

Ontology modelling for gamification of feedback in higher education: integrating game elements through the MDA framework

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Abstract

Gamification is a broad topic that is being discussed in many areas, with a large increase in the volume of research after the COVID-19 pandemic. Together with the ongoing digitalisation of almost everything, gamification has its solid ground in all scales of different areas as well as in the area of higher education, where this paper belongs. As gamification becomes more popular, the quality of its outcomes may deteriorate. This paper proposes the connection between gamification and game design by proposing an ontologically based model for classifying game elements based on the Mechanics, Dynamics and Aesthetics (MDA) framework. This theoretical model linking these two fields should provide a clearer tool for selecting the right game elements during the gamification process. Together with this theoretical model, the ontology model of feedback in higher education is proposed. Finally, the case study is designed to verify the theoretical model of connections between gamification and game design by using the proposed model within the process of gamification feedback in higher education in the form of a gamified application. Furthermore, the link with the Gamification Tutoring Ontology (GaTO) model is proposed to further advance research in this area. With this theoretical model created and the validation method proposed, the next step of the research would be to carry out the validation with the case study designed in this paper.

Keywords

ontoUML, gamification, higher education, MDA framework, game elements, GaTO

1. Introduction

The concept of gamification is a popular concept used in various fields stretching from general business to education. Not so explored is gamification used in the areas of higher education and especially in the area of feedback process in the field of higher education. In general, when talking about gamification, we are talking about using game principles and game elements in different contexts than in games. We can use the definition by Karl Kapp [1] to fully grasp the basic principle of what gamification is about.: “*Gamification is using game-based mechanics, aesthetics and game thinking to engage people, motivate action, promote learning, and solace problems.*”

The primary goal of this paper is to establish a theoretical connection between game design and gamification by proposing an ontology-based categorization of game elements, utilizing the MDA framework from game design theory. Additionally, it aims to outline the foundational ontology of the feedback process in higher education. This model characterizes the elements used within feedback and explores the potential for gamifying this process.

The formulated research question in the paper is the following: *Is a game design framework such as the MDA framework usable in designing game elements in the gamification process?*

The gamification should incorporate game elements characterized by the proposed MDA framework-based categorization. Models are based on the principles of the ontoUML modelling language designed by Guizzardi [2] and created with the help of using OntoUML lightweight editor as a modelling tool. Since the OntoUML modelling language specializes in describing ontologies and is based on the UML language, it has been chosen for model creation.

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The benefit of the proposal of an ontology-based categorization of game elements utilizing the MDA framework is in the novelty of the approach, which connects the gamification area with the game design area on the theoretical level in the deeper understanding of used game elements in the gamification process. The importance of closely connecting gamification with game design is clear to many authors. [3, 4] The reason is to maximise the benefits of gamification while minimizing the possible harmful effects.

The motivation for undergoing this process is to enhance understanding of the mentioned game-based mechanics and elements and to develop a comprehensive framework for gamification of the higher education sector. This framework is intended to serve as a set of recommendations for implementing gamification in higher education to boost student motivation and outcomes. Moreover, the framework should be applicable across various fields of higher education and be more general in nature. Therefore, the ontology-based conceptual models for describing the mentioned terms could provide valuable insights in the future.

2. Gamification in higher education

Gamification is described by many definitions and theories. In this paper, the theory by Karl Kapp [1] used in the introduction part is used. Several studies were published on the effect of gamification in the field of higher education. Usually, a case study is created with an experimental verification part conducted in order to prove the benefits of gamification in university studies. As an example, the field experiment by Welbers [5] and colleagues can be stated. The tailored feedback is being used there as a feature to increase the engagement of students.

Great overview of work published in the field of gamification is provided by Subhash and Cudney [6] in their systematic literature review. This review identifies key frameworks and usages of various game elements.

In detail, the domain this paper is set into is higher education and its gamification. More precisely, it is the feedback process of higher education and the possible gamification usage in this process. The benefit of the formal representation of gamification used in higher education feedback is a clearer overview of the possible automation of this process with the use of gamification. Thus, the overall improvement of the process.

2.1. MDA framework and game elements

MDA framework is a framework used in the game design process. The MDA stands for “mechanics”, “dynamics”, and “aesthetics”. MDA represents a formal approach to understanding games. This approach attempts to bridge the gap between game design, game elements and their development and technical game research and criticism. [7] By shifting across the three levels of abstraction within MDA framework, we can grasp how game systems behave dynamically. Viewing games as dynamic systems aids us in devising methods for iterative design and enhancement. This approach enables us to mitigate unintended consequences and adjust for desired behaviour. [7]

Game elements are basic principles of gamification since gamification can be defined as the usage of game elements outside of the game environment [3]. Using the theory proposed by this framework in the gamification process could prove highly valuable. The main contribution of this paper is the proposal to categorize game elements based on the MDA framework theory. This can facilitate a stronger connection between gamification engineers and game designers at the theoretical level. Since it would provide a theoretical connection between gamification and game design itself, it would provide a basis for further research in the area of connecting gamification with game design.

2.2. Feedback in higher education

The general topic of gamification in higher education is refined into the field of university feedback. Adcroft [8] suggests that university students and their tutors hold different perceptions of feedback.

Based on these different perceptions, it is valuable to describe the university feedback model by the ontoUML model. OntoUML is selected because the possibility to define the basis of the ontology and display basic characters of used terms within the feedback concept in higher education. There are not many articles describing gamified feedback, but there are papers touching ICT supported feedback processes such as the following:

- Description of online tools for feedback [9]
- Online vs Offline feedback [10]
- Digitize feedback process [11]

Based on those papers it is safe to say that ICT is a valid tool to be used in the support of feedback processes. What remains a possibility to improve is engagement in filling out the feedback and handing it over. If gamification is a valid tool to be used to increase the engagement of the feedback process and overall motivation to provide meaningful feedback, it is still a problem that needs to be fully understood and described.

3. Conceptual and ontology modelling

In this paper, conceptual modelling is employed as a principle. To correctly understand it, the following definition was considered:

"Conceptual modelling is the activity of formally describing some aspects of the physical and social world around us for purposes of understanding and communication. Such descriptions, often referred to as conceptual schemata" [12] The aspects of the world around us, in terms of this paper, are the gamification elements and the feedback elements described in the forms of ontology-based models. Conceptual models, in general, allow us to describe and represent different parts of the real world. They can be utilized to enhance understanding of a problem and facilitate communication about a specific problem or area [12].

3.1. OntoUML

OntoUML is an ontologically well-founded language for conceptual modelling based on Ontology, developed as an UML extension using Unified Foundation Ontology (UFO). Its origin can be traced back to Giancarlo Guizzardi's PhD thesis: "Ontological Foundations for Structural Conceptual Models", [2] where UFO was introduced and applied to improve a part of UML 2.0. metamodel for better conceptual modelling and domain ontology engineering.

OntoUML has been extensively utilized by academic, corporate, and governmental organizations worldwide for creating conceptual models in diverse fields. It has been considered for the OMG SIMF (Semantic Information Model Federation) [13] Request for Proposal and is explicitly recognized as the basis for the "Data modelling Guide (DMG) For An Enterprise Logical Data Model (ELDM)" initiative. Additionally, the fundamental theories that underpin OntoUML have influenced other widely-used conceptual modelling languages, such as ORM 2.0.

4. OntoUML models and discussion

In the following part, two ontoUML models were created. The model for the general feedback process in higher education was created. This model was enhanced by gamification and how gamified feedback can influence the model. The second model is dedicated to game elements and their characterisation based on the MDA framework used mainly in the game design.

4.1. Gamified feedback model

The first step in developing an ontology-based model for feedback in higher education is to define relevant terms for inclusion in the model. These terms can be categorised into two groups: feedback-related and higher education-related.

The identified terms in the first group are the following:

- Feedback
- Personal feedback
- Academic feedback
- Gamified feedback
- Positive feedback
- Negative feedback
- Neutral feedback
- Gamification element.

The second group is represented by the following terms:

- Student
- Tutor
- Person
- Study
- Academia.

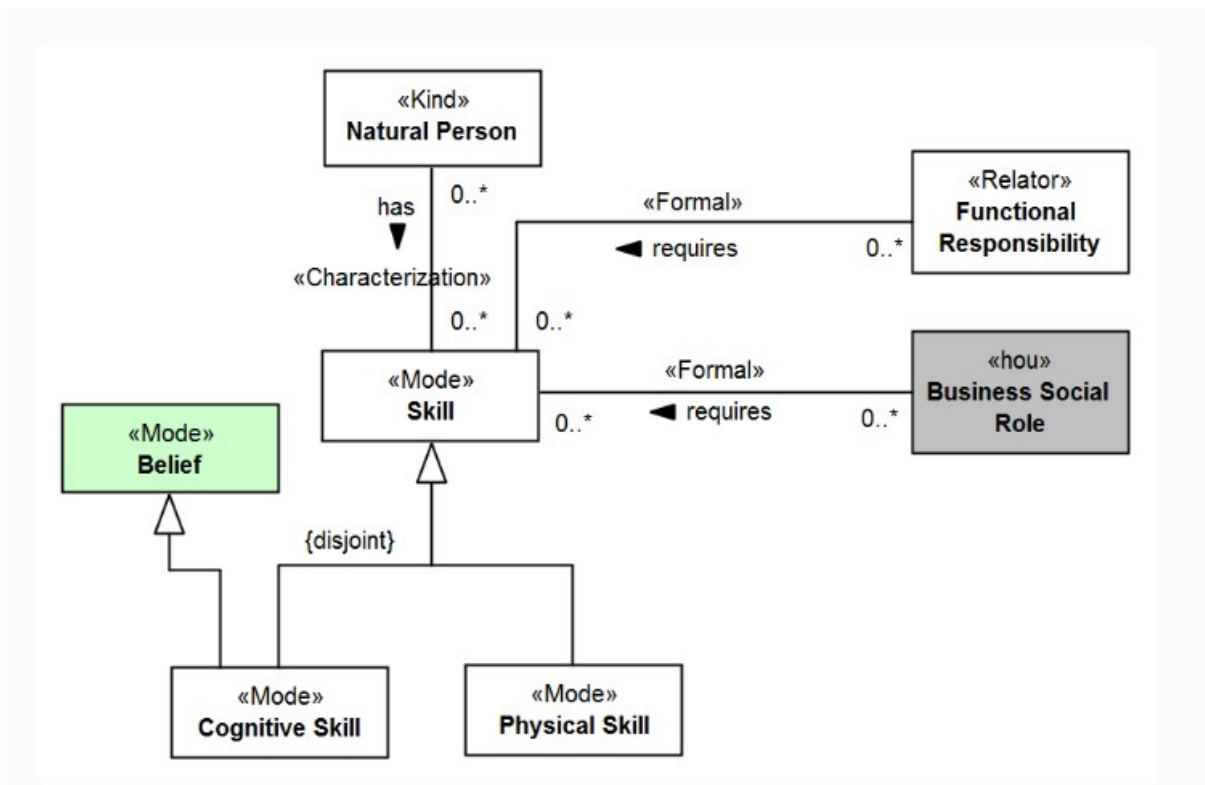


Figure 1: Fragment from the OntoUML Org Ontology (O3) by Marek Suchanek

Based on those identified terms, the ontology model of the feedback in the area of higher education was created in figure 2 by author. This model describes how feedback is being filled from students' perspectives towards their tutors. It identifies students and tutors as roles of the kind identified

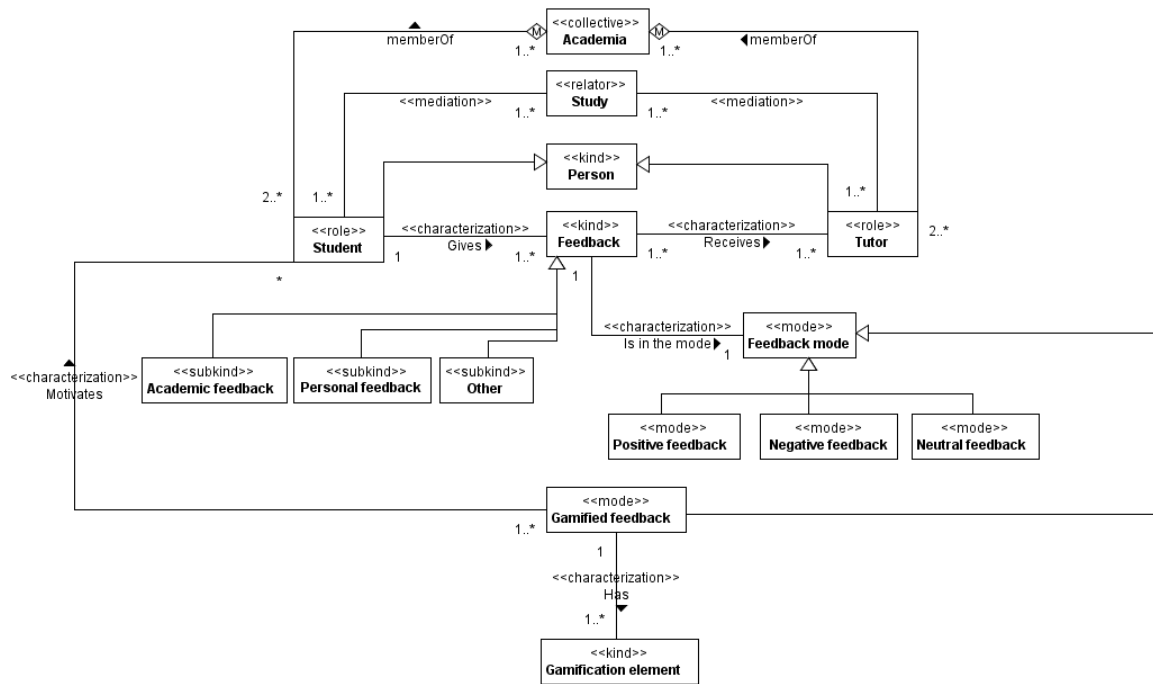


Figure 2: Gamified feedback

as a person. Those roles are connected together by the common relator, which is study, and they are part of the common collective, which is academia. Another kind the feedback was identified as a kind representative of a second group of terms. Feedback also connects students and tutors by characterisations since one gives the feedback and the other receives it. The feedback modes were specified regarding an example by Suchanek in ontoUML specification in figure 1 [14]. In similar sense the feedback is defined with joint generalisation into one general feedback mode that is connected to feedback kind via characterization.

Feedback is divided into several subkinds, such as personal or academic feedback, and it has several modes, such as negative or positive feedback. In this group of modes of feedback, they are connected together and only one of them can be used at the same time. On the other hand, there is also a second mode group which contains only one mode of feedback that is gamified feedback. So even though feedback can always be gamified, it can only be positive, negative or neutral. The key mode that is described here is sole standing gamified feedback. This feedback mode is powered by game elements represented by another kind called game element. This gamified feedback is connected with the student’s role through characterisation. This characterisation should represent the student’s motivation to provide feedback towards the tutor, that is increased by gamification used in gamified feedback mode (thanks to the game elements).

This model provides an overview of feedback in higher education and the influence of gamification on this process. Gamification is characterised by gamification elements that are also described in the following model.

4.2. Gamification elements classified by MDA framework

The MDA framework described in the previous part created by Leblanc and colleagues [7] is a valuable tool to assess the gamification frameworks and to design games. The assessment of gamification frameworks by the MDA framework was already done in some papers. For example, Kusuma [15] and colleagues looked at several gamification frameworks and tried to assess them using the MDA framework. They found out that the best way forward is to use mechanics and dynamics to boost the aesthetics to the maximum in order to boost motivation and engagement. For example, giving in-game

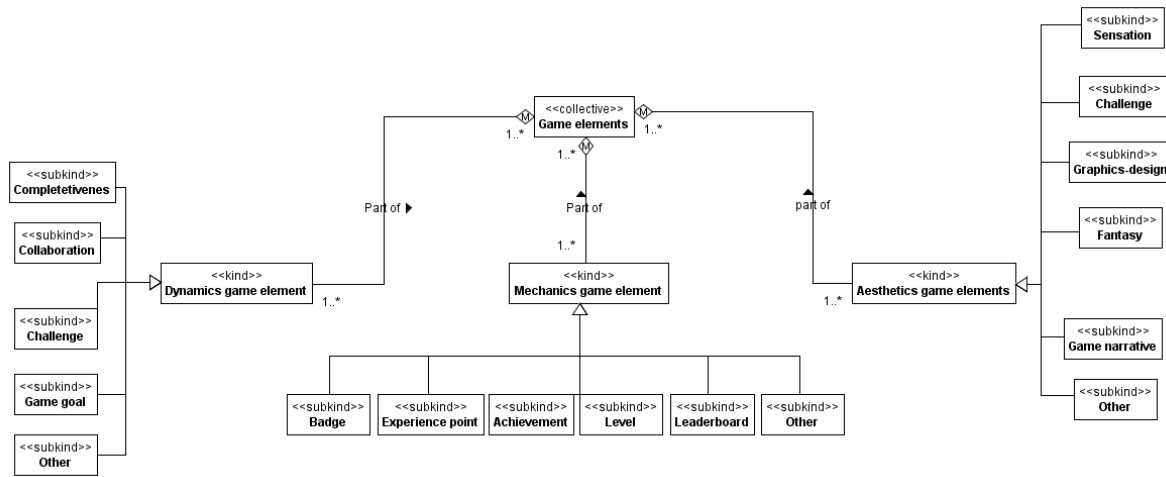


Figure 3: Classification of game elements based on MDA framework

points and rewards in the form of badges or trophies could give students a sense of achievement and greatly increase their motivation to use the app and, at the same time, learn the subject. The global goal here is to substitute money-based motivation in processes where it is not possible.

The main proposal here is to use MDA framework to describe game elements used in the gamification process. The ontological model of game elements and their categorisation was created to achieve this. In this model in proposed in figure 3 by author, game elements are stated as a collective of elements used in gamification. This collective contains 3 kinds:

- Mechanics element
- Dynamics element
- Aesthetic element

Each of those kinds is also related to several subkinds that are the concrete types of game elements. Since concrete elements may always differ, the ontological conceptual model makes sense in this case. To display the general overview and connection between game elements categories. The categories proposed in the model reflect the three components of the MDA framework. During the gamification process, this classification should guide the selection of game elements to address various aspects of a non-game environment. Each element corresponds to a different pillar of the MDA framework, representing diverse user perspectives on the process. The benefit of this approach is the minimization of incorrect game element selection within specific subprocesses of the gamified process.

Interesting discussions can revolve around the term "game elements." In the initial model of the feedback process in higher education, this term is referred to as "kind." However, in the model of game elements, it is generalised into the "collective". Kind is described as a representation of rigid concepts that provide an identity principle for their instances and do not require a relational dependency. However, the «Collective» construct is also used to represent rigid concepts that provide an identity principle for their instances.[14] By those descriptions from ontoUML documentation, it can be seen that both constructs can describe similar things. Thus, it depends on the context in which the model is created.

The GaTO model seen in figure 4 [16] (Gamification Tutoring Ontology) already proposed the usage of dynamics and mechanics in terms of gamification and game elements. Dermeval and colleagues [16] created an ontology dedicated to gamification in tutoring systems. In this ontology, they stated game element terms to be generalised from Mechanics and Dynamics. However, they are not concerned with aesthetics in this model, and they are not working with the MDA framework at all. For further research, it could be valuable to add aesthetics based on the MDA framework also into the GaTO ontological model together with the authors of GaTO. Instead of the Aesthetics, they are using "Components"

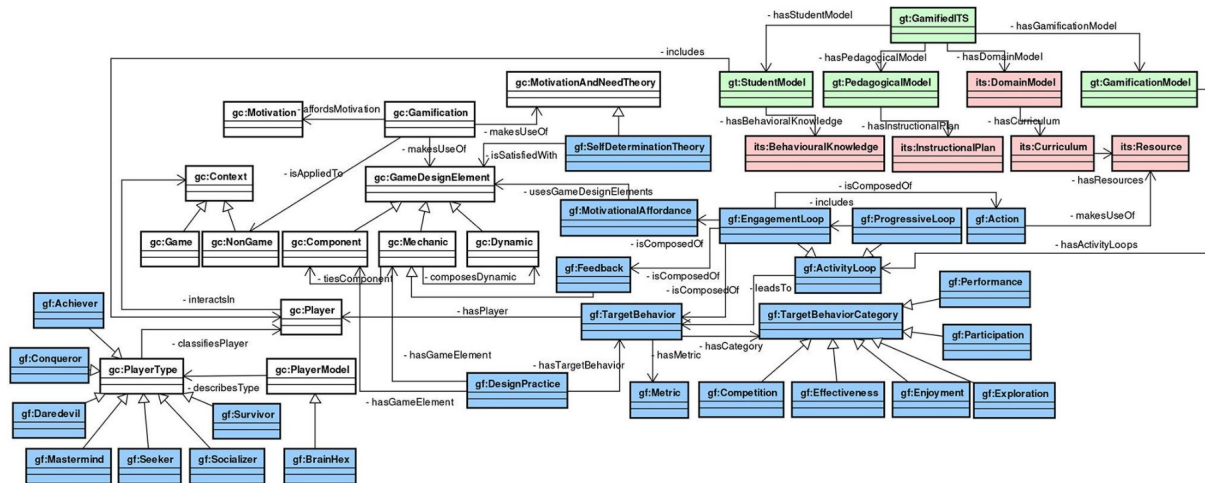


Figure 4: Gamification tutoring ontology by Diego Dermeval and his colleagues

described by Werbach and Hunter as more specific forms that mechanics or dynamics can take. [17] So, taking the MDA framework into account and connecting it with the GaTO and general gamification theory can be a valid way forward.

5. Verification

A case study is proposed to verify the connection between gamification and game design. Although the case study has not yet been executed, its design is detailed in this section of the paper, and future results are pending.

The objective of the case study will be to verify the proposed connection between gamification and game design; a case study is designed to evaluate the effectiveness of game element selection based on the MDA framework classification. The focus is on enhancing user motivation to provide feedback through a mobile application used by university students. A mobile application designed to provide feedback to university tutors has been selected for this case study. The goal is to increase user engagement and motivation to complete feedback forms by integrating game elements. The selection of game elements will be guided by the proposed MDA framework classification. Each category of the MDA framework will be addressed by a different game element to meet the varied expectations of users. The reasoning behind the selection of these elements and how they fit within the MDA framework will be detailed in the subsequent sections of the case study.

The final step of the case study involves qualitative research, specifically through focus groups with university students who use the application. These focus groups will compare the gamified and non-gamified versions of the app. Additionally, the students will compare the gamification proposal based on the MDA framework with a proposal that does not use this framework. This comparison will help assess the effectiveness of the MDA framework in guiding game element selection for gamification.

The case study aims to provide insights into the effectiveness of using the MDA framework for selecting game elements in gamification. It will evaluate whether this approach better meets user expectations and enhances their motivation compared to a non-framework-based gamification strategy. The findings from the focus groups will be used to validate the proposed connection between gamification and game design, pending future results.

6. Conclusion

This paper is dedicated to conceptual modelling and ontological modelling of gamification and feedback in the area of higher education. In the first part, the ontological and conceptual modelling theory is

outlined. Models are created using ontoUML notation and created in OntoUML lightweight editor. In the second part of the paper, the feedback process is discussed, with the possibility of gamifying this process in order to increase the engagement and motivation of students to provide feedback to the university. The second model is dedicated to game elements and their categorisation. Since game elements are an essential part of gamification, it is important to categorise them and formerly display them. The MDA framework is proposed to be used as an outline of the categorisation of game elements. This has not yet been done in any papers, but similarities were found in the Gamification Tutoring Ontology created by Dermeval et al.. The proposal of using the MDA framework seems to be promising since it links game design theory with game elements as a crucial part of the gamification process.

In conclusion, the theoretical answer to the stated research question in the introduction part of the paper is that the MDA framework is indeed a usable concept in designing and selecting game elements within the gamification process. However, this will need to be confirmed by the proposed case study from the previous chapter.

In terms of further research, primarily the execution of the proposed case study should be done. Also, the investment in creating a proper taxonomy of game elements and their categorisation is recommended. Since there are several points of view on how to categorise them. The ontology model proposed here can be used in this effort. Also, the GaTO or MDA framework or others can be used. The potential connection of this model with the GaTO model could be possible by contacting the authors of the GaTO model and discussing the ontology with them.

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