Technological and Implementation Issues in Moodle-Based Digital Badge System

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Abstract: Digital badges, touted as a gamification tool that can potentially influence learner motivation, engagement and participation, are being used increasingly in a variety of educational domains to facilitate and motivate learning. Using a badge system design implemented in the Moodle learning management platform, data was collected from four experiments from 2015 to 2017 to examine the effects of gamification with the use of digital badges on introductory programming students' intrinsic motivation. This paper provides an in-depth examination of seldomly discussed technological and implementation issues we encountered in implementing our Moodle-based badge system, worthy of exploration to support future gamification studies in this area. Our gamified implementation is analyzed according to five main factors primarily adopted from an IT implementation framework: (1) assessment of needs, (2) choice of technology, (3) technological infrastructure, (4) system and environmental factors and (5) evaluation. The findings highlight enabling and challenging factors associated with the technology and badge implementation. Our experience shows that badge systems may be influenced by contextual factors such as cost and scale of implementation. We provide recommendations to guide educational stakeholders, particularly those considering Moodle as their badge implementation platform.

Keywords: Digital badges, Gamification, Implementation, Motivation, Introductory Programming.

1. Introduction

A digital badge is "a representation of an accomplishment, interest or affiliation that is visual, available online, and contains metadata including links that help explain the context, meaning, process and result of an activity" Gibson, et al, 2013 p.2). They originated in the offline world from purposes such as identification, membership or rank, to its more prevalent use in education to denote achievements and skills, and to incentivize learning (Gibson, et al, 2013; Halavais, 2012). Digital badges, along with points and leaderboards, are considered gamification elements serving multiple learning purposes (Alsawaier, 2018; Gibson, et al, 2013). Gamification, defined as the use of game-like features in non-gaming contexts (Deterding, Dixon, Khaled & Nacke, 2011), is increasingly being used to motivate and engage students in technical higher education (Iosup & Epema, 2014). In the programming domain, gamification has been used to teach concepts (Arawjo et al, 2017), improve skills (Barrón-Estrada, Zatarain-Cabada & Lindor-Valdez, 2016) and engage students (Ibanez, Di-Serio & Delgado-Kloos, 2014).

Various badge design guidelines and recommendations have been proposed (Hickey et al, 2014; McDaniel & Fanfarelli, 2015), however, mere implementation of guidelines does not necessarily guarantee user engagement (Alves, Maciel & Anacleto, 2014). Evaluating technology implementations assesses effectiveness, whether there is need for redesign, and suitability for purpose (Jackson, 1998). Shields and Chugh (2017) recommend the double-loop learning process by Tagg (2007) to help educators with digital badges implementation. Key to this process is the reflective stage where implementation changes are conducted based on feedback, leading to a re-evaluation of the implementation. Necessary adjustments are made or if significant, initial assumptions guiding implementation, awarding and usage processes are re-examined and revised (Shields & Chugh, 2017; Tagg, 2007).

Our work discusses our implementation of a gamified system using badges in Moodle, an open source learning management system (LMS) which supports a constructivist approach to learning. Our preliminary study began with a baseline assessment of the intrinsic motivational levels of students in an undergraduate introductory

programming course. A comprehensive review of literature on digital badges was undertaken to identify major considerations undergirding their educational functions and design (Facey-Shaw et al, 2017). Subsequently, badges were implemented in Moodle to motivate introductory programming learners. This paper focuses less on the empirical results of the study, rather it provides an in-depth examination of the technological and implementation issues encountered through the lens of an IT implementation framework. These issues are seldomly discussed in the literature but worthy of exploration to support future gamification studies in this area. This comprehensive evaluation can guide educational stakeholders interested in badge implementations, particularly those considering Moodle as their badge platform.

2. Implementing technologies

In Cresswell, Bates and Sheikh (2013), technology-related factors considered for successfully implementing large-scale health information technologies include: clarification of problems to be addressed by the technology, consideration of technological options, choice of an affordable system that meets needs, appropriate infrastructure and continuous evaluation. Inappropriate or inadequate technologies and time pressures (Webb, Bunch & Wallace, 2015) can hinder effective implementation of technology. Affordances of the system, that is, properties compatible with and relevant for human interaction, can also allow for user-centered analyses of technology (Gaver, 1991) used in implementation.

An information technology (IT) implementation framework presented by Kukafka et al (2003) integrates literature on IT implementation approaches with consideration of the complex, multi-dimensional use of IT and the multiple factors influencing its usage. This framework is adapted from the precede/proceed model (Green & Kreuter, 1993) used in health promotion programs and which addresses multiple determinants of behaviour. The various phases involved in the framework by Kukafka et al (2003) are (1) assessment of organization needs and goals, key of which focuses on choice of technology; (2) organizational needs amenable to IT system solutions, where components of the needs that can be managed by an information system are identified; (3) behaviours and environmental factors linked with system use, which identifies system-specific, individual and collective behaviours and environmental factors associated with system usage; (4) predisposing, enabling and reinforcing factors associated with behaviours linked to system use and (5) system use-inducing factors that focus on proactive approaches to positive system usage. Technology innovation (efficiency, customization, innovation attributes, sense of ownership and ease of use), accessibility to the innovation, technological infrastructure, availability of technology support personnel and timely changes to innovation by developers (Moore, 2004) can affect system usage performance and attitude.

The foregoing provides a lens for discussing and evaluating the implementation of our Moodle badge system. Our paper focuses on five main factors: (1) assessment of needs, (2) choice of technology, (3) technological infrastructure, (4) system and environmental factors and (5) evaluation (Cresswell, Bates & Sheikh, 2013; Kukafka et al, 2003; Moore, 2004). Our iterative evaluation aligns with the checking stage of the double-loop learning process (Shields & Chugh, 2017; Tagg, 2007), serves to highlight enabling and challenging factors associated with our badge implementations, and includes recommendations for future work.

3. Digital badge system implementation

To investigate the relationship between digital badges and intrinsic motivation, we conducted several experiments exploring the motivation levels of undergraduate students pursuing a first-year introductory programming course. Data, including the results from an intrinsic motivation survey, Moodle log activity and qualitative feedback from focus groups, was collected over a three-year period from four experiments carried out in two academic sessions in 2015, one session in 2016 and the fourth in 2017. Most students in the course were pursuing a Bachelor's degree in Computing, while less than 5% were enrolled in Bachelor's degree in Actuarial Science. Badges were designed in accordance with specific learning activities and uploaded into Moodle. Badge learning activities included posting pseudocode or C code solutions to challenge forums, quizzes on the course content, forum posts reflecting on performance, reading general course material, producing flowcharts and attending classes. Our findings were mixed - quantitative intrinsic motivation results were slightly negative however qualitatively, results revealed that badges were positively received and motivating. In this paper, we examine our implementation in light of technology-related factors as earlier

discussed. Given increasing badge research, understanding issues arising under similar experimentation conditions can be useful reference points for future research (McDaniel & Fanfarelli, 2015).

3.1 Assessment of needs

Introductory programmers often lack motivation to sustain interest and attention as they struggle with seemingly difficult programming concepts. This challenge is well-supported in the literature (Gomes, Santos & Mendes, 2012; Jenkins, 2001; Watson & Li, 2014). Inconsistent attendance, low active problem-solving participation within and outside classroom settings and struggles with flowcharts to aid understanding of programming logic were among the main concerns of our teaching faculty.

Our study desired to explore the use of learning technologies to influence motivation to learn programming within individual and social settings. For the first experiment, we reviewed the main learning outcomes in our introductory programming course and mapped the outcomes to badges to be used in the system. In subsequent experiments, we incorporated badges representing a more social and reflective approach to learning. Depending on implementation scale, extensive consideration of the badge ecosystem and approaches to badge system development, such as how badges integrate with learning content and technological platforms (Grant, 2013), will be required prior to implementation.

3.2 Choice of technology

The decision to use the Moodle LMS (https://moodle.org) as our gamification platform was influenced by factors discussed below:

- Moodle was already in use at the university and supported the learning process for our target student group, making this approach very cost-effective. The existing course site primarily hosted course content. For large-scale implementations or multi-level interventions, choosing technology to match organizational and end-user needs may be more important than adopting that offered by current technology (Kukafka et al, 2003). In our context, the badge implementation was targeted at an individual course level. Infrastructure, lack of research funds and costly advanced technological devices warrant a look at how existing technological infrastructure and low-cost technology can be utilized to design contextually effective programming learning environments (Grönlund & Islam, 2010; Imtinan, Chang & Issa, 2012). Balancing needs with cost-effectiveness, however, can lead to system limitations (Kukafka et al, 2003) but considering technological options and their inherent risks and benefits is recommended, especially for large-scale implementations (Cresswell, Bates & Sheikh, 2013).
- Moodle supports activity modules reflecting a social constructionist view of learning. The underlying infrastructure has a pedagogical framework which supports collaboration, knowledge representation, observing of peer activity, understanding of user contexts and a flexible, adaptable learning environment (Moodle.org, 2013). For example, we considered Moodle forums to present programming challenges to students. Peers could see who posted solutions, review the solutions and point out any errors, or merely observe student-lecturer and student-student interactions.
- Badges were already implemented in the Moodle 2.6 version at the time of the first experiment. The system allows an instructor to award badges based on a variety of selected criteria.
- Besides badges, other gamification elements such as points, leaderboard and rankings were also featured in Moodle, some upon the installation of available plug-ins. These additional elements allowed us to experiment with social learning approaches, though badges were our primary gamification incentive.

Our thinking was that the social incentive-based, pedagogical environment supported by the existing Moodle LMS could provide a seamless learning context within which introductory programming students could be motivated to effectively participate and collaborate. As a commonly used LMS by universities, Moodle has featured in a number of gamification studies on motivation and engagement (Barata et al, 2013; Kyewski & Krämer, 2018; Hew et al, 2016).

3.3 Technological infrastructure

Consideration of the technological infrastructure is important to mitigate potential risks with the system that might impact on usability and performance (Cresswell, Bates & Sheikh, 2013). Even after choosing a system, reflecting on its continued usage is important to minimize risks that may later arise.

Badges were being implemented within the university for the first time during Experiment 1. We therefore did not have the benefit of previous institutional gamification experience to guide the implementation. Characteristics of technology such as customization and ease of use can affect implementation outcomes (Moore, 2004). The intuitive nature of the badge setup, existing online, technical documentation and the online community of active badge users enabled our implementations.

Enabling factors within an organization's infrastructure are key to facilitating a successful implementation (Kukafka et al, 2003). Both the university's distance learning and learning technology support units provided technical assistance with the implementation, such as testing and installing certain badge-related and other gamification plug-ins used within the experiments, for example, Level Up, Level Availability and Restriction by Badge (https://moodle.org/plugins/index.php). The bureaucratic nature typically associated with universities, however, meant navigating chains of command to ensure timeliness of implementation.

Occasionally, the wider technological infrastructure suffered from slow wireless connections, at times leading to challenges accessing the LMS. During these times, user attitudes to the infrastructure were negative (Cresswell, Bates & Sheikh, 2013) and affected usage of the badge system. However, the periods of inaccessibility were relatively low. On one attempt at an experiment, system failure resulted in a partial loss of badge distribution data. The experiment was abandoned but re-done in a subsequent semester. Monitoring system performance and backup of badge data were done periodically to provide feedback on system availability.

3.4 System and environmental factors

System-specific factors require careful analysis to ensure system usage (Kukafka et al, 2003). We first assessed the existing badge functionality to determine suitability for our learning activities. An independent, external Moodle platform through which we could install recommended plug-ins, upload badges and conduct a simulated test of setting up and awarding badges was helpful.

In the early experiments, badges were created using the Open Badge Designer tool (openbadges.me/designer.html) and uploaded in our university's LMS at the beginning of the semester. Later, images from openclipart.org were used to create the badges. Incomplete registration and enrolment procedures often prevented students from accessing the Moodle LMS during the first week of the semester, thus our badge-related activities usually began by the third week when most students were able to access the system.

Badges were initially organized in four categories – attendance, participation, flowchart and course. Each category consisted of a series of badges culminating in a master badge for that category. For e.g. in the Flowchart category, acquisition of the three flowchart badges led to a flowchart expert badge (Figure 1).

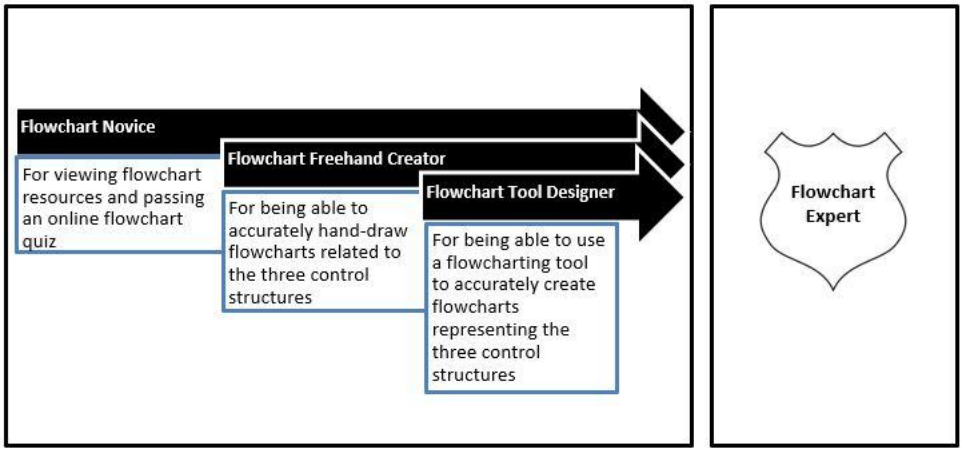

Figure 1: Badges in the Flowchart category.

Students could earn badges across these categories using a non-linear approach. However, badges in the Course category were dependent on prior acquisition in the other categories (Figure 2). In the second experiment, additional badges were added to some categories, e.g. Participation, after previous results indicated most students acquired starting badges in a category but failed to achieve its master badge.

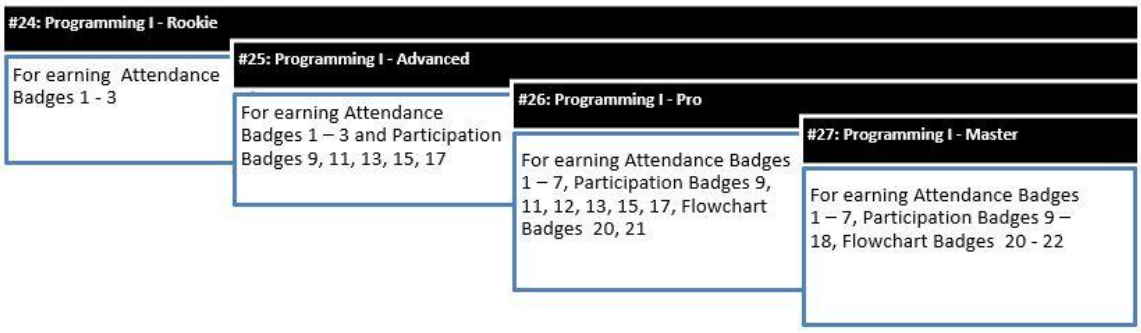

Figure 2: Badges in the course category.

By the fourth experiment, our badge categories had changed to advice (e.g. with badges such as Helpful Programmer, Programming Motivator), content (e.g. Challenger, Content Guru) and competitive badges (e.g. Leaderboard First Place). In each case, the non-linear approach was maintained for the various categories whereas overall course badges were dependent on the type of badges achieved.

Badges were awarded manually or, in a few instances, automatically. Manually issued badges were relatively straightforward to set up. Automatic badges required a more technical approach. For example, to obtain the Flowchart Novice badge, students had to view resources on flowcharts then take a short quiz with a required passing grade of 50%. A separate page was set up, accessible only to students who passed the quiz (https://moodle.org/mod/forum/discuss.php?d=232499#p1011235). Clicking on this page allowed the automatic issuing of the badge.

Notification on badge availability was provided verbally and as a Moodle resource. In our early experiments, attendance badges were available as awards (O'Donovan, Gain, & Marais, 2013). They were subsequently removed in later experiments due to tedious, manual recording of attendance which often led to their untimely award. Also, student feedback indicated that such badges were not valued (Denny, 2013). Research suggests that the more users there are that earn a particular badge, the more diminished is its value (Immorlica, Stoddard & Syrgkanis, 2015).

Students were notified of badge awards via email or as an LMS message. Awarded badges were displayed on their profile page or in the Latest badges section. In the first experiment, students complained of receiving

insufficiently described badge notifications via email. More descriptive details were added in subsequent experiments. In one experiment, badge awarding did not lead to an automatic triggering of emails hence students had to log into the LMS to learn of badge awards. The technology support unit was consulted to rectify the problem.

In one experiment, three badges were initially hidden to encourage experimentation (Eleftheria et al, 2013) and assess student feedback upon their discovery. To implement this, badge criteria was set up but not enabled until a student met the criteria. We realized badges used within the same course but with a new student cohort were aggregated with those previously awarded. To prevent this, we created various instances of the Moodle course. Badge names should be unique within the system so minor changes were made to file names to satisfy this constraint.

Structural features implemented in our badge system to reflect a social approach included the students' ability to rate each other's posts. Nominating peers for badges can lead to increased participation (Nolan, Preston & Finkelstein, 2012) thus badges were available for rating a post (e.g. Rater badge) and creating a highly-rated post (e.g. Helpful Programmer badge). A customized rating scale with positive terms (Useful, Very Useful, Extremely Useful) was created in Moodle to facilitate this. Iosup and Epema (2014) suggests that only positive badges should be used in education.

In the fourth badge experiment, we used the Badge Ladder tool to incorporate a leaderboard with 10 levels to promote achievement and friendly competition. Experience points associated with each level could be achieved by viewing various resources in the course. Default icons per level were changed to incorporate stars and colours (Figure 3) to provide visual feedback on the remaining stars needed to accomplish the top level and to encourage further participation. Additionally, badges were available for students acquiring first, second and third place on the leaderboard at the end of the semester.

Figure 3: Level 1 and 5 icons in the Leaderboard

Other social considerations included allowing students to view badges of their peers but this feature was not available in the Moodle 2.6 version. To view peer badges, students had to click on each participant's profile. While useful, in a course with many students, this method was impractical unless a student was interested in badges of specific peers. In other badge platforms, dashboards are provided to show individual and class badges, and other analytical information to indicate individual and class progression and for student reflection (Santos et al, 2013).

Finally, we briefly highlight how Moodle facilitated our overall experiment design. In the first 3 experiments, all students, despite their tutorial or lecture groupings, had access to the course badges. By the fourth experiment, we established a control and experimental group to compare the engagement and participation of students with badges versus without badges. Whereas all students had access to course notes and general resources, the Moodle groups feature was used to make activities, such as forum postings, visible only to the badges group. This made it easier to award badges to eligible students.

3.5 Evaluation

Timely changes to an innovation can affect usage and attitudes (Moore, 2004). Over time, feedback from previous experiments and new Moodle features enhanced our implementations. Badges were added and removed as our research orientation changed. For example, in the second experiment in 2015, two new badges, Avid Adventurer and Enthusiastic Reader were added to introduce an additional level between the Reader/Little Adventurer and the Super Reader/Super Adventurer badges, the starting and master badges for those badge types since the master badges appeared difficult to attain. Also, in September 2016, attendance

badges were removed since these appeared to be of little value and more content-related badges introduced, while our September 2017 experiment focused on social-oriented badges. Badge laddering and experience points were also incorporated. Figure 4 reflects the evolution of badges over the experiments.

Jan 2015 Badges	Sep 2015 Badges	Sep 2016 Badges	Sep 2017 Badges
Course Newcomer	Course Newcomer	Helpful Programmer	Challenger
Course Resident	Course Resident	Programming Motivator	Challenge Creator
Course Citizen	Course Citizen	Submit Post	Great Challenge Creator
Course Senator	Course Senator	Reply to Post	Content Guru
Course Ambassador	Course Ambassador	Flowchart Creator	Documenter
Justice of the Ps - Lab	Justice of the Ps - Lab	Flowchart Expert	Inquirer
Justice of the Ps - Tutorial	Justice of the Ps - Tutorial	Pseudocode Creator	Explainer
Justice of the Ps - Lecture	Justice of the Ps - Lecture	Pseudocode Whiz	Rater
Flowchart Novice	Flowchart Novice	Code Creator	Self Learner
Flowchart Freehand Creator	Flowchart Freehand Creator	Code Whiz	Helpful Programmer
Flowchart Tool Designer	Flowchart Tool Designer	Quizzer	Reflective Programmer
Flowchart Expert	Flowchart Expert	Master Quizzer	Motivator
Challenger	Challenger	Programming 1 - Bronze	Programming Advisor
Super Challenger	Super Challenger	Programming 1 - Silver	Knowledge Provider
Little Adventurer	Little Adventurer	Programming 1 - Gold	Knowledge Seeker
Super Adventurer	Avid Adventurer	Programming Master	Leaderboard First Place
Reader	Super Adventurer		Leaderboard 1st Runner-up
Super Reader	Reader		Leaderboard 2nd Runner-up
Self Learner	Enthusiastic Reader		
Master Learner	Super Reader		
Reflective Programmer	Self Learner		
Shining Star	Master Learner		
Top of the Class Participant	Reflective Programmer		
Programming 1 - Rookie	Shining Star		
Programming 1 - Advanced	Top of the Class Participant		
Programming 1 - Pro	Programming 1 - Rookie		
Programming 1 - Master	Programming 1 - Advanced		
	Programming 1 - Pro		
	Programming 1 - Master		

Figure 4: Badges used in 2015 – 2017 Experiments

To preserve badge-related data, we created separate instances of the Moodle course. Unlike other course resources, badges used in a previous course offering had to be re-uploaded due to unique name requirements. In some instances, icons were re-used but file names changed, or in other cases, icons were changed altogether. Maintaining badge documentation for each experiment and mapping badge types according to their categories, helped us to build our incremental badge system. Moodle logs were useful in evaluating student participation and activity.

For manually awarded badges, consistent system monitoring is necessary to ensure student completion of activities result in timely award. Automatic badges are ideal but may not be possible due to course structure, additional course instructors, whether in-class or off-line activities are rewarded, type of learning activities and other factors peculiar to the course setting.

Monitoring and evaluation are important in identifying errors or access patterns (McDaniel & Fanfarelli, 2015). Ongoing backups and prompt archiving of the course on completion help to preserve data for future analysis. Moodle limitations hindered us from exploring how some individual and collaborative learning activities could be combined with various gamification elements (Sousa-Vieira et al, 2016). This phenomenon is not unique to Moodle however, and has led some researchers to develop their own platforms (Santos et al, 2013; Sousa-Vieira et al, 2016). Our experience shows that the gamification system chosen may be influenced by contextual factors including cost and implementation scale.

4. Conclusion, recommendations and future work

This article discussed technological and implementation issues associated with a Moodle-based badge system designed to motivate introductory programming learners. We reviewed our gamification experiments over a three-year period according to five factors primarily adopted from an IT implementation framework (Kukafka et al, 2003): assessment of needs, choice of technology, technological infrastructure, system and environmental factors and evaluation. Our findings highlight enabling and challenging factors with students' gamification experience, influenced by cost, implementation scale and other contextual factors. From our experiences, we offer these recommendations:

- Determine purposes for badge use by carefully assessing course or programme needs. Also, carefully plan and map learning activities associated with badges or other gamification elements. The Moodle platform should be reviewed at the planning stage to determine whether learning activities can be facilitated or if additional plugins are necessary, considering lead time for any required approval procedures.
- Choose a technological platform according to needs and learning activities. The ideal gamification platform is one customized to accomplish the specific purposes of the desired system, however, choice of platform will likely be constrained by factors such as scale or cost. While we were able to use the existing Moodle infrastructure and its low cost technological approach for an individual course, gamification interventions spanning multiple courses or an entire programme may require significant consideration of badge design and implementation strategy.
- The structural features of badges, how learners interact with the badge environment to accomplish learning goals and how the system facilitates badge achievement are all important considerations for implementation. Clear procedures should also be established for badge accomplishment.
- Monitor and evaluate system performance continuously and obtain early, periodic feedback from potential badge awardees. System performance monitoring may be outside the scope of those implementing badges, however, procedures such as backing up the Moodle course, reviewing participant and other log activity reports, and soliciting in-class feedback on badge achievements are recommended.
- Establish and maintain good relationships with support teams - instructors, technological units, technical administrators etc., and seek out expert users of badge systems. Online forums, research databases and fellow instructors can be good repositories of information.

This review has highlighted the role that technological and implementation issues play in the effectiveness of badge implementations. Future work will examine gamification with the use of badges and other elements in various contexts to further explore their learning contribution.

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