Tailoring Gamified Educational Systems to Users and Context: An Extended Abstract

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Contextualization: This article presents an extended summary of the results obtained in the thesis defended in the Postgraduate Program in Computer Science and Computational Mathematics (PPG-CCMC) at the University of São Paulo (USP) in December 19, 2022 [1, 12]. The work was developed by the first author, in a period of 45 months, under the supervision of the last author.

Computing Education (CE) is hard to learn and teach. Computing students often lack motivation to learn, which likely decreases performance and increase dropout rates. Gamification might alleviate such motivational issues, which would consequently contribute to improving CE, but research demonstrates that standard gamification strategies might fail and end up negatively influence learning outcomes. To mitigate such failures, scholars have explored personalization of gamification. However, at the start of this Ph.D. research, the literature was unclear on how to properly personalize gamification, as well as how it compares to the standard, one-size-fits-all approach. Moreover, we found a lack of approaches validated within the scope of CE [11]. We faced this problem with 10 studies, in the context of CE, organized in three parts and based on an iterative method (see [12] for details).

Part 1: What factors impact the success of gamified systems? While empirical evidence demonstrates there are several factors that moderate (i.e., maximize or minimize) gamification's effect on learning outcomes, which suggests those should be considered when personalizing gamification, what are those factors, as well as how they act remain an open problem.

We addressed those gaps with four (quasi-)experimental studies in the context of CE, which are described in Chapter 3 of the thesis. As results, in [10], we found task-related factors moderated gamification's effect, but it was limited to a one-time usage of a single game element. In [9], we found similar results based on a six-week intervention that deployed an enriched gamification design, which also indicated usage time's role on gamification's effect. In [5], we analyzed multiple possible moderators simultaneously, after a 14-week usage period, yielding results that question our previous findings. In contrast, findings from [6] extended those from [9] based on a 14-week study of another gamification design. Overall, those findings corroborate previous literature from two perspectives. On the one hand, they provide evidence that user and contextual factors might moderate gamification's effects. On the other hand, they demonstrate the challenge of understanding which/how those factors affect gamification's success. As the main takeaway, these studies suggested that multiple user and contextual factors, as well as their interaction, play a significant role in gamification's success. Thus, supporting the view that, if one wants to personalize gamification, they should do so by considering user and contextual dimensions simultaneously.

Part 2: How to Personalize Gamification to Users and Context? Our previous studies revealed that user and contextual dimensions, especially when considered simultaneously, play an essential role in properly understanding student motivation and performance in the context of gamified educational systems. Nevertheless, our literature review demonstrated personalization strategies are mostly based on one or few user dimensions, often failing to consider contextual information and dimensions' interactions [11]. Furthermore, our review also revealed that most personalization strategies are conceptual. Hence, they cannot be readily deployed into gamified educational systems.

We tackled those lacks with two studies that inform the multidimensional personalization of gamification with guidelines that we implemented in a web-based, ready-to-use prototype of a recommender system. In [2], we contributed a conceptual personalization approach considering the task users of a gamified educational system would do, but limited to this single dimension and lacking guidance on which game elements to select. In [8], we advanced that approach by acknowledging both user and contextual information should be considered simultaneously, modeling user preference as such, and providing a concrete personalization strategy implemented as a free-to-use recommender system that provides transparent guidance on which game elements to use when/to whom. Mainly, these results advanced the literature by offering guidance and technological support for those interested in deploying gamification personalized to multiple dimensions into their educational activities. This can be achieved by either consulting our recommender system to receive recommendations on which game elements to use or using it as a service to automate the personalization of the gamification design of an educational system.

Part 3: How Personalized and One-size-fits-all Gamification Compare? Despite we contributed guidance and a recommender system that inform the multidimensional personalization of gamification, those still lacked an empirical validation with users to understand how gamification personalized based on such recommendations compares to the OSFA approach. Related work suffered from a similar issue [11].

We addressed that lack with empirical evidence from two experimental studies conducted within the context of CE, which are described in Chapter 5 of the thesis. In [3], the findings suggested that multidimensional personalization improved student autonomous motivation, compared to the OSFA approach, by supporting their needs and mitigating drawbacks from regular assessment activities.

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Although the results were promising, we found no support for those findings in our replication [4]. Nevertheless, Study 2's exploratory analyses provided additional insights. For instance, they suggested *gender* and *education* positively moderated personalization's effect, in contrast to *preferred game genre* and *preferred playing setting*. Exploratory analyses also revealed motivation varied according to six characteristics for students who used the OSFA design, while the motivation of students who used personalized gamification varied according to only four factors. Additionally, qualitative results indicated the gamified assessments provided positive experiences that students considered well designed and good for their learning, although a few of them mentioned the overall gamification needed improvements. Overall, those results suggest a new way of seeing personalization's role in gamification and inform designers, instructors, and researchers by: i) showing whereas personalization might not increase the learning outcome's average, it might improve gamification by reducing its outcome variation; ii) showing gamified review assessments provide positive experiences students consider good learning means; and iii) raising several hypotheses to be tested in future research.

Evidence-based Personalization Model Refinement: Most personalization strategies are based on potential experiences: they were created according to people's opinions, not feedback collected after actually using gamified applications [11]. However, there is no guarantee that one's opinion of what they like the most will translate to, for instance, increased motivation. Accordingly, the findings from [4] raised the hypothesis that relying on a personalization strategy based on true, instead of potential experiences, could maximize personalized gamification's effectiveness.

We tackled this gap with an initial study that refines our previous personalization approach and provides a new, data-driven recommender system: GARFIELD - The Gamification Automatic Recommender for Interactive Education and Learning Domains[1], which is introduced in Chapter 6 of the thesis. GARFIELD is a recommender system for personalizing gamification based on feedback from real usage data. GARFIELD's aim is to recommend a suitable gamification design that will lead students to an expected level of intrinsic motivation while also considering their characteristics (e.g., educational background and gaming preferences). Overall, GARFIELD provides a reliable starting point for practitioners and researchers to expand and improve in future research as - to our best knowledge - it is the first tool that guides practitioners and instructors on how to personalize gamification to multiple user and contextual dimensions based on empirical data [7].

Products: According to Google Scholar, the 10 publications that resulted from this thesis sum over 300 citations at the time of submission. Furthermore, this thesis generated two recommender systems, two datasets, a number of assessments/quizzes on CE, and data analysis plans (see the publications for details). Finally, this thesis helped hundreds of Computing students and over 10 professors from four institutions around Brazil as we had the opportunity to enhance their lessons with gamified activities while conducting empirical studies.

Contributions: This thesis' main contributions to CE are threefold: i) empirical evidence on which factors moderate gamification's effectiveness; ii) guidance, conceptual, and technological support on how to personalize gamification to user and contextual information simultaneously; and iii) empirical evidence on how our personalization approach affects student motivation and what to expect from it compared to OSFA gamification. We acknowledge that, as with every research, this thesis has a number of limitations that we discuss in Chapter 7 [12]. Nevertheless, we believe our contributions are valuable to practitioners and researchers by, respectively, informing the design of gamified practices based on empirical evidence from the CE domain and raising research questions to be addressed in future research, both in the Computing as well as in the overall domain of technology-enhanced learning.

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