Intelligent Authoring of Gamified Intelligent Tutoring Systems

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ABSTRACT

Intelligent Tutoring Systems can successfully complement and substitute other instructional models in many contexts. However, it is very common to students to become bored or disengaged using ITS. The inclusion of gamification capabilities (e.g., level, points and so on) in ITS design aims to engage students and to drive desired learning behaviors. Researchers have been noting that teachers are increasingly demanding to act as active users of systems with such features. In this context, the main challenge of this project is contributing to the actively participation (i.e., design) of teachers in the use of gamified intelligent tutoring systems. This challenge leads to the following research questions: (i) "how could we enable teachers to customize the construction of gamified ITS in a simple way and without requiring technical capabilities from them?"; and (ii) "how could we also provide good design principles in order to aid teachers in the customization of gamified ITS?". Thus, our aim is to develop an intelligent authoring platform to enable teachers for customizing gamified ITSs. In this way, we describe in this text a set of specific objectives that must be completed to achieve this general aim.

Keywords

Intelligent Tutoring Systems; Gamification; Intelligent Authoring

1. INTRODUCTION

Empirical evidences suggest that Intelligent Tutoring Systems (ITSs) can successfully complement and substitute other instructional models in many situations [10]. They are consistent with the most frequently implemented ITS features enabled by student modeling, namely high individualized task selection, prompting and response feedback.

In general, the traditional development of ITSs do not make efforts to engage and motivate students. On the other hand, motivated, challenged and intrigued students tend to have better learning results [20]. In this way, relying on theories and models of motivation and human behavior, many works have been using persuasive technologies (e.g., gamification) in connection with education [7]. Gamification can be defined as "the use of game elements and game design techniques in non-game contexts" [21]. It has been used in the context of web-based education by adding game elements (e.g., levels, points, badges, and so on) to learning contexts aiming to engage students and to drive desired learning behaviors [8].

Meanwhile, teachers are increasingly demanding to act as active users of systems with such features. For instance, a recent survey [14] with 41,805 K-12 teachers in USA reports that more than a half of them consider learning how to use educational technologies which distinguish instructions to students (i.e., ITS) the most important item for their professional development. Moreover, another survey [13] with aspirants teachers in USA reports that they consider the access to educational technologies with support to customized instructional plans as one of the main factors that will determine their future success as teachers.

In this context, the main challenge of this work is contributing to the actively participation of teachers in the use of intelligent tutoring systems that consider motivational aspects of the students using gamification. However, since teachers have different expectations and/or methodologies as well as could use ITSs in several domains and different educational levels, they should be able to customize them according to their preferences. Thus, by actively participation we mean that teachers may be primary actors of gamified ITSs, for example, by selecting which functionalities they are interested to incorporate in ITSs, by defining which gamification behaviors they expect from their students, by choosing which pedagogical strategies they may consider or by creating and/or reusing content.

The design of ITSs is very complex. It should take into account the four classic ITS models (domain, student, pedagogical and interface models) [22] as well as should deal with several stakeholders, such as developers, authors, teachers, students and so on. The inclusion of gamification features in ITS design significantly increases the complexity of constructing these systems, since gamification elements may be combined to several ITS features.

On the one hand, there is an increasing interest by teachers to actively use (i.e., customize) systems with such features, but on the other hand it is very complex to build them. Thus, "how could we enable teachers to customize the construction of Gamified Intelligent Tutoring Systems in a simple way and without requiring technical capabilities from them?". However, only enabling teachers to customize these systems without providing some kind of support for their decision-making is not enough, because it is likely that they would build ineffective tutors both from performance and motivational aspects. In this way, "how could we also provide good design principles in order to aid teachers in the customization of gamified ITS?"

2. MAIN CONTRIBUTIONS

Aiming to contribute to the challenges previously mentioned, we present in this section the objectives of this PhD project. However, before presenting our objectives, we will briefly discuss some theoretical concepts and important technologies that are used in this work.

Researchers have been investigating the use of authoring tools for building intelligent tutoring systems since the beginning of ITS research [12, 22, 17]. The aim of using such tools includes, for example: (i) reducing the effort for designing ITSs; (ii) decreasing the required level of skill to construct ITSs; (iii) aiding ITS authors/designers to organize domain or pedagogical knowledge of the system; (iv) supporting good ITS design principles; (v) enabling quickly prototyping for ITS design; and so on.

However, the development of authoring tools to aid the construction of ITS with game elements may be considered an open problem/challenge in computers and education research. So far, to the best of our knowledge, we could not find any work in the literature that propose to use authoring tools for enabling teachers to build gamified ITS. Furthermore, as mentioned by Sottilare et al [17], the opportunity of integrating game elements and intelligent tutoring systems by the use of authoring tools may enable an expected increasing in students motivation and engagement along with effective instructional techniques provided by ITSs.

In this way, to address the questions raised in the end of Section 1, and taking into account the potential benefits of using authoring tools in the context of Gamified ITSs, our aim in this PhD project is to develop an intelligent authoring platform to enable teachers for building Gamified ITSs.

As part of the "intelligent" aspect of our authoring platform, we represent the knowledge about gamification theories and ITS models as well as good gamification behavior practices in a way that it can be used to aid the authoring process. For instance, some pre-defined gamification behaviors (e.g., performance, participation and so on) with predefined game elements choices may support a better and more simple decision from the teacher. In order to represent such knowledge in a way that could be processable by the authoring platform, we are relying on the concept of ontologies. Ontologies can be logically reasoned and shared within a specific domain. Thus, ontologies are a standard form for representing the concepts within a domain, as well as the relationships between those concepts in a way that allows automated reasoning.

Additionally, taking into account the high variability of gamified ITSs (i.e., there are several technological, ITS and gamification features that could be combined in different tutors) as well as the need for representing the knowledge about configuration choices of a teacher, we also intend to create a configuration model that could be automatically reasoned by a gamification ITS platform to deliver a specific system according to author's choices. In this context, we are relying on the concept of feature modeling to manage the variability of gamified ITS.

Moreover, enabling the automatic analysis of feature models and hence providing reconfiguration of a gamified ITS is also required. Achieving these characteristics could allow for example, to monitor learner's motivational levels at the time they are interacting with the ITS and to reconfigure the system with a different gamification behavior that could improve the engagement of students. Thus, in comparison to other mechanisms for automatic analysis of features models, description logic (DL) based methods (e.g., ontologies) promise to provide improved automated inconsistency detection, reasoning efficiency, scalability and expressivity [3].

Figure 1 presents an overview of the intelligent authoring process for building gamified ITS from teacher's perspective. In order to achieve our general objective, we intend to reach the following specific objectives:

(a) Investigate and select proper ITS models from the literature to be represented in ontologies;

(b) Investigate and select proper models of motivation and human behaviors from the literature to be represented in a gamification ontology;

(c) Define a set of gamification behavior good practices from empirical research papers in the context of education online to be incorporated in the gamification ontology;

(d) Specify an integrated ontology relating gamification and ITS ontologies;

(e) Design and implement the authoring platform taking into account the gamification and ITS knowledge represented in ontologies. This platform must consider authoring of content as well as authoring for customizing the design of gamified ITS by teachers;

(f) Define an ontology-based feature modeling approach to represent the configuration knowledge of the authoring platform which can be used to instantiate a specific gamified ITS.

3. RELATED WORK

The literature review about the use of authoring tools to build gamified ITS was conducted in three different ways: (i) analysis of the papers that propose authoring tools and that are included in a recent book [17] that reviews the use of authoring tools for building ITS; (ii) searching in google scholar for papers in the topic; and (iii) conduction of a systematic review of the literature in topic, which is currently in the writing stage.

After performing these three steps, we have found seven authoring tools that can be considered related to our platform: ASSISTments [15], ASPIRE [11], CTAT [1], SimStudent [9], xPsT [5], GIFT [18] and Ataide's tool [2]. Although, these works present important contributions for authoring ITS, none of them address the challenge of authoring gamified ITS. Moreover, Gonzalez et. al [6] propose a conceptual architecture for building gamified ITS. However, this architecture does not allow intend to allow teachers for customizing gamified ITSs. This PhD project intends to develop an authoring platform in order to enable teachers without any technical ability (e.g., programming skills) to customize gamified ITSs. Our platform makes use of a knowledge layer which includes gamification and ITS theories as well as good design principles to support the authoring process.

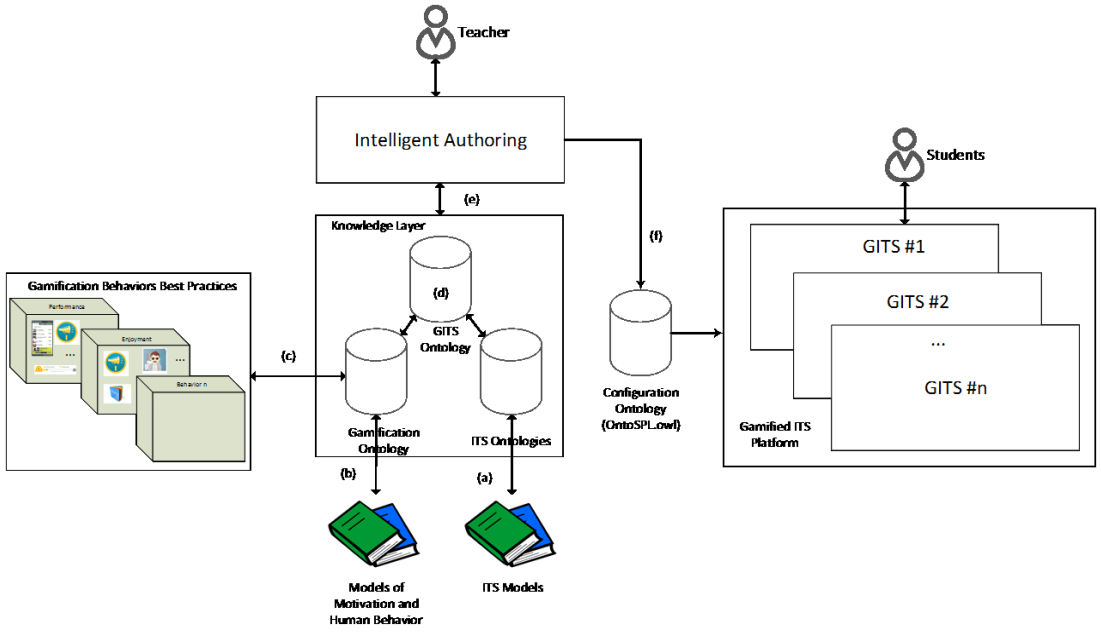

Figure 1: Overview of the Intelligent Authoring for Building Gamified Intelligent Tutoring Systems

4. ONGOING WORK AND FURTHER RESEARCH

In this section, we explain the specific objectives that we have already performed and which activities we still need to execute. In addition, we will further explain how we intend to validate our proposal.

To perform the objective (a) we have first studied several ITS theories and models (i.e., domain, student and pedagogical) and then we have adapted ITS ontologies available in the literature.

In order to complete the objective (b), mentioned in Section 2, we have first studied several theories related to gamification (e.g., Fogg's behavior model, Self-Determination Theory, Reinforcement theory, flow theory and so on) to understand the gamification domain. Then, we specified a domain ontology according to the Self-Determination Theory (SDT) – since one of the main definitions [21] of gamification is supported by such theory – to represent the core concepts about gamification domain. Several gamification concepts along with their relationships are represented in the ontology, for instance, Game Design Element, Game Components, Game Mechanics, Game Dynamics, Motivation, Player and so on.

Afterwards, in order to achieve objective (c), we have first searched for empirical studies that report positive effects on the use of gamification in education from published systematic literature reviews on the topic (e.g., [16] and [7]. Next, we grouped these effects by using a gamification design framework (i.e., 6D framework [21]) according to common target behaviors for using gamification. Based on these groups, we defined six behaviors, which we call good practices, i.e., performance, participation, enjoyment, competition, exploration and effectiveness. They are called good practices because they establish a gamification design that has presented positive empirical results in the literature. Finally, we relied on the gamification domain ontology defined in the previous objective to represent these practices in the ontology.

To achieve the objective (d) we have connected gamification concepts to ITS concepts in an integrated ontology (named Gamified Tutoring Ontology - GaTO) based on the gamification ontology and on the ITS ontologies specified in the execution of objectives (a), (b) and (c).

In order to achieve the objective (e) we have conducted the requirements engineering and architectural design phases for the authoring platform. We are currently implementing the specified architecture (75% of the implementation is already developed). It is noteworthy that some non-functional requirements are crucial to the design of the authoring platform, for instance, usability. As we are designing an authoring platform for teachers, this requirement drives several decision-makings, since it is of utmost importance to the effectiveness of the authoring platform.

The output of the authoring platform is a configuration model that represents which features of a gamified ITS should be incorporated in the tutor authored by teachers. In this way, to achieve objective (f) we defined and validated an ontology-based feature modeling (OntoSPL) approach [4, 19] that is used to constrain the design space for features selection by authors. This ontology may be further used by a gamified ITS platform to deliver a configured tutor according to the configuration represented in the ontology.

Finally, after concluding the implementation of the authoring platform we will further validate our platform in three different ways. First, we intend to evaluate the usability (i.e, based on Nielsen's heuristics) for customizing gamified ITS from teachers perspective in academic settings. Second, we intend to analyse the authoring platform integrated with a gamified ITS platform aiming to characterize the effort for creating gamified ITSs with respect to the time of creation and ease of use from a teacher viewpoint in industry settings (i.e., MeuTutor). Finally, we also intend to analyse gamified ITSs designed by teachers using our au-

thoring platform to characterize them with respect to motivation and learning performance from a student viewpoint in academic settings.

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