Prescriptive analytics motivating distance learning students to take remedial action: A case study of a student-facing dashboard

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Abstract

Student-facing learning analytics dashboards aim to help students to monitor their study progress, achieve learning goals and develop self-regulation skills. Only few of them present personalised data visualisations and aim to develop agentic students who take remedial action to improve their study habits, learning and performance. In this paper, a student-facing dashboard, designed following principles of participatory research, was tested with 30 undergraduate students, who engaged with it over a period of 4 to 15 weeks and while studying an online course. This is one of the few dashboards available that presents all different types of analytics to students: descriptive, predictive and prescriptive. A mixed methods approach was used to assess its usefulness and impact on motivation to study and take remedial action to support learning. Data analysis showcased that such a dashboard can be "a roadmap to success" by motivating students to study more and improve their performance, in addition to helping with monitoring, planning and reflection. While all dashboard features were perceived as being useful, special value was placed on prescriptive elements, in particular material recommendations and contacting tutors and university support teams, emphasizing the significance of making explicit on a dashboard the actions students should take to improve their performance. Implications for future studies are discussed.

CCS Concepts

• **Applied computing → Interactive learning environments**.

Keywords

learning analytics dashboards, student-facing dashboards, prescriptive analytics

1 Introduction

An increasing number of studies present the design and evaluation of learning analytics dashboards (LADs) for students, often described as student-facing dashboards. These dashboards are mainly targeting higher education students, who are campus-based (e.g., [26]) or studying from a distance (e.g., [22]). LADs present an added value to the latter group, for online and distance learning students may experience isolation, demotivation, a lack of belonging and higher levels of withdrawal from studying than campus-based students. A student-facing dashboard can help students monitor progress in comparison to other students and make them feel part of a larger community of learners [22]. LADs are seen as a tool that can facilitate the development of self-regulation and achievement of personal learning goals [20], with some studies also noting a positive impact on student performance and motivation [7].

The design of LADs varies; they present a range of data visualizations to students such as peer comparisons, online engagement with material, predictions of future performance and material recommendations. Most LADs present descriptive elements of student performance such as online engagement with material and only a

few of them include predictive information and prescriptive or recommended elements [11, 16, 23]. Personalized or customized dashboards based on student performance, or other measures such as motivation and goal orientation, are less common, with researchers noting the need to move away from "one size fits all" dashboard implementations [24]. A LAD should aim to develop agentic students, that is students that take action to improve their study habits, skills and performance. Fostering awareness and reflection may be a significant learning skill, yet this is not enough for students to take remedial action and improve their performance and competencies [12]. Developing agentic students could be achieved by allowing students to customize dashboards i.e. choose what data to view, help them to interpret and understand data, and enable them to identify actionable insights such as set and meet personally relevant learning goals [2]. Towards this goal, personalised and prescriptive data could offer students concrete advice about what is needed to improve their performance and achieve desirable changes in their learning [23].

In this paper, we present one of the few student-facing dashboards that feature personalised ***descriptive***, ***predictive*** and ***prescriptive*** elements about student progress and performance. Data visualizations, including the generation of individual predictions of future performance and material recommendations, have been personalized considering students' prior performance, demographics and online study activities. In this study, we examined the impact of using this LAD on students' perceptions of usefulness and motivation to take remedial action and improve learning. Students' perceptions were captured through a survey and individual interviews while log files were examined to understand students' usage patterns. We conducted the study at The Open University, UK (an online and distance-learning higher education university) with 30 undergraduate students who used the dashboard while studying a business course.

1.1 The usefulness of student-facing dashboards

Several studies have examined students' perceptions regarding the usefulness of specific LAD features. Amongst the dashboard features endorsed by students are study planning, organization of learning, and monitoring [8], study and content recommendations [3, 19], skills recommendations [3], and unit level feedback [3]. Mixed perceptions have been recorded regarding features such as peer comparisons [19], their support of motivation and academic achievement [10] and of a mastery as opposed to a performance orientation [25]. Also, predictive elements evoked varied student responses including motivation, skepticism, confusion, and fear and doubt over accuracy of predictions [13, 21].

The observed variation in students' perceptions of usefulness seems to relate to who the learners are; for example, predictive features motivated learners with high levels of motivation, yet they reduced motivation for those with lower levels of motivation [27]. There are also mixed results regarding high achievement; while in one study, high achievers were less satisfied with a LAD than low achievers - more likely due to already being aware of their progress and performance [14], in another study, successful students were those endorsing and accessing the LAD more often [5]. In online settings, a LAD displayed by a researcher during an interview was found to be more appealing to students with average performance,

younger students (<40 years old) and those with low self-efficacy [19]. In this paper, we describe a real-time case study in online settings, in which students' perceptions of usefulness are captured, after engaging with a personalised LAD for a period of time and while studying an online course.

In addition, we aim to capture any impact of students using the dashboard on taking actions to improve performance. Although LADs are designed to positively influence student behaviour and performance, there is yet limited evidence to support such impact [11]. The few studies available show mixed findings such as no effects on student learning outcomes after using a randomised approach with a small sample [15], positive effects on grades only for students from low-SES [9], higher scores for the treatment group yet with no randomisation [14], positive effects on performance on quizzes and mastery exercises for specific specializations [11] and better final grades for students accessing the dashboard that those who didn't [1]. The LADs used in the above studies present a different set of design features that may explain a lack of consensus regarding student performance outcomes. There is a need for more studies that will assess the impact of LADs on student actions, determine whether they can work motivationally and help students take remedial actions for their learning.

1.2 Motivating students to take remedial action

Most LADs aim to support specific target outcomes for students. These are mainly focused on monitoring processes including awareness and reflection of learning progress and performance. Limited attention has been given to designing LADs that aim to motivate students and change study behaviour such as seeking help, putting more effort, and managing time [16, 26]. Self-regulated learning (SRL; e.g., [17]) is one of the theories commonly used to explain target outcomes for LADs [16]. Given the above insights, LADs are found to support certain phases of SRL including monitoring and reflection, yet not others including forethought and planning such as motivating students to allocate more study time and asking them to set learning goals, or control such as selecting learning strategies, increasing effort and changing a learning task [17, 26]. There remains a gap in designing LADs that "support learning - moving from description of practice to providing actionable insights" ([16], p.23) and "translate awareness of learning processes to actual self-regulated learning" ([10], p.1). To the best of the authors' knowledge, only one study (see [18]) has been designed so far offering actionable insights to students, in addition to descriptive and predictive data. The LAD designed for this purpose presents all range of analytics including descriptive, predictive and prescriptive. Yet, on a closer look at the LADs features, it becomes evident that prescriptive analytics are giving students an estimation of the risk of course completion, explanations of how predictions are calculated, and a score recommendation for assignment and engagement in order to lower the risk of failing e.g., if your score reaches 0.70 and your engagement 0.54 then your risk becomes low. What is still lacking is a comprehensive dashboard that, in addition to descriptive and predictive elements, provides students with a set of actions they can take to improve their predicted score and achieve better learning outcomes. Another study that offers actionable insights [3], yet it does not include any predictive elements, presents students

with recommendations of videos, practice problems and web links to address specific knowledge gaps as captured by the dashboard and provides feedback on how to increase specific skills such as time management and persistency. The student-facing dashboard used in this paper provides actionable insights to students in the form of personalized material recommendations for study while also encouraging students to reach out to their tutor and student support teams for help, as and when needed.

1.3 The student-facing learning analytics dashboard used in this study

The student-facing learning analytics dashboard implemented in this study has been designed following a participatory approach with 20 online students, who determined data information they would like to be displayed on the dashboard. This approach ensured that the dashboard is responsive to students' learning needs while studying online, is intuitive and easy to use. The dashboard interface was visually appealing with design features presented and structured in an organised manner, making it easy for students to navigate and interact with them. Our aim was to minimise cognitive load and maximise usability, allowing students to focus on their learning rather than on how to use the dashboard. The feedback we received from students resulted in including the following features in the dashboard. See Figure 1 where the different elements are highlighted and marked with varying capital letters.

- **Descriptive features:**
  - **(A)** Student Interactions: Detailed insights about module activities, such as VLE engagement, tutorial attendance, and frequently accessed materials.
  - **(B)** Insights about student's learning, including an overview of the content of the module and of the materials that a student has so far interacted with, which ones they have not, and which ones they have more frequently accessed.
- **Predictive features:**
  - **(C)** Individual predictions on the likelihood of passing the next assignment, coupled with highlights of the current status of the student within the module.
- **Prescriptive features:**
  - **(D)** Support Information: Easy access to tutor and student support teams (SST) contact details as the first point of contact for any queries or support needs, following engagement with descriptive and predictive individual student data.
  - **(E)** Personalized recommendations: Two types of recommendations are offered to students. **E1** Automatically generated personalized recommendations of materials to support learning based on module insights and historical data and, **E2** recommendations made by tutors (i.e., recommendations made by the module team). These recommendations are the same for all students.
- **(F)** Achievements: The dashboard presents students with a list of badges, as a means of gamifying student interactions with the dashboard and facilitating ongoing engagement with it. Such elements have shown a positive impact on student performance [1]. Badges are acquired for completing

recommending material, submitting tutor-marked assignments (TMAs), or seeking tutor help.
- **(G) Highlights:** This constitutes a summary of the status of the current week. It includes the latest prediction, when is the upcoming assignment, the latest achievement obtained, and a link to the recommended material.
- **(H) Feedback:** The dashboard enables instant reporting of feedback and potential technical issues.
- **(I) Available modules:** This allows the student to select the module for which they want to see their information

A unique feature of the dashboard is the inclusion of prescriptive elements, in particular a recommender system. This system analyzes individual student data and historical data to offer personalized study material recommendations. Each student receives tailored advice on what materials to study next, aiming to aid their learning journey and motivate further study. The development of this recommender system involved a rigorous process of understanding key learnings and challenges faced by online students in previous presentations of the same course. The algorithm's complexity lies in its ability to adapt to diverse student needs and provide precise, actionable recommendations that align with unique academic contexts. Additionally, the dashboard highlights how students can contact tutors and Student Support Teams (SSTs), ensuring immediate access to support when needed, especially in response to negative performance predictions

2 Aim and Research Questions

The aim of this study was to capture and analyse the perceptions of undergraduate students about the impact of using a student-facing learning analytics dashboard on usefulness and motivation, while studying an online and distance learning course. Specific research questions were as follows:

- RQ1: What are students' perceptions about the usefulness of using a student-facing dashboard while studying an online course?
- RQ2: Which specific design features (descriptive, predictive, prescriptive) do students perceive as useful for their learning?
- RQ3: What are students' perceptions about the degree to which using a student-facing learning analytics dashboard motivates them to study and take remedial action? The study received a favourable opinion from the ethics committee, the student panel and the data protection office of the University under study.

3 Methodology

3.1 sample

We sent an invitation letter to all students of an undergraduate module (*name hidden for review*) of the Faculty of Business and Law. Thirty (N=30) students consented to take part in the study of which 24 declared to be white, three (n=3) other, two (n=2) Asian, and one (n=1) Black. Six students (n=6) stated that they have a disability and two (n=2) that they experience mental health issues. In terms of the Index of Multiple Deprivation, measuring relative deprivation in the country of the University under study, nine (n=9)
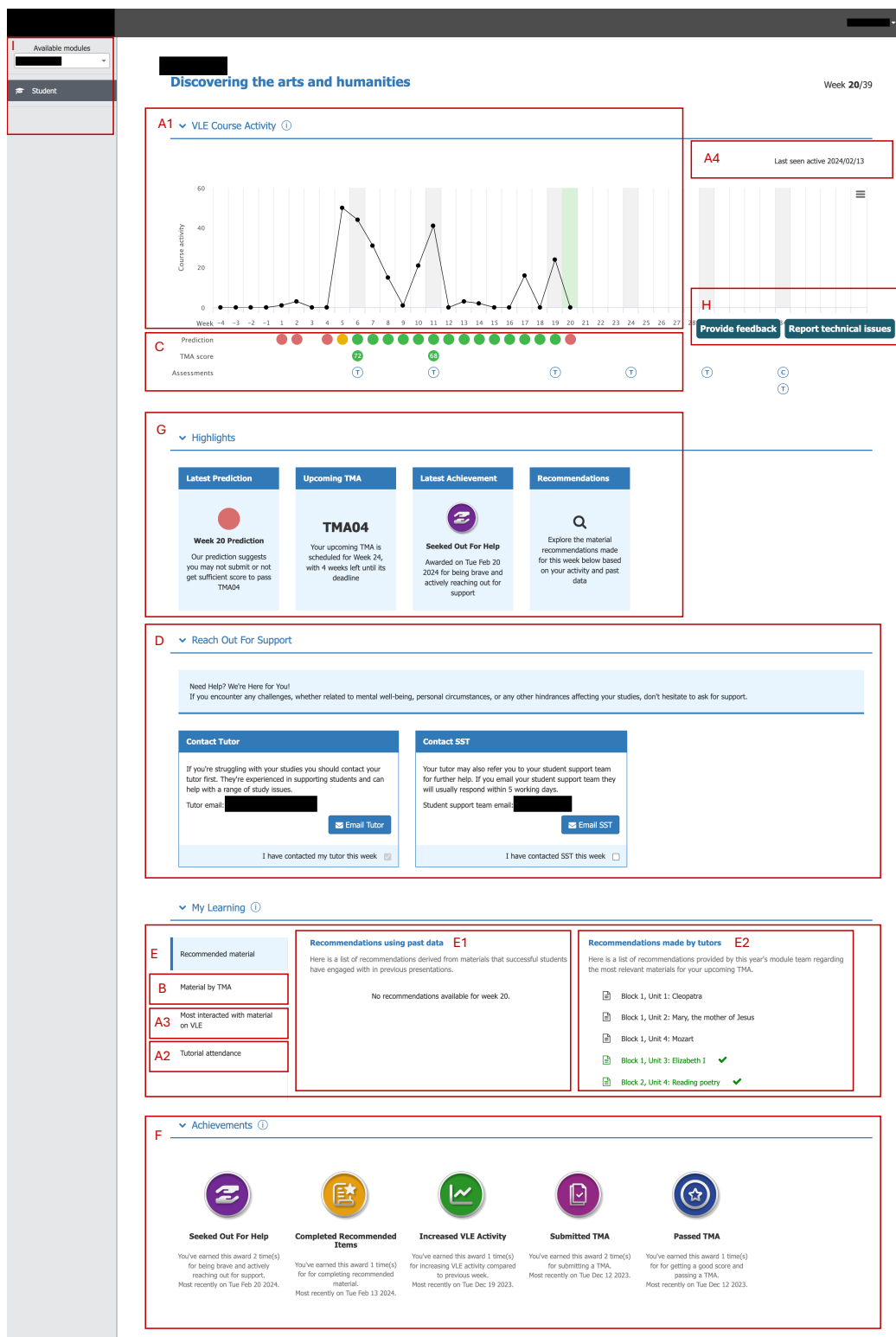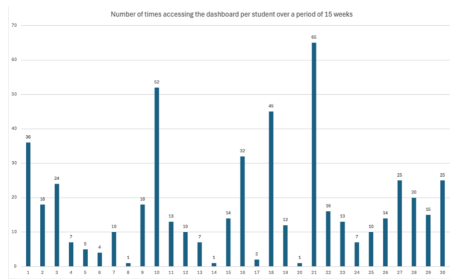
Figure 1: Screenshot of the student-facing dashboard used in this study

Figure 2: Number of visits to the dashboard over a period of 15 weeks

students were in the range of 0-30%, 11 students in the range of 35-65%, and 10 students in the range of 65-100%. Of the 30 students, 23 completed a follow-up survey and 10 took part in an individual semi-structured interview. Twenty-one (n=21) of them declared that they watched the training material (a short video) about how to use the dashboard and that they found it useful. Students received a £20 Amazon voucher for checking the dashboard on a weekly basis and completing the survey and an additional £20 Amazon voucher for taking part in an interview.

Over a period of 15 weeks, students accessed the dashboard between 1 and 65 times, with an average of 17.4 times (see Figure 2). With the exception of four students, the rest of the students accessed it at least 4 times. To reinforce engagement with the dashboard, a weekly email reminder was sent to them by the research team. As explained in the survey responses below, this was seen as useful by students, reminding them to check on the dashboard at least once per week. On average students accessed the dashboard at least once per week for 7.5 weeks out of 15. Eleven students (n=11) accessed the dashboard between 10 and 14 weeks and 14 students between 4 and 9 weeks.

3.2 Methods of data collection

Data were collected from a survey and an interview, asking students to share their thoughts after using the dashboard. The survey collected information about the reasons for using (or not) the dashboard, useful features, impact on motivation to study and learn, and recommendations for improvements. Interviews aimed to triangulate survey data and collect more in-depth information about topics raised in the survey. Indicative interview questions were: Can you please share your screen and show me what exactly you did while using the dashboard? What did you find more useful while using the dashboard and why? Did you take any actions after checking the dashboard? What do you think could be improved on the dashboard and why? Interviews lasted for approx. 30 minutes and were conducted by Author 2 and 3. In addition, log files from using the dashboard were analysed to identify the frequency of accessing the dashboard.

3.3 Methods of data analysis

Closed survey questions and log files were descriptively analyzed using frequencies and averages. Both descriptive and inferential statistics (Spearman's r) were used to address RQ2. Open-ended

survey questions and interview data were thematically analysed [4]. To ensure reliability of the analysis, an inter-rater reliability exercise was conducted; two transcripts were independently analysed by Authors 1 and 2, producing two lists of codes and themes. The authors discussed the two lists of themes, identified and resolved any disagreements (e.g., naming of a theme, grouping of subthemes under a single theme) and agreed on a common coding structure to be used in the analysis.

4 Data Analysis

4.1 Survey analysis: descriptive statistics and open-ended questions

The survey analysis identified the following themes: ease of use, usefulness, motivation to study and take action, innovative insights about studying, dashboard improvements and future use.

Ease of use: Twenty participants (n=20) stated that it was easy for them to use the dashboard with three (n=3) stating "somewhat". They stated that the system was simple to use, clear to understand, straightforward, self-explanatory, easy to navigate even without watching the training video. Less positive responses related to difficulties in loading the dashboard, the area where material could be accessed and a prediction for one student was not confirmed (they did not do well on their next assignment). The weekly email reminders sent by the research team to participants were seen as useful, prompting students to check on the dashboard weekly. As explained: "[I used it] whenever I was sent an update with a link to log in" (P22).

Usefulness: The great majority of students found the dashboard useful. They explained that they used it for a range of reasons including: a) getting recommendations of what to study: "To see what it was all about. For suggestions for tasks to complete each week" (P3) and planning for next assignment submission "While preparing for assignment 1, I found the recommended course material section very useful. It helped me plan my revision accordingly." (P15), b) keeping track of progress/staying organised (P4) and "see [ing] what I may have missed" (P14), "Just to check if I was on course to pass my assignment and also monitor how far in the course I was" (P16), "The overview of what I need to do, what's complete and what's pending is my favourite part. It helps me stay organised." (P15), c) motivating themselves "useful motivation seeing amount of engagement made weekly" (P9), d) easy access to information related to "when my assignments are due, view my assignment score and to double check when I have studied." (P20), e) out of curiosity "To see how it worked and to see what materials were suggested for me to look at next." (P7) and "interested to see how the prediction function worked." (P8), and f) for the voucher payment "To see the predictions but then when I fell a bit behind, I stopped using it. I initially signed up to trial it because it was a paid thing, and I would be logging in anyway" (P22).

The dashboard features students found *very or extremely useful* in their learning were in order of popularity: the course activity and prediction – VLE graph (n=18), recommended material (n=17), tutor material recommendations (n=15) with 4 students not using/not knowing about it, highlights and trends (n=14), recommendations using past data (weekly) (n=13), contact your tutor and SST (n=11) with 6 students not using/not knowing about this feature, most

interacted with material on VLE (n=8) with 2 students not using/not knowing about it, tutorial attendance details (n=8), with 4 students not using/not knowing about it, badges (n=6), with 5 students not using/not knowing about it. Five students (n=5; 22%) found the following four features as *moderately useful*: Contact your tutor or SST, Recommended material, Recommendations using past data (weekly), and badges. The features that were viewed as *slightly or not at all useful* by a few of the students were: the badges (n=7), tutorial attendance (n=7), most interacted with material on VLE (n=7), and recommendations using past data (n=4). The two features that none or only one of the students found less useful were the *recommended material* and the *contact your tutor and SST* respectively, indicating the significance of those features for nearly all the students who interacted with the dashboard.

Motivation to take action: Fourteen students (n=14) affirmed that using the dashboard *motivated them to study*, with 5 of them stating "somewhat" and 4 stating "no". Those who perceived the use of the dashboard as motivational explained this by stating that: a) certain features motivated them to keep studying "when shows prediction motivates you to get higher and keep using it (P2), "I wanted to keep my prediction above average" (P20), b) they tried to improve their performance and engagement with material "I wanted to beat the previous weeks progress (P4), "As I can see how much I clicked, I wanted to improve" (P11), "I felt more motivated and 'obliged' to login and study/use the course materials to improve my dashboard scores." (P8), c) they were checking whether they are on track of passing a next assignment "seeing if I was on target to pass my assignment" (P23), d) they were reminded about material they (did not) interact with "reminded me to check in and check I had interacted with module material, kept my study plans on track" (P9), e) the dashboard was seen as a roadmap for success "I feel that the dashboard gives me a roadmap to following in order to achieve a good result. It shows me the material I need to focus on which saves so much time doing it myself. (P15), as offering structure to studying "I thrive on stats and structure, and it has it" (P5), a means to access accomplishments "It shows what I have accomplished" (P13) and a revision path "Gives path for revision topics" (P24).

In addition, students were asked about any specific actions they took in response to information viewed on the dashboard. Fifteen participants (n=15) took some form of *action related to their learning*, with 6 stating no action and 2 "somewhat". These actions were: a) consistent and scheduled program of study: "Study consistently" (P4), "I kept better on schedule" (P10), b) plan next studying steps "Wrote down what to look at next" (P7), "Planned my next study periods as the lead up to assignment" (P20), c) engage with recommended material "Engaged with all the recommended content" (P9), "Looking at recommended links" (P14), d) prioritise what to study next "Helped me prioritise which units to focus on when my time and executive function were limited" (P18), e) contact tutor (unsuccessfully) "Tried to contact tutor unsuccessfully. Fell behind slightly but was reassured by the visuals I wasn't too far behind and that I was still on course" (P16), f) log in the course website "I logged in to the course website" (P19), g) "Use the dashboard guidance alongside the assignment guidance for answering questions" (P8) and h) "Study more" (P13).

Innovative insights about studying: Thirteen participants (n=13) stated that they have learnt something new from using the dashboard that benefitted their studies, with 5 stating "somewhat" and 5 stating "no". As explained, participants learnt about a range of dashboard features including prediction scores (P2), suggested readings and what had been completed (P9), recommended material (P14) and highlight trends and revision (P24). They also learnt about a) useful units of learning "When assignments were due and which units of learning were particularly useful for those assignments" (P18), b) the effort they put in studying "The time I spent in my units (P19)", That some weeks I put less effort in than others (P4), c) how to navigate the course website better and spot what to read next: "I learned to navigate the course website a little better and it helped me to find what I had missed" (P21), "To either go back to parts I was unsure of or look at further links" (P17), d) double-checking material: "Double checking that I was using the recommended material from past data and tutors to complete my assignment" (P8) and e) "Being organised is key" (P15).

Improvements: Despite the overall positive perceptions regarding usefulness, some students stated issues that should be addressed in the design of the dashboard in the future, including predictions not being confirmed because of printing material out and studying offline: "It is a useful tool however I did find this predicted me 'red' for my assignment but I had printed all material from the website as I knew I would not have access for that week. I ended up getting 82% on my assignment" (P21) and tutors not getting back to students as quick as expected, suggesting that a chatbot could be of added value to their studies "The dashboard is very useful [...] I like the links to contact your tutor, student support, etc although obviously students may not get a quick response to either of those routes. The university could use a chatbot type function for some student enquiries maybe, particularly for Level 1 courses as I remember people asking a lot of similar [...] questions re finding info, how to book tutorials, access recordings, etc." (P8) Students shared a number of recommendations as to how the dashboard could be improved in the future: Language used "Tone of achievement messages" (P7); Accessibility "I wondered if people who are colour-blind might find the dashboard less helpful? I love the colours as instinctive 'quick guides' to the information conveyed but if that is something that is difficult for a student to differentiate, they might prefer symbols e.g., ticks, crosses, exclamation marks, stars, warning signs, etc" (P8); Connection to course website "link to main website for reading materials, easier to navigate" (p.9), "I think the dashboard should be incorporated within the module website - if this was all in one place, I feel everything would be easier to navigate." (P21); Functional contact tutor button (P16); Show material a student has accessed so far "Besides showing when you accessed the site also show what material was accessed to show whether you were on track with the schedule" (P10); Direct links to specific module links "Provide links to the individual recommended units (if you don't already do so) to take us straight to them instead of us needing to search through the module website to find them" (P18); Connect VLE graph to course content: "Link from the graph directly to the module content" (P20); and improve how unit completion is measured "The access to the units section as once you've clicked through to print out it assumes you have completed that unit even if you haven't" (P23).

Future use: Nineteen (n=19) students stated that it is likely or extremely likely that they would use the dashboard in the future, with only 3 students stating this as being extremely/unlikely. These

responses were explained by factors including usefulness and motivation, in particular the offering of immediate feedback "I like the immediate feedback from the dashboard on what I am doing re my studies and module material use." (P8), monitoring of studying "I like to use it to monitor my progress" (P23), an effective reminder "It's a good reminder for me to keep on schedule" (P10), boosting confidence and offering reassurance "I believe it gives extra confidence to look further at topics and study guides" (P17), "good motivational tool and provides assurance" (P9). Special benefits were reported from a student with neurodiverse characteristics, including time management and a sense of achievement: "Is a good tool for time management as well as dopamine for us neurodivergent as it gives us a sense of achievement when we see the green circles when we have interacted with the module material" (P18).

Nineteen (n=19) students would recommend using the dashboard in the future to other students. Some of the students noted a number of features they would like to see on it including the prediction score for each assignment, countdowns, engagement hours (how long is spent on each unit alongside the recommended time per unit), link of VLE graph with course information, link directly to a next assignment description, a checklist with badges/achievements for students to see what they need to do to earn them, integration with the university's website and students' reports of how well they understood specific learning outcomes.

4.2 Survey: Inferential statistics

To address RQ2, a non-parametric Spearman's rho correlation test examined the relationships between motivation to study and the different features of the dashboard, assessed by students in terms of usefulness in their learning. There were significant positive correlations between motivation to study and only two of the dashboard features: recommended material $rs(19) = .468$, $p = .032$ and most interacted with material on VLE $rs(16) = .536$, $p=.022$. No significant relationships were identified between motivation to study and other features of the dashboard including course activity and prediction (VLE graph section) $rs(20) =.302$, $p=.172$, highlights and trends $rs(20) =.285$, $p=.199$, contact your tutor and SST $rs(14)=-.080$, $p= .769$, tutorial attendance details $rs(16) =.389$, $p=.110$, badges $rs(15) =.289$, $p=.261$, recommendations using past data $rs(19) =.235$, $p=.305$, and tutor recommendations for each assignment $rs(16) =.416$, $p=0.86$. This analysis showcases the usefulness of prescriptive data and its positive association with students' motivation to study as opposed to other features of the dashboard including descriptive and predictive data. These insights are further explained and confirmed in the analysis of the open-ended survey questions above and the interview data analysis below.

4.3 Interview analysis

Table 1 presents the themes/subthemes emerging from the analysis of 10 interviews with students. This is followed by a narrative analysis per theme.

Useful features: The analysis of the interview data confirmed survey findings, highlighting that the students found the dashboard to be useful to their studies, easy to use and accessible: "It was intuitive to use" (Interviewee 2); "There wasn't really any challenge because it's quite straightforward, like everything is there" (Interviewee 5). Aligning with survey findings, the most useful features were the recommended material, the VLE graph and contact buttons, as well as the email reminders sent to access the dashboard. The most mentioned feature was the ***recommended materials***. Many students discussed how this feature allowed them to keep track of the course materials and prepare successfully for the next assignment: "I think it's a useful tool. To see what you've missed" (Interviewee 3) and "It's the recommended by the tutor section that I really enjoyed" (Interviewee 10). Although first in popularity in the survey analysis, the ***VLE graph*** was the second most useful feature discussed in the interviews. They found it useful to both track their progress, and also motivate them to study more or interact with more materials: "I thought it was really interesting to see how many clicks I'd made in which week and see where I've had my peaks" (Interviewee 2); "It's kind of addicting to see how many interactions we've had. So, once I see that it's going down, I have to go back up" (Interviewee 5). Another feature largely discussed was the ***contact buttons***. The students who used these found that the immediate availability of the contact details and the auto-filled email prompted them to seek support which they may have not done before: "I use the email tutor bit and contact student support which is really good because it actually fills out an email for you" (Interviewee 7) and "That was really handy because it's quite awkward to find the contact details on like the university portal" (Interviewee 8). Interviewees also highlighted how the ***weekly email reminders*** sent by the research team provided a useful prompt to log in to the dashboard. A student said: "I only went on it prompted by emails because I just forgot" (Interviewee 4) and another one explained: "The way you've sort of sent the weekly emails, you know the link is right up there. That's perfect for somebody like me, of the little sort of prompter" (Interviewee 9).

Less useful features: *The **VLE graph**, **badges** and **contact buttons*** were discussed by a few students as being less useful for their learning. The former was explained by the level of students' awareness of studying: "The graphical display of how often I've been on the course is sort of irrelevant to me because I know how often I've been on it" (Interviewee 4); "It's not really something I need to visualize to see like I know by the amount of time that I'm putting in" (Interviewee 8). The least useful feature discussed was the achievement badges. Interviewees noted how badges were often earned for doing very little, such as logging in or having a higher interaction week: "I don't understand the premise of the badges. Like when you log on it shows an award" (Interviewee 3). Only three of the students explained how they hadn't used the contact buttons. The first explained that they "don't ask for help or I will try everything in my power to find out stuff on my own" (Interviewee 3). Whereas the second highlighted how they had all the information for contacting their tutor or student support on the student home "so I use the course website" (Interviewee 4). The third one did not use it, for when they tried to, the feature did not seem to work. A few students also discussed other features as being less useful including the ***predictions***, ***recommended material*** and ***tutorial attendance***. The students who did not find the predictions useful, described accuracy and a lack of information on how they are calculated as their main reasoning for this: "I don't really know

Table 1: Themes emerging from the analysis of 10 interviews with students

Theme	Subthemes	Explanation
Useful features	Recommended material	How recommended material was seen as the most useful feature
	VLE graph	How the VLE graph was seen as the second most useful feature
	Contact buttons	How contact buttons were seen as useful by most students
	Email reminders	How email reminders motivated students to access the dashboard
Less useful features	VLE graph	How the VLE graph was seen as less useful to students
	Badges	How badges/achievements were seen as less useful than other features
	Contact buttons	How 'contact' buttons were seen as less useful than other features
	Predictions	How predictions were seen as less useful than other features
	Recommended materials	How recommendations were seen as less useful than other features
	Tutorial attendance	How tutorial attendance was seen as less useful to students
Impact on assignment preparation	Progress	How the use of the dashboard impacted students' assignment progress
	Study recommended material	How studying recommended material impacted students' assignment preparation
	Time studying	How using the dashboard increased time spent studying for assignment
Impact on motivation	Keep track of studies	The dashboard helps students keep track of their study progress
	Study harder	The dashboard motivates students to put more effort in studying when needed
	Organized way of studying	The dashboard provided structure as to how to study
Suggestions for improvement	Accessibility	Recommendations for improvements related to accessibility
	Bugs, typos	Bugs and typos that could be improved on the dashboard
Future intentions	Recommending it to others	Students would recommend the dashboard to others
	Sharing of study schedule	Sharing a study schedule with other family members

how accurate it is, like how it is basing how much we do with like what grade we're gonna have? I don't really understand how they do that so I kind of just ignore it" (Interviewee 5). Whilst most students found the recommended materials useful, some explained that, because all the materials for studying were available in the assignment guidance, recommendations had no added value: "if you go into the assignment guidance, it says [...] if you want to refresh yourself, go to this page" (Interviewee 4). Tutorial attendance was seen as less useful due to the fact that students would watch recordings of tutorials (rather than joining synchronously) due to home/work life responsibilities: "tutorial attendance is not really a priority because I tend to watch the recordings because I work full time" (Interviewee 1); "I've watched the recording back and I'm like, I've still attended a tutorial admittedly not live, but I have still attended" (Interviewee 10).

Impact on assignment preparation: When discussing whether the dashboard impacted students' assignment **preparation and submission**, some students found it did whereas others found it less impactful. Those that did find it impactful discussed how having the information all in one place saved them time and enabled them to identify if they had missed key texts: "Without it [...] it would have been so much clicking around the actual, course page" (Interviewee 7); "I guess they just made me feel more on top of it and that [...] I was looking in the right places" (Interviewee 9). When discussing how the dashboard impacted on their **progress**

towards their assignment submission, one student explained how "it helped me not to miss things" (Interviewee 3). Others found that the dashboard assisted in their **study of recommended materials** by "having it all in one place rather than going through the assignment questions" (Interviewee 2) and that this encouraged them to "click on all the material because it's just there to help" (Interviewee 7). The dashboard also assisted some students with their **time management**; when asked about whether they would have achieved the same grade without the dashboard, one student claimed that "I think so yeah. But I think it would have been a longer process sort of thing clicking around" (Interviewee 7) whereas another identified that the dashboard helps them "to stay on track because it shows where the assignments are supposed to be handed in, so I know how much time I have left" (Interviewee 5).

Impact on motivation: Aligning with survey findings, students highlighted how the dashboard enabled them to keep track of their studies, study harder when needed, and become more organised. They discussed the **VLE graph** as having a motivating impact. Even those who identified it as a less useful feature, they highlighted how it could be motivating for others: "I get satisfaction overseeing the green everywhere…it made me work harder on my assignment because I didn't want it to be any colour other than green" (Interviewee 3); "It's very motivating to kind of like make me go ahead of the content as well" (Interviewee 5). Some of the students found

that the ***predictions*** were motivating to them, with one student claiming "it makes me feel good and makes me want to do even better" (Interviewee 1) later highlighting how they thought it was "a really positive thing and if it told me I wouldn't get a better than average pass, I would have put more effort in" (Interviewee 1). As discussed earlier, many of the students found the material ***recommendations*** on the dashboard useful to their studies. One student discussed it in terms of its motivating impact on their learning highlighting how it enabled them to go back and ensure they hadn't missed any materials: "if something wasn't ticked, then I'd have to look at it" (Interviewee 3). Finally, some students found that the dashboard enabled them to be "more cohesive, more organized" (Interviewee 3) and provided them with a "a more structured way, a more focused way" (Interviewee 9) of learning. This motivated them to engage with more of the material as opposed to the course website: "sometimes with the course website when it comes up next and you go next you kind of lose where you are" (Interviewee 3).

Suggestions for improvements: Accessibility was discussed within the interviews, with students highlighting different accessibility issues that should be improved in the future including a) how some disabled students prefer to print off materials rather than read on a computer. This impacts negatively on their predictions as they often interact largely within a one-week period when printing necessary materials: "If you have a disabled student like me who does use printed packs, if it's just on the number of clicks on the course website it's not going to provide as accurate a prediction" (Interviewee 2), b) the amount of information on one page that could be inaccessible by some students, and how some information could be found in both the dashboard and the student home causing issues for those students who are neurodivergent: "I find it difficult to look at for too long" (Interviewee 2); "I'm not good with duplication, so if I've it one place and another place I have to check both places to make sure they align. If they don't then I'll worry about it" (Interviewee 4). Other issues discussed related to more integration with the student home, fixing bugs within the system and providing more explanation as to how the predictions were calculated:"These bits I found a bit difficult because if I clicked on an email…it takes very little, ticks, then it unticks straight away. So, I didn't know what the point of having that box was" (Interviewee 2). Another students suggested: "I think it would be worth having a link directly to the tutorial recordings on the dashboard" (Interviewee 1); "Perhaps having more description as to how you're getting that prediction…I feel like if they have more description then I know what to do better so I can have a better grade" (Interviewee 5). They also mentioned how certain wording related to the badges could be improved: "On the latest achievement , it had something on there which I think was meant to be a motivational message…I wasn't so sure on the wording because it felt a bit, not condescending, that's not the right word" (Interviewee 2).

Future intentions: Aligning with the survey findings, many students showed a ***wish to use the dashboard in the future*** highlighting how it helped to keep them on top of their learning, and providing them with a clear learning path to the submission of assignments: "I'm gonna continue using it. Definitely like I said, for me…the visuals of the fact I've got x weeks till I've got an assignment…that for me is a really clear vision of how long I've got to study for" (Interviewee 1); "I think because it's got all the

information in one place and it's good for me to see it in a different way and sometimes it reminds me to do things that I haven't remembered" (Interviewee 2); "100% I'd use it for more than this…If I had access to this for every module I did, I would be very happy" (Interviewee 3). One student discussed how the dashboard provided them with the opportunity to share their learning schedule with their spouse "but if I show [them] this or I send [them] a screenshot of this to [their] phone, it's really clear when a good date for me to have to out for a night out or you know go on holiday" (Interviewee 1). This highlights how the dashboard can be useful for planning activities beyond students' learning and have an impact on home life:"I couldn't recommend unless I sat with someone and saw how they did their work (Interviewee 4).

5   Discussion of Findings

In this study, we detailed a case study with 30 online and distance learning undergraduate students who were asked to use a student-facing dashboard while studying a business course. The dashboard is a rather innovative implementation that presents to students personalised descriptive, prescriptive and predictive learning analytics, the latter in the form of recommendations of material and contacting tutors and student support teams for support, when needed. Students were surveyed and interviewed about the usefulness of the dashboard and its potential impact on motivation to take remedial action and promote self-regulated learning. The interview and survey analysis showed that the great majority of students found the dashboard useful, easy to use, and self-explanatory (RQ1). The reasons explaining positive perceptions of usefulness included the fact that students could get recommendations of what to study, they could keep track of progress and stay organised, they were motivated by e.g., seeing their weekly online engagement with the course, and they could easily access information about their assignments such as due dates, assignment scores, material already studied. These factors showcase the key role a student-facing dashboard can play in reinforcing specific studying strategies and motivating learning. These insights align with theories of acceptance and use of technology in which perceived usefulness - that is positive impact on job (here study) performance and perceived ease of use directly influence technology acceptance [6]. The dashboard features students found significantly useful were the course activity graph, the recommended material and the contact buttons to reach their tutor and student support teams. Yet, as revealed in the interviews, for some students these features were seen as less useful. It could be argued that these are students who have already developed skills of how to self-regulate their learning by being aware of how much time they spent studying and knowing where to find assignment information and how to reach out for help. Other features that were perceived as less useful were the predicted assignment scores; this was explained by accuracy fears due to a lack of explanations as to how predicted scores are calculated. This insight aligns well with existing studies in which predictive elements evoked mixed student responses, including a fear over their accuracy [13, 21]. Tutorial attendance was also perceived as a less useful feature as this was not accurately captured by the dashboard; some students chose to watch a video recording of a tutorial rather than the live event - the dashboard only presented the latter information. In

response to RQ2, while all features of the dashboard – descriptive, predictive and prescriptive - were perceived as useful by some or most of the students, the two features most positively perceived by all participating students (no negative perceptions recorded in the survey) were the recommended material and the contact your tutor and student support teams. This stresses the significance of incorporating prescriptive elements in LADs that can showcase to students the actions they can take to support their learning – in this case to read specific material and reach out to their tutor and university support teams. Aligning with this finding, statistical comparisons showcased significant positive correlations between only two of the dashboard features - recommended material and most interacted with material on VLE – and motivation to study, indicating how specific prescriptive elements are positively associated with students' motivation to study. A positive endorsement of study recommendations, over other elements such as comparisons with peers has also been recorded in other studies with online students (see [19]) as well as in a blended learning course [3]. In terms of the degree to which the LAD under study motivated students to take remedial action and support their learning (RQ3), most students stated that the dashboard motivated them to study. In both the survey and interview analysis, they further explained that predictive and engagement data about their study progress motivated them to improve their performance and "beat previous week's progress" as shown on the dashboard. Also, the LAD enabled awareness of learning, such as knowing whether one is likely to pass their assignment, reminded them of material they "missed" to interact with, and offered a structure to learning by keeping track of progress and providing suggestions for revision topics. The dashboard was seen as a roadmap to success; a means to achieve a good result. These insights showcase how the LAD under study did not only motivate awareness and reflection – often recorded in the literature - but had a positive impact on students' behaviour and performance, an area not well studied yet [11]. In particular, students took specific remedial actions in response to LAD insights including a) studying more by engaging with the recommended material to e.g., answer questions and by logging into the course website, b) planning their next studying steps e.g., prioritise what to study next in preparation for submitting their next assignment, thus assisting with time management, c) studying in a consistent and scheduled manner and d) contacting their tutor. These insights showcase that a LAD with descriptive, predictive and prescriptive learning analytics has the potential to support different stages of self-regulated learning [17] including forethought, planning and control [26] by providing students with actionable insights [16] that can effectively motivate self-regulated learning [10].

6 Conclusions and Future Directions

This study detailed the perceptions of 30 students about the action of a student-facing learning analytics dashboard, that features descriptive, predictive and prescriptive elements. Our findings, based on both survey data and interviews, showed how this LAD had a positive impact on students' behaviour and performance. As future work, it is our intention to elaborate further on these findings by capturing the actual impact of using this LAD on students' assignment submission rates and scores as well as on completing and

passing their courses. We also aim to make the dashboard available to a larger cohort of students on more than one course and for a longer duration, from start to the end of a course. Drawing insights from this study, we plan to review and revise the current version of the dashboard particularly addressing comments related to offering explanations about the generation of predictions, integrating data about watching recorded tutorial and enabling students to provide information when studying offline. Findings from this case study are overall positive and promising, stressing the value of offering a well-designed dashboard to students with explicit pathways for remedial action and the impact this can have on motivating them to take action and self-regulate their learning.

In particular, this study brings to light two important lessons for the design and deployment of student-facing learning analytics dashboards. First, the significance of helping students become more aware of their study patterns. For students who lack the skills or awareness needed to self-regulate their learning, providing data-driven insights can serve as a critical intervention, helping them make more informed choices about their study habits. Second, dashboards that only present data without offering clear remedial actions may fall short of their potential. Students who struggle academically may not know how to interpret performance data or what steps to take next, which underscores the importance of including prescriptive elements that guide them toward specific actions, such as revisiting relevant material or seeking support from tutors. These insights suggest that the value of learning dashboards lies not only in their ability to inform but in their ability to guide, and future designs should prioritize actionable feedback that supports student agency and decision-making.

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