How to use Gamified Dashboards and Learning Analytics for Providing Immediate Student Feedback and Performance Tracking in Higher Education

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ABSTRACT

With the wide use of the Internet and digital data sources, there has been a recent emergence of easy access to student data within learning management systems (LMS), grade data through student information systems (SIS) and broader sector data through benchmarking metrics and standards. Learning analytics on top of this data has introduced greater capabilities for improving student performance through immediate feedback. Current literature considers the role of dashboards for student performance and feedback, but few papers consider the efficacy of fast feedback to students or other ways that information can be fed back to learners. In this paper, we consider the work done by three leading groups addressing the impact of gamification in university education, with a specific focus on how data is presented to the learner, that is using elements such as points, levelling up, narrative and progression to scaffold learning. Results indicate increases in student motivation, engagement, satisfaction, retention and performance enhancements.

Keywords

Game-based Learning, Serious Games, Dashboards, Learning Analytics, Higher Education.

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1. BACKGROUND: USING GAMIFIED INTERFACES AND ANALYTICS TO PROVIDE FEEDBACK TO STUDENTS TO REINFORCE LEARNING AND IMPROVE PERFORMANCE

Learning analytics builds upon the ready availability of 'big data' or large datasets about particular cohorts and individuals. Currently, while there are numerous learning analytics capabilities in place, data is not always collected in a consistent way. Systems can be cumbersome and not immediate enough for real improvements to performance or are not being presented uniformly for student performance [1]. Most analytics capabilities are currently being used partially and not systematically, are being trialed or rely upon feedback models that are slow and not flexible or adaptable for the learner or learner cohort.

Recent research on gamification has shown how increasing user motivation is regarded as a key defining feature of gamification [2]. From 55 gamification studies examined in [4], 62% (n=34) reported on the motivational aspects of participants engaging through gamification. This finding is consistent with the general findings of the gamification meta-analysis of [3]. Of these studies, 94% (n=32) reported a positive motivational effect resulting from incorporating gamification, strongly suggesting that gamification consistently increased participant motivation in completing or undertaking study tasks. Despite being the most popular game element used in the study, Star found that 'employing points alone increases quantitative measures of task performance while narrative increases intrinsic motivation and quality of output' [4],

which is why approaches that utilize two or more elements are more likely to be successful. Table 1 presents the game elements found in the study [4].

Table 1. Game elements used in sample. Reproduced with kind permission from [4].

Game Elements	Brief Description	Alternative Terms	Sample (n=40)*
Points	A unit for measuring or counting action or activity.	Experience points, karma points, social points, redeemable points, skill points, score	68% (n=27)
Badges	Visual icon denoting achievement.	Achievement, trophy	38% (n=15)
Level / Status	Increasing stages usually denoting overall progress. Can be numeric or textual.	Stage, title, rank, progress	35% (n=14)
Goals	Stated objectives or the aim or desired result of activity.	Objectives, challenges, quests	28% (n=11)
Leaderboards	Display of name of participants and associated scores.	Scoreboard, ranking	23% (n=9)
External Rewards	Physical or tangible desirable items.	Prizes, gifts, incentives	13% (n=5)
Role play / Story	The narrative premise of the activity.	Narrative, character	10% (n=4)

In [5], a flow model for understanding feedback design in games was developed (Figure 1). This study outlined a model which brought together the four dimensional design framework [6], the flow principle from [7] and elements of feedback modelling. In other work, [8] developed a feedback model for supporting the design of feedback in games. Collectively this work has shown the efficacy of feedback as a key learning scaffold, its connection with reinforcing positive and negative motivation and strong indications that immediate over longer term feedback can shape learning behaviours and support behavioural change if well designed and aligned with learner expectations [9].

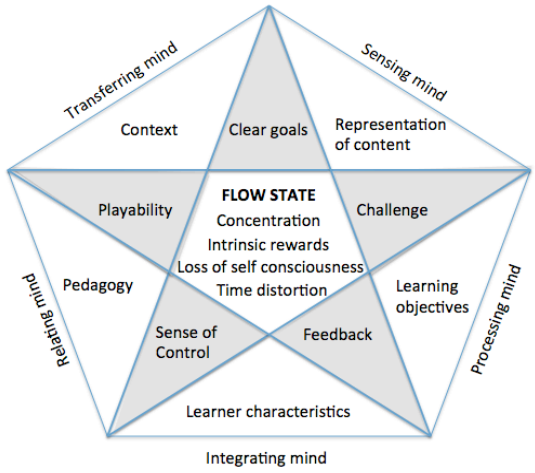

Figure 1. Flow model from [5].

Feedback in learning has been relatively under researched. [1] in their study indicate two models of feedback: one driven by the teacher and one driven by the learner. They advocate for the latter and advise that curriculum design best practices are needed to embed these approaches into practice. Certainly, any learning process requires information feedback in order to allow monitoring the progress of the learning activities. Although previous studies on students' self-regulation already demonstrate the importance of feedback and self-regulated learning in online learning processes [10][11][12], they did not take into account visualization requirements [11]. More recent research specifically remarks the importance of providing visual support to enhance the understanding of the learning process and enable self-regulated learning [13]. In [14], the authors found that "most students were able to articulate an interpretation of the feedback presented through the dashboard to identify gaps between their expected and actual performance to inform changes to their study strategies. However, there was also evidence of uncertain interpretation both in terms of the format of the visualization of the feedback and their inability to understand the connection between the feedback and their current strategies".

Some literature has aimed to bring together games and learning analytics, for example, the work of [15] addresses the implications of combining learning analytics and serious games for improving game quality, monitoring and assessment of player behaviour, gaming performance, game progression, learning goals achievement and user's appreciation. Another example, the Learning Mechanics – Game Mechanics (LM-GM) model [16] evaluates the effectiveness of a serious game by identifying and mapping its pedagogical and entertainment features, without including a way to visualize this information. A reference model for learning analytics that includes information visualization is presented in [17].

Game analytics techniques are comprehensively reviewed in [18]. In [19], the authors argue how games analytics are not enough to support a full assessment process and discuss the application of learning analytics to assess how students interact with games through two case studies including information visualization. Other research groups have also reported lessons learned using dashboards in conjunction with gamified learning in educational and scientific settings [20][21]. [22][23] advocate for robust statistical analysis of data being used and reflect upon the importance of timeliness in feedback for supporting better student retention rates.

2. EXAMPLES OF GAMIFIED DASHBOARDS

This section describes the work done by three leading research groups in the UK, Belgium and Australia.

1. StarQuest is a gamified social collaboration platform, which provides a private online environment for small groups of individuals to find and share digital content.
2. Navi Badgeboard and Navi Surface are two learning analytics dashboards that support awareness and reflection for individual students.
3. Curtin Challenge is a pioneer challenge-based learning application that gamifies online learning, team-based design and problem-solving experiences.

2.1 StarQuest (University of Coventry)

StarQuest analyses data regarding the behaviour and actions of individual participants and groups, and measures performance levels that represent cooperation, competition, and contextual variables. Among the measured factors are: environmental, personal, cultural, interpersonal (e.g., how long participants have known one another, whether they like one another or not), situational, and contextual (e.g., attitude toward their organisation) ones.

Starquest provides feedback on cooperation, competition and contextual variables through a series of dashboards including a health bar, goal framing, leaderboards and performance pages.

The design of the game and dashboards is based on an extensive literature review presented in [4].

Specifically, each type of activity has been associated with a certain number of 'health points' represented by the dashboard health bar. Health can reach a maximum of five full hearts, and the score decays over time; the longer the time interval over which a player is inactive on the platform (Figure 2).

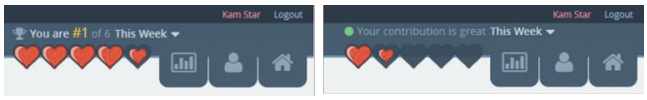

Figure 2. StarQuest health bar.

StarQuests' dashboards provide also the level of completion of the goals associated with the core activities of the platform, and two types of leaderboards, a competitive and a cooperative one, displaying rankings for collective efforts and specific subject areas. Finally, the performance page displays comparative scores for all the participants (Figure 3).

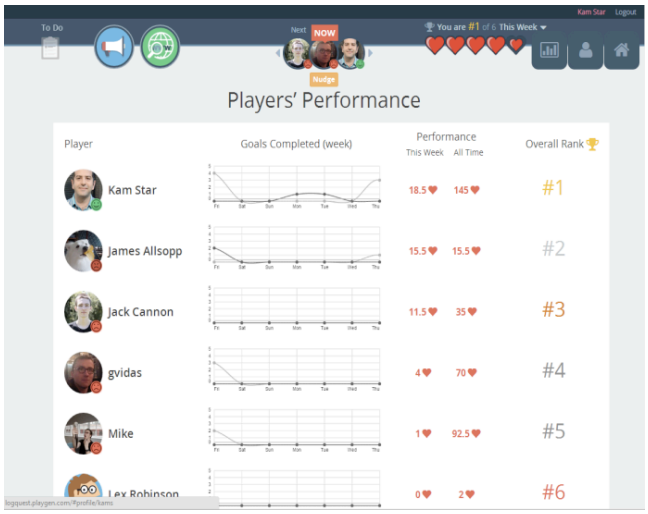

Figure 3. StarQuest players' performance dashboard.

In October 2014, 294 undergraduate students participated in the StarQuest experiment's platform for over an eight-week period.

Participants were drawn from three courses on media and communication (first year), computer science (first year), and sports psychology (second year), and randomly assigned to one of the three considered experimental conditions (cooperation, competition and control). Personality was assessed using the Five-Factor Model (FFM) traits prior to participants' use of the StarQuest. Performance measurements consisted of three quantitative measurements: number of posts, number of comments, and total amount of time spent on the platform.

Performance significantly varied between the control condition and both gamified conditions (cooperation and competition). The study found that some personality traits and context have an influence in students' performance with the gamified platform. In particular, extraversion and openness have a significant positive performance impact in competitive scenarios, and agreeableness under cooperative conditions. Neuroticism impacted performance positively under all conditions (Table 2).

Table 2. StarQuest - Influence of FFM traits (linear R^2 for Mean) in three conditions: cooperation, competition and control. Reproduced with kind permission of [4].

Influence of FFM traits	Cooperation	Competition	Control Group
Openness	.005	(.003)	.005
Conscientiousness	(.022)	.029	.017
Extraversion	(.025)	0.81	0.61
Agreeableness	.051	(.009)	.013
Neuroticism	.046	.004	.0002

Values in () brackets indicate a negative slope.

The study results further reinforce suggestions made by other researchers [3] concerning context and perceived utility as a greater determinant of adoption and usage than gamification. In general, first year students tended to use the platform far more than those in second year. Also in relation to the academic context, students from media and communications tended to be more adept at finding and sharing media on the web, whereas sports psychology course spent on average 50% less time and made 69% fewer posts.

2.2 Navi Badgeboard and Navi Surface (KU Leuven)

Two gamified learning analytics dashboards have been developed at KU Leuven [20]. A first personal learning dashboard supports awareness and reflection for individual students. A second dashboard uses an interactive visualization on a multitouch tabletop to support collaborative awareness and reflection.

They both rely on the use of badges to support awareness and reflection. The personal learning dashboard, Navi Badgeboard, is presented in Figure 4. Color is used to indicate which badges have been achieved. Greyed-out badges have not been achieved. The number next to the badge (e.g. the number highlighted by the red circle in Figure 4) indicates how many students in class have been awarded this badge. If the number is high, awareness is raised that the student is one of the few students that has not yet achieved this badge.

Figure 4. Navi Badgeboard: a personal gamified learning analytics dashboard.

Navi Surface is a second interactive visualization that uses badges to support awareness and reflection of students, and is represented in Figure 5.

The visualization is designed for use on a tabletop and enables collaborative exploration of badges that are earned. Similar to Navi Badgeboard, Navi Surface includes a view that presents an overview of earned badges. This view is represented in the bottom left part of Figure 5. Next to this view a list of students is represented. The upper part represents an interactive "Playfield" to explore badges, students and their interrelationships. All badges and students can be dragged onto the Playfield. The badges in the Playfield light up the names of students that have been awarded these badges. Student names light up the badges that have been awarded to the respective students. Dropping badges onto the Playfield also displays their detailed information. Students can collaboratively explore this information space as the application supports multi-touch. Both dashboards have been evaluated in several user studies and indicate that the dashboards help to increase awareness [24]. A particular interesting aspect is that the use of these gamification elements increased engagement of the students with the dashboards. In many of our earlier dashboard evaluations, actual use of the dashboard was more limited [25][26] and therefore had little effect on student behavior.

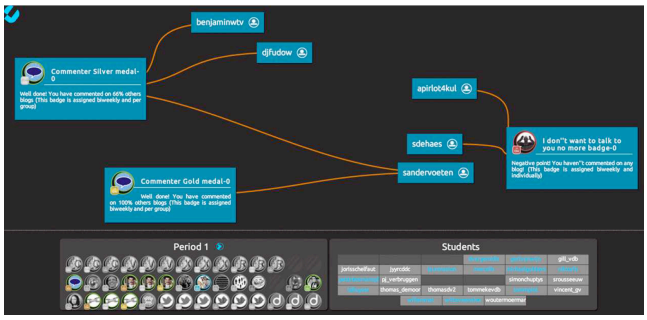

Figure 5. Navi Surface: The bottom left shows the list of badges of a specific period. The bottom right contains the students' names. The items in the Playfield (top) are touched and held to display the relationships between them.

2.3 Curtin Challenge Platform (Curtin University)

Curtin Challenge is an application developed at Curtin University in Western Australia to facilitate Challenge Based Learning (CBL). It incorporates game-like attributes such as automated feedback, points, leader boards, badges and leveling up for rewards. CBL integrates aspects of collaborative problem-based learning, project-based learning, and contextual teaching and learning while focusing on current real world problems [27][28][29]. Students largely teach themselves through self-organized activity, open-ended inquiry during exploratory learning, and creative self-determined expression within the bounds of required products that will be judged by peers, the world at large and by experts. The Curtin Challenge platform supports any number of people from thousands to tens or hundreds of thousands via gamified digital learning experiences. These may be in the form of individual challenges or challenges that support team-based design and problem-solving.

A series of dashboards provide detailed feedback on the challenges to students, teachers and administrators. The student dashboard includes information on activity, module and challenge completion (Figure 6), badges achieved and level reached, their overall score and progress against their own goal. Progress on activities and modules is demonstrated through a percentage figure in the centre of a grey circle which becomes orange and as activities are completed with one hundred percent equally a fully orange circle. The English Challenge demonstrated in Figure 6 incorporates a progression of difficulty gamification approach. Modules must be completed sequentially and begin at a simple level with progression becoming is increasingly difficult [33]. The dashboard demonstrates modules that are locked need to be completed.

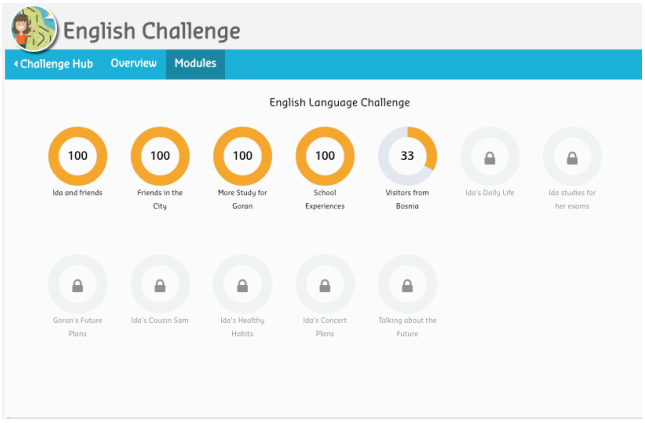

Figure 6. Completion dashboard in Curtin Challenge.

Administration dashboards include information on drop-off rates (Figure 7), how students have rated modules and average hours to complete modules including over specific date ranges and weekly participation. Data surfaced through the administration dashboard gives teachers the capacity to respond and adapt or modify the learning and assessment activities based on evidence of engagement. Consistent activity drop-off could indicate an issue with the learning design or the level of difficulty.

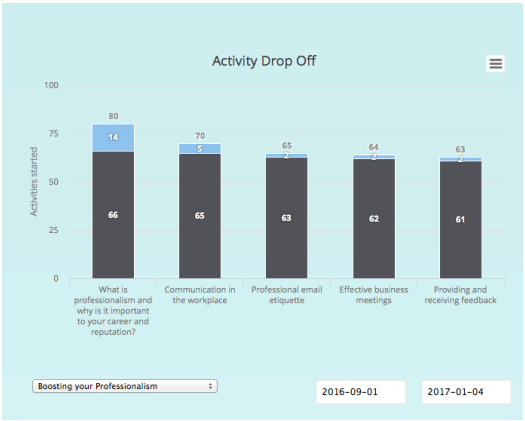

Figure 7. Activity drop-off rates in Curtin Challenge.

In 2009, the NMC partnered with Apple Education to analyse the results of the first CBL pilot, which involved 321 students and 29 teachers in six US high schools embarking on a set of projects that spanned 17 disciplines. Based on the remarkable results, in 2011 a second more in-depth study was planned that involved 19 institutions, this time spanning grade levels from 3 to 20, with the support of Apple Education. This report documents the outcomes of Challenge Based Learning in the 19 institutions engaged in the

Implementation Project. The major findings of the study can be listed as follows:

1. CBL is effective in building 21st Century Skills
2. CBL engages students in learning
3. Teachers find CBL effective in engaging students and helping them master the material — and a good use of their limited time.
4. CBL is ideally suited to teaching in a technologically rich environment.

Source: [27].

The 2011 Implementation Project found there were no striking differences in the student experience between students at different grade levels and ages, other than those attributable to the dynamics of the student working groups.

3. DISCUSSION AND CONCLUSIONS

In this paper we summarise the state of the art on the use of dashboards to provide real-time student feedback and performance tracking in game-based learning systems. We describe the application of gamified dashboards by providing three recent examples from university groups leading the field.

The experimental platform StarQuest has produced a practical social collaboration platform capable of delivering personalised game dynamics to hundreds of students at the University of Coventry. Navi Badgeboard and Navi Surface has supported students at KU Leuven in actively exploring their efforts and outcomes, by providing visualization techniques beyond personal analytics, and multi-user interaction to facilitate collaborative sense-making, and Curtin App has shown how challenge-based learning can integrate 21st century tools, requiring collaboration and assisting students in managing their time and work schedule, while effectively scaling to large numbers of students. For further details on methods and evaluation, and a more thorough discussion of each implementation, please see [4][24][25][26][27][31][32].

The different methods used in the evaluation of the examples do not allow comparative analysis of the efficacy of gamified dashboards. Personal traits, social and contextual factors have traditionally been used to predict the uptake and attitude towards gamification, as indicated also in the results of the experimental evaluation of StarQuest. Challenge-based learning and Curtin Challenge show how the influence of these factors may be overcome/neutralised when the students are encouraged to use technology to solve real-world challenges. The use of the gamified dashboards Navi Badgeboard and Surface has helped to increase student engagement and awareness, and has provided the basis for a larger comparative evaluation with other dashboards [20].

The aforementioned examples aim at increasing effective action from the feedback, providing a series of models, mechanisms and lessons learned to make effective use of dashboards in game-based learning, as well as guideless on how to visualise learning information and promote active exploration by students. On the basis of the findings of these studies, we can highlight the following advantages of using gamified dashboards in higher education:

1. Gamification: Gamified elements and dashboards enhance competition and collaboration in learning settings. Personality traits and context influence the success of the uptake of the learning environments [4].
2. Visualisation: Through the optimisation of visualisation techniques, gamified dashboards support students in effectively exploring their efforts and outcomes [20].
3. Challenge-based learning: With an adequate planning and preparation, challenge-based learning and gamified dashboards allow 21st century skills to emerge naturally from the learning activites, increasing also engagement of all students [27].

While the field has not yet succeeded in drawing definitive conclusions with regard to closing the feedback loop between data collection and learning, the work of these and other research groups around the world will continue as further studies and developments will be necessary to validate the effectiveness of the findings and achieve the successful implementation of gamified dashboards in higher education.

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