds [6]. Despite positive performance expectancy (PE) perceptions, some teachers raised the need for training to gain a more in-depth and accurate understanding of the system (FC) while also noting technical difficulties (EE) that often inhibited interaction. It is worth mentioning that, as in other studies [19, 20], some teachers had mixed perceptions about EAI; they had concerns about the ethical implications of using EAI, in particular, the fact that students are not aware of how exactly their data are used to support their learning and also, they do not have access to EAI data that would inform their learning. Their recommendations for improvements were related to enhancing the dashboard interface by improving accessibility, adding information about course material students are accessing when they are struggling with their studies and ways of how a teacher could support a student shown as at risk.

Overall, teachers' perceptions about EAI were found to relate to the degree to which they were using the EAI dashboard and the degree to which they understood its functionality and added value. Across all groups of teachers, there was a strong need for training; such training would introduce teachers to how the EAI works, what interventions would help students at risk and what the benefits are over and above other approaches of monitoring students. The quantitative analysis of UTAUT provided further insights as to the factors influencing behaviour intention (BI) to use EAI in the future; BI was influenced by perceived benefits EAI brings to teaching (PE), teachers' overall positive attitudes towards EAI (ATT), low levels of anxiety (ANX) and self-efficacy when using EAI (SE) (Figure 3). Some of these relationships (PE; ATT; BI) were moderated by teaching experience, with new teachers being more favourable to using EAI than the more experienced ones. As shown in thematic analysis, experienced teachers were rather more confident in their skills and their own perception of identifying students who are struggling with their studies and hence perceived PLA as less significant.

Following the original UTAUT visualisation [30], Figure 3 presents a context-specific, modified version of UTAUT applied to open and distance higher education and the usage of PLA by teachers. Teaching experience had a moderating effect on relationships between performance expectancy, attitudes, and behavioural intention [16, 30], with less experienced teachers endorsing more the use of PLA than experienced teachers. Amongst the factors that were not related to behaviour intention (BI) (see yellow boxes in Figure 3) are the faculty teachers are in and, in contrast to the original model, social influence (SI). The factors that negatively affected PLA use were a lack of facilitating conditions (FC) – in this study also shown to negatively influence performance expectancy (PE) – and low effort expectancy (EE).

7 CONCLUSIONS

This study contributes to the need for a context-specific understanding of technology adoption and usage as described by the Unified Theory of Acceptance and Use of Technology (UTAUT). Insights from this study showed that the usage of PLA by teachers has been positively influenced by performance expectancy, self-efficacy, positive attitudes and low anxiety. In contrast, it has been negatively affected by a lack of facilitating conditions and effort expectancy, indicating that the type of technology and context within which it is used are significant factors determining understanding of technology usage and adoption.

A limitation of this study is that it did not analyse the actual engagement of teachers with the dashboard such as how often and when they used it and triangulate that with their self-reports, to give a more accurate picture of PLA practices. Also, while the need for training was strongly suggested by participants, this may actually be explained by a need to redesign the dashboard and its features by, for example, adding on demand instructions or clarify what graphs and visualisations show by adding explanations. This would help teachers engage with PLA without the need for attending a training. In addition, while social influence was unrelated to usage, it is worth being re-examined especially given that endorsement by seniors (mentioned in this study) may have a positive impact on PLA adoption.

While insights from this study provided an in-depth account of teachers' perceptions about PLA usage – both those who are, or not, using PLA, they pointed to future directions that would further support our understanding of PLA use in higher education, including the need to provide training to teachers in ways they can understand why and how to use PLA (especially given that approx. 40% of them were not aware or have used PLA in their practice yet), the need to test and identify interventions that best support students at risk such as phone and email communication [2], the need to engage teachers systematically with PLA so teachers become aware of cases of students who may unexpectedly struggle with their studies [7], such as the use of email by teacher managers reminding teachers about the availability of predictions [5] and identify further individual-specific factors that may explain usage, such as gender and age.

Overall, this study suggests that certain conditions can facilitate adoption and use of predictive learning analytics in higher education including identifying and explaining the added value of using analytics to support teaching (over other approaches), providing ongoing technical and other support to teachers, delivering appropriate training about its use including effective approaches to supporting students at risk, designing easy to use and comprehensive dashboard features, and producing evidence of impact of using PLA on student outcomes. Also, to ensure ongoing use of

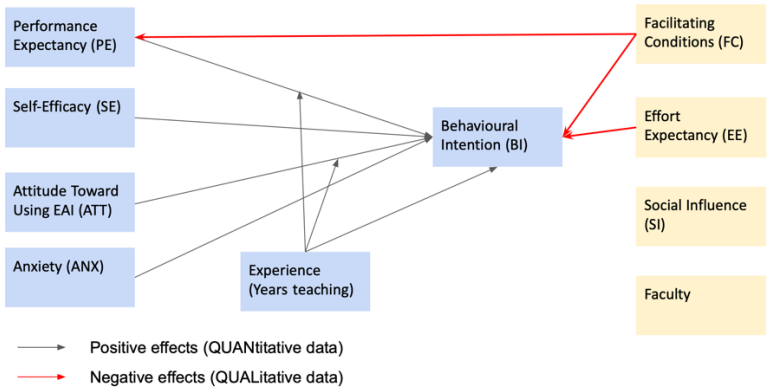

Figure 3: A UTAUT version reflecting university teachers' usage of predictive learning analytics

PLA, including use by teachers with no previous experience, there should be mechanisms in place that raise awareness of the tool and enable teachers to start using it at any time such as ongoing communication e.g., newsletters and professional development events.

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APPENDIX 1 RELIABILITY ANALYSIS, MEAN, SD, N AND ITEMS OF UTAUT QUESTIONNAIRE

UTAUT dimension	Cronbach's Alpha	Mean	SD	N	Items	Source
Performance Expectancy (PE)	0.94	3.27	.93	223	1. I find the dashboard useful in my job. 2. *Using the dashboard enables me to gain weekly information about my students. 3. *Using the dashboard gives me additional insights about my students I wasn't aware of. 4. *I know more about my students after using the dashboard. 5. *I know that certain students may be at risk earlier than when I was not using the dashboard. 6. *I was able to intervene and retain some students because of the dashboard. 7. *The dashboard made me more systematic on how I monitor my students. 8. *The dashboard made me more proactive in supporting students before they fail.	[30, 1]
Effort Expectancy (EE)	0.92	3.21	.94	228	1. My interaction with the dashboard is clear and understandable. 2. It is easy for me to become skilful at using the dashboard. 3. I find the dashboard easy to use. 4. Learning to use the dashboard was easy for me. 5. *I am not sure about what some of the dashboard features mean.	[30, 1]
Social Influence (SI)	0.81	2.72	.70	222	1. *My manager thinks that I should use the dashboard. 2. *Other teachers think that I should use the dashboard 3. The senior management of the Faculty has been helpful in the use of the dashboard. 4. In general, the Faculty has supported the use of the dashboard.	[30, 1]
Facilitating Conditions (FC)	0.75	2.92	.84	224	1. I have the resources necessary to use the dashboard (e.g., technical support, Faculty support). 2. I have the knowledge necessary to use the dashboard. 3. *I received training as to how to use the dashboard. 4. A specific person (or group) is available for assistance with dashboard difficulties.	[30,1]
Self-Efficacy (SE)	0.66	3.35	.62	223	1. I could use the dashboard if there was no one around to tell me what to do as I go. 2. I could use the dashboard if I could call someone for help when I get stuck. 3. I could use the dashboard if I had a lot of time to interact with its features. 4. I could use the dashboard if I had just the built-in facility for assistance.	[30]
Attitude Toward Using Technology (ATT)	0.88	3.08	.87	226	1. Using the dashboard is a good idea. 2. The dashboard made my teaching more interesting. 3. *Working with the dashboard is engaging. 4. I like working with the dashboard.	[30]
Anxiety (ANX)	0.87	2.01	.88	225	1. I feel apprehensive about using the dashboard. 2. I am afraid that the dashboard will affect my opinion about certain students. 3. *I hesitate to use the dashboard of fear of a prediction being a "self-fulfilling prophecy" (a prediction will be confirmed no matter how I respond to it). 4. *The dashboard is somewhat intimidating to me.	[30,1]
Behavioural Intention (BI)	0.86	3.66	1.00	225	1. I plan to use the dashboard in the next few months. 2. *I would recommend the dashboard to other teachers.	[30,1]