

## A Framework for Utilizing Unexplored Game Elements in Designing Learning Systems

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### ABSTRACT

Gamification is defined as the use of game elements and designs in non-gaming areas and applications such as education, marketing, and healthcare. That is to facilitate and develop the engagement of users with a product or service. Researchers have found that gamified learning has the ability to improve student success, interaction, and enjoyment of courses. Recently, researchers suggested that one way to achieve that is through the personalization of students' experiences. However, research has been focusing on a narrow group of game elements which does not ensure equal consideration when designing for different personality types.

In this paper, the researchers' aim is threefold that is: to identify the unexplored game elements in the learning domain to ensure equal experiences for different personality traits; to study the utilization of the identified unexplored elements and how they can be used in relation with different personality types and learning styles to make learning tasks more desirable and enjoyable; to inform and enrich the design of gamified e-learning systems. To achieve that aim, the researchers analyzed the literature to identify the unexplored game elements, conducted a focus group study to examine the utilization of unexplored game elements along with other contextual aspects.

Then to formalize the results reached from our study and provide more systematic means for software engineers to extract useful information that can inform their designs, an ontology was implemented for that purpose. Finally, an existing gamified e-learning framework was adapted to illustrate how the formed artifacts and models interrelate to realize the research aim.

*Index Terms: Gamification, Learning Styles, Ontology, Personality Traits, Software Engineering*

### 1. INTRODUCTION

GAMIFICATION as a term was introduced in 2002 by Nick Pelling who described it as "applying game-like accelerated user interface design to make electronic transactions both enjoyable and fast" [6]. While Bartle in 2003 described gamification as "turning something not a game into a game" [9]. Then in 2011, it was defined as "the use of game design elements in non-game contexts" [42]. "Gamification is

a noun, which means the use of game design, game elements, and play for non-entertainment purposes" as described in [28].

Ever since its introduction, it has been employed in serious contexts to enhance engagement, motivation, and participation in order to change users' behavior [43]. Nowadays, gamification is emerging in many fields like Marketing [6], crowdsourcing [29], software development [9]; [5], government [36], and health [43]. In this paper, the researchers are more focused on gamification in education as it has been attracting attention in the context of education.

According to the calculations in statista [15], the gamification industry was forecasted to expand from \$4.91 billion in 2016 to approximately \$12 billion in 2021.

Users are the main intended audience of these systems and a key factor to its success. Thus, according to [23], to make gamification successful, more focus must be paid to the human factors. Otherwise, it will be called "Fake Gamification", which is a process that only adds decorative game elements to the systems without including elements that have an effect on human characteristics, extrinsic and intrinsic motivations [11]; [18]. However, most gamification in education studies focuses only on a few game elements and neglecting the main purpose of gamification in education, which aid all students to immerse and effectively collaborate in the specified course or lecture [1]; [2]; [34]; [39]; [45].

Personalized content motivates users much further compared to "one size fits all" [19] leading to better course satisfaction [6]. According to [42] and [32], customization and personalization achieve better results and are more effective than generic approaches. Researchers have attempted to personalize learning environments by using different factors such as age, gender, personality traits, user types, and learning styles [18]; [6]; [25]; [37]. With personalizing design and content, learning can become more effective by displaying the relevant content using the relevant style to the right users [12].

On the other hand, other findings have demonstrated that the "one size fits all" approach raises risks such as undesired behavior and declining student performance [40]; [23]. Examples from what researchers have found are that the effect of leaderboards differs according to personalities. It can positively or negatively influence performance according to personality type [3]. Also, while rewards may be motivating for some users they can decrease the confidence of others [40].

Different researches were made on personalizing education experience by integrating it with big five personality traits [43] or gamification player types [1] and learning styles [33]. Most researchers in gamified learning tried to find a better way for personalization by merging several factors. For example [43]; [42], focused on the big five and some game elements. While mentioned learning styles and a couple of game elements [46]. In big five, and learning styles were presented [21]. Others in attempted to gamify the learning experience according to the task nature [35].

According to [23] and [12], there are user types neglected in the design of gamified learning systems as only a few elements correlated to them are used in learning applications and platforms. That is why gamification risks are emerging [40]. Various gamification elements motivate different user types. They support gamification designs as they can be used as elements, emotion, feedback, mechanics, dynamics, or schedule depending on application purpose [28].

This paper presents a study that further explores the merging of four different factors: 1) game elements with a specific focus on un-explored game elements; 2) personality traits; 3) learning style; and 4) task nature, for a better-personalized design of learning systems that cover all the needs of different personality types and their motivators.

The use of gamification in designing and implementing learning systems is a challenging task. It includes knowledge about game elements (such as points and leaderboards), fundamental components of course management (such as required tasks), and other contextual information (such as learning styles and/or personality traits). To deal with this challenge, a formalized method is needed to support the concepts with the possibility of automated reasoning that helps inform design decisions in gamified learning systems. Researchers [14]; [4]; [8] created gamification ontologies for different domains such as software engineering, lifecycle management, and learning.

However, to the best of the researchers' knowledge, there are no standardized approaches to the systemic use of gamification design knowledge that help guide design decisions in personalized gamified learning systems. Thus, to address this issue they have developed a gamification ontology that organizes and adequately links the concepts and knowledge related to personalized gamified learning systems design. SPARQL queries were developed to demonstrate the benefits of their ontology implementation [16].

Finally, the researchers adopt an existing gamified learning framework via enriching it with tools and mechanisms that aid software engineers in developing gamified e-learning systems that utilize the unexplored game elements in a personalized manner based on users' types, learning styles, and tasks nature.

The rest of this paper is structured as follows: Section 2 provides a brief background on the big five personality traits, player types, and learning styles. In addition to a summary of the state-of-the-art research of the field.

Section 3 summarizes the analysis of the unexplored elements. Section 4 shows the adopted research methodologies. Section 5 presents the participatory design study principles for unexplored gamification elements in gamified learning systems and the results reached. Section 6 shows the ontology IMPLEMENTATION. Section 7 provides the gamified e-learning framework. Finally, the last section presents the conclusion.

## 2. LITERATURE REVIEW

In this section, a discussion of the research work along with the foundation concepts related to our scope is presented.

### 2.1. GAMIFICATION AND LEARNING

Gamification is a technique that encourages student participation using different activities and incentives [43]. Profoundly embedded in the motivational paradigm of active education, gamification is an innovative educational approach that systematically utilizes the different elements and features of gaming culture [22]. Gamification examples include: playing educational games to learn new academic

skills, gaining points for completing given activities or competing with peers to achieve a particular goal [17]; [31]. Several researchers have been conducted on how to incorporate gamification in the education context. In [19] and [25], it was found that points, badges, and leaderboards are extremely powerful motivators that help students feel rewarded for their efforts and keep track of their progress, and encourage persistence. Also, challenges help students to stay motivated in the process of learning [3]. Moreover, progress bars, avatars, and dashboards are a few examples of elements that improve the skills of gaming and learning [17]; [1].

Interestingly, [2] and [7] demonstrated that gamification elements and dynamics provide a positive motivational impact on students' engagement and academic performance. However, both of them mentioned that more longitudinal studies are needed on gamification in addition to mixed-method designs to help understand the relationship between gamification, engagement, and motivation. Unfortunately, most gamification in education studies focuses only on a few elements and neglect the main purpose of gamification in education, which is aiding students to immerse and effectively collaborate in the specified course or lecture. It was discussed in several studies that only BPL (badges, points, and leaderboards) were used and the other elements which are directly mapped to most of the personalities were ignored [21]; [19]; [43]; [1]; [2]; [31].

## 2.2. USER TYPES AND GAMIFIED LEARNING

It is now commonly accepted that personality characteristics have a major effect on academic achievement [11]. Several studies have suggested the need for personalizing gamified systems according to users' personalities [43]. Personality trait theories have long sought to nail down how many personality types exist. Big Five Personality Traits are the most used model of personality in academic psychology. Those five personality traits are abbreviated as OCEAN [33]; [43], which are: **Openness**: known as curious and open to new ideas; **Conscientiousness**: known as organized and systematic; **Extraversion**: known as being outgoing and enjoying social situations; **Agreeableness**: known as being tolerant and trusting; **Neuroticism**: known as being anxious and moody. Furthermore, Marczewski proposed six user types called "Gamification User Hexad" that have different motivations whether intrinsic or extrinsic in addition to their mechanics and dynamics [28]. There are six player types that have different motivations and understanding, and their corresponding gamification techniques have a great effect on the design [43].

Gamification User Types Hexad framework classifies users as follows: **Philanthropists** who are altruistic and willing to give without expecting a reward [20]; **Socializers** who want to interact with others and create social connections [43]; **Achievers** who seek to progress within a system by completing tasks, or prove themselves by tackling difficult challenges [43]; and **Free Spirits** who are motivated by the freedom to express themselves [20]. They like to create and explore within a system; **Players** will do whatever to earn a reward within a system, independently of the type of the activity [41]; **Disruptors** tend to disrupt the system either directly or through others to force negative or positive changes [41]. Adding to them General and Rewards Schedule are the eight main categories of the 52 gamification elements while each main category has a couple of sub-categories [28].

The word "learning styles" refers to the understanding that each student learns in a unique way [13]. An individual's learning style refers to the preferred way in which the student receives, processes, recognizes and preserves knowledge for further use [33]. It is crucial for educators to consider the differences in the learning styles

of their students so that they can incorporate best practices in their day-to-day tasks, curriculum, and assessments [20].

Felder Learning Styles (FLS) are divided into four different dimensions and eight different learning styles which are [13]; [33]; [46]: **Sensing learners:** like to observe facts, gather data, concrete examples, strict information, and prefer to solve the problem via standard methods but they prefer practical tasks; **Intuitive learners:** prefer theories, concepts, dislike repetition, and prefer conceptual issues. They are innovative; **Visual learners:** prefer visual information such as diagrams, pictures, videos, graphs, and flowcharts and prefer questions with visual elements. They remember what they see clearly; **Verbal learners:** they like written, textual documents, books, lectures, spoken explanations and prefer Essay questions. They remember best what they hear; **Active learners:** enjoy practical assignments and experimentation to try things out. In addition, they like concrete examples, case studies, working in groups, and dislike being passive; **Reflective learners:** prefer to spend time examining and thinking through information and presentations with topics to think about. They like to work alone but they like to give their opinion as well; and **Sequential learners:** learn through linear steps. Materials must be read in a specific order and tasks with multiple steps are preferred. They can work with partial or superficial information; **Global learners:** follow holistic thinking processes and create their own learning plan. They can connect difficult materials, conceptual solutions and synthesize information.

It has been established by several authors that the current era's key is personalization [6], [1]; [42]; [20]. Knowing the influence of individual features on gamification experience will inform the successful design of gamified learning strategies and enable them to be effectively incorporated into the learning environments [41]. In other words, each student needs to be educated and rewarded in a way that motivates especially him/her.

[46] presented a model that consists of gamification elements in e-learning, phases of development management of e-learning, and Felder-Silverman learning styles. A gamified e-learning course model was proposed with the base of learning styles for materials and curriculum with Moodle as the basis of the development [46]. In addition to the structuring of the teaching material based on the FLS model and assessments, some activities were not mentioned and personality traits were not put into consideration as well.

Rapeepisarn in [35] put into consideration different aspects in designing educational computer games like learning styles, learning activities with game genres for developing quality-learning experience in class. On the other hand, Prensky's Study used activities and learning techniques in educational computer games. For example, Practice and feedback; Learning by doing and learning from mistakes; Goal-oriented learning; Task-based; Role-playing; Coaching, and intelligent tutors. However, the researcher did not mention elements and how the model will be applied in real life.

Previous research [17] has demonstrated that game elements have a relationship with motivation and can be applied to different software systems. Game Development or Educational System Development courses "GaMDeF" is a guide rather than a definitive design that provides different insights into the relationship between game elements and motivation [6]. However, it is more suited for computer games implementations. Although they mentioned 16 elements, they also said that some of them are hard to be used and incompatible with the learning systems. Even though they focused on motivation and learning neither personalities nor learning styles were mentioned in [5].

### 2.3. GAMIFICATION AND ONTOLOGY

Ontology is to put the knowledge of a specific domain and represent it in a way that different applications can use [14]. The ontology introduces the categories, properties, relations between the concepts, data, and entities of one or many domains [8] to support the developed theoretical concepts with the possibility for automated reasoning.

In [4], seven sub-ontologies which are core gamification concepts, organizational concepts, psychological concepts, evaluation concepts, ethical concepts, risk concepts, and concepts related to the user were named OntoGamif (Ontology for the Gamification domain). They argue that gamification may fail because there is a gap in the understanding of its implementation and design. Rokia et.al provide a clear description of concepts in the gamification domain in OntoGamif [4]. For example, Identifying gamification goals and design elements; Providing a global picture of the gamification domain; Showing possible gamification risks; Clarifying gamification concepts; identifying the different dynamics and mechanics; Understanding employee behavior and personal goals; and Identifying main ethical issues.

Other domain-specific ontologies were developed. For example, according to Félix *et.al*, 2017 Software Engineering and software organizations need gamification to make the tasks more attractive and challenging to be fulfilled [14]. A framework composed of an ontology GOAL (Gamification focused On Application Lifecycle Management) to integrate and support gamification into the organization. In [14], a gamification ontology was created to encourage the use of gamification in software projects.

In the learning domain, Chalco et al. created an ontology to support the gamification of Scripted Collaborative Learning (CL) scenarios in which the game elements are tailored for each situation [8]. The ontology OntoGaCLeS supported knowledge about personalization, game design and their effect on students' learning and motivation. According to [8], a study was made on undergraduate students. The results showed that participants in gamified sessions were more motivated than the ones in non-gamified sessions.

More work is still needed to produce a more integrated ontology implementation in gamified learning that incorporates: 1) personality aspect, such as Big five personality traits, 2) learning styles; 3) educational tasks, and 4) gamification elements in an integrated way.

### 3. ANALYSIS OF UNEXPLORED GAMIFICATION ELEMENTS

In this section, the researchers discuss and investigate the gamification elements examined and/or utilized in the learning systems in the literature. According to [12], 32 unexplored elements were discussed in less than 10 papers in the literature. The authors analyzed more than 200 papers to reach this result. Also, it was found that only six elements have more than 40 references in literature, only nine elements vary between 10 to 28 references, 14 elements vary between 1 to 9 references, and finally, 23 elements are never mentioned in any reference at all.

The elements are used only to motivate 1/5 of the world's personalities which means that the researchers are trying to thrust the rest of the population into one kind of interest [12]. They argue that this is one of the main reasons that gamification risks

are emerging. Gamification has many factors to succeed but it must be used in the right way. By formulating mappings to inform better design in a way that ensures coverage for all user types in the learning context.

There is no direct mapping between the big five personality traits and game elements. However, there is a mapping between the big five personality traits and gamification player types [43]; [1]. Also, there is a mapping between the gamification player types and the game elements [41]. Therefore, there exists an indirect mapping between the big five personality traits and game elements. Adding to that, there is no mapping between Felder Learning Styles [13] and gamification player types or elements. However, there is a mapping between the big five personality traits and Felder Learning Styles [38]. Therefore, there exists an indirect mapping between Felder Learning Styles, gamification player types, and the game elements.

Thus, this section discusses the mapping between gamification player types and the big five personality traits in addition to learning styles [12]. The new combined mapping as shown in Figure 1 consists of three levels between gamification player types, big five personality traits (OCEAN), and learning styles which led the researchers to a conclusion that the world focuses only on one single personality type, which is "conscientiousness". Whether it is in a player mode or a learning mode this is the only person that will succeed easily as the whole system is designed to go with his/her abilities to learn and grow. Unfortunately, the systems are trying to force the rest of the types to succeed in a way that is hard for them to achieve mastery. For example, extroversion will only succeed because he/she is positively correlated with all learning styles not because it is just a fit. He/she will be able to learn as he can be intuitive/sensing, which is the main focus of conscientiousness but maybe he needs the other learning styles to get everything well organized in his brain. Nevertheless, if openness to experience is not able to receive some active/reflective ways of learning, it shall be very hard for him/her to succeed. This is just the way his/her brain works but the system does not put this into consideration.

For the purpose of this research, the results achieved in [12] will be used as input. The researchers will further explore the design and use of the identified unexplored game elements while considering more factors such as the tasks performed in the learning environment and the users' learning styles.

## 4. RESEARCH METHODOLOGY

A qualitative approach [26]; [27]; [44] was chosen due to the exploratory nature of this research as more exploration was needed to gather insights from actual users to decrease the gap between students and learning and increase their motivation and long-term satisfaction and enjoy-ability. The main areas the researchers wanted to explore were:

- RQ1) From the users' perspective, what are their viewpoints and ideas regarding the utilization of unexplored game elements in gamified e-learning systems?
- RQ2) From the users' perspective, how can un-explored game elements be associated with the learning tasks?

Focus groups [44] were used as a qualitative data collection method to investigate the unexplored elements that motivate the learning tasks while putting into consideration the personality traits and learning styles of users.

In the present study, the researchers recruited three participants for the pilot study and 15 participants for the actual full study as shown in Table 1. The focus groups were divided into two sessions, one contains eight participants and the second contains seven participants. All the sessions were video recorded and transliterated precisely to help in the analysis stage. Each session lasts for 120 minutes. For the review process of the current paper, the design of the study, the materials used in it, and samples of what the participants wrote or drafted, can be viewed on this link [https://drive.google.com/drive/folders/1s0\\_kQg\\_HOTg1l6RrSo0py8F6J01iV1bV?usp=share\\_link](https://drive.google.com/drive/folders/1s0_kQg_HOTg1l6RrSo0py8F6J01iV1bV?usp=share_link).

The participants attended in a large university that has lots of branches in the Arab region and several dual programs with universities in the US and UK and ABET-accredited. In addition, it contains multiple nationalities and has wide variations in demographics. We have chosen participants that age between 18 and 24. All of the participants majored in computer science in their mid-high college years (2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> years) as they have more experience and can provide more value and insights.

In this study, the researchers choose two ready-made questionnaires for the recruitment of the participants to identify their personality traits and learning styles. They are the Big five-personality trait: BFI-S (15 questions) [24] and Felder Learning Styles: FLS questionnaire (44 questions) [13].

Invitation emails were sent to the targeted participants with two links for the questionnaires. This step was made to ensure full coverage of all personality traits and learning styles in our study and the results are shown in Table 2. The rows represent the participants, the first five columns show the personality type results, while the last eight columns show the results of the learning styles.

Content analysis [26]; [44] was used to analyze the results of the focus group. It was the most suited technique to analyze the collected data in the current research. Finding the answer to who says what, to whom, with what effect, and the common patterns and characteristics of the document's content of this kind of research have uncovered new findings and concepts that evolved through conducting this study.

## 5. DESIGNING GAMIFIED LEARNING SYSTEMS –USERS' VIEWPOINT

In this section, the researchers explain the study that they have conducted with actual users to identify their point of view on the utilization of unexplored gamification elements in the learning context. In addition, they are building upon the results that they have reached from the analysis in [12] that there are unexplored game elements in the learning context. Therefore, they have no prior hypothesis of the usage of such game elements in the design of gamified learning systems and that is why they explore this with actual users. First, they explain the study purpose and the pillars they build upon. Second, they explain the types of sessions that were conducted and their benefit and structure. Third, they elaborate on the supporting materials that were prepared and used during the study to help immerse the users to gain their in-depth opinions and feedback during the discussions. Then, they explain the reached results of the study. Finally, they discuss the threats to validity.



## 5.1. PURPOSE OF THE STUDY

According to the literature, many papers discussed the big five personality traits and game players [43]. While others showed the big five personality traits and learning styles [33]. On the other hand, some mentioned learning styles with some tasks [46]. Finally, a few showed some game elements with some tasks [35] as discussed in the literature.

However, in the present study the researchers combined four different pillars for exploring the design of gamified learning systems, which are: 1) Personality traits; 2) Learning styles; 3) Learning tasks; and 4) Unexplored game elements. As discussed, the personality trait is an important pillar that provides a simple scheme to know and understand users and their behavior. Also, identifying how a student learns best and accommodating to those requirements may have a significant impact on how he/she understands and interacts with the various topics being taught or required tasks. The researchers also argue that the task nature plays an important role in their choice of the suitable game element. Finally, they utilize in their study the identified unexplored game elements that can help enrich the learning domain and satisfy more user types.

Hence, the purpose of the current study can be summarized as follows:

1. To find a mapping between personality traits, learning styles, and game elements.
2. To discover the preferable game elements for the user types with learning styles in certain tasks.
3. To uncover the use of unexplored game elements in the learning context.
4. To provide guidance for software engineers to design personalized gamified learning systems.

## 5.2. SESSIONS PLAN

In this section, the researchers explain the two session types used in the study, their aim, and their structure, which are: **1) the pilot study** and **2) focus group sessions**.

### 1) PILOT STUDY

A pilot study was conducted with three participants to evaluate the feasibility of the study, provide training to the researcher conducting the focus groups, and determine whether the time required to finish the focus group is suitable. In addition, the participants were requested to provide comments to detect ambiguities and difficult questions, supporting material, immersion scenarios, presentations, and tasks. Furthermore, it aided in determining whether each question elicited an acceptable variety of replies. The goal was to ensure that responses could be translated in terms of the needed information and topics. This focus group was not analyzed and was not included in the study's findings.

Following this pilot study, measures were done to increase internal validity. The pilot research revealed two major concerns that needed to be addressed. First, some questions were removed due to duplication, and their ordering was changed due to confusion issues. Second, the supporting materials, specifically the immersion scenarios used to engage users, were rephrased to make them clearer and easier to understand.

## 2) FOCUS GROUP SESSIONS

Two focus groups were conducted with each of the recruited participants. Each session took about two hours of presentation and discussions. All the focus groups were voice and video recorded with consent from participants. Those records were then transcribed later to be used in the analysis.

Participants were involved in the focus groups through a participatory design approach. Participatory Design is a term used to describe creative activities done with end-users to explore their ideas about a tool, product, or service to guarantee that it fulfills their requirements and expectations. Thus, the end results are produced in collaboration with the intended audience, resulting in improved results and experiences, as the technique may provide clear insight into their terminology, priorities, and preferences.

The focus groups sessions were divided into four parts:

1. **Breaking the ice** and filling in demographical information.
2. **A 10-15 min introductory presentation** was given about gamification in general. The target of this step is to show the participants different platforms and make them understand gamification as a concept and how it can be used in various ways, especially in the learning context.
3. **Understand the unexplored game elements:** A slide was presented to explain each element with an example or scenario to make it clear for the participants which can be viewed on this link [https://drive.google.com/drive/folders/1sQ\\_kQq\\_HOTg1l6RrSo0py8F6J01iVlbV?usp=share\\_link](https://drive.google.com/drive/folders/1sQ_kQq_HOTg1l6RrSo0py8F6J01iVlbV?usp=share_link).
4. **Gather participants' opinions** After explaining each element as participants were asked a group of questions. They were encouraged to discuss and brainstorm ideas on how each unexplored element can be utilized to motivate and engage in the learning tasks. Each participant had to make suggestions separately according to his/her opinion on which element best suits this task or how they can be used to enhance this task motivation, satisfaction, and enjoy-ability as shown in Figure 3.

## 5.3. SUPPORTING MATERIALS

This section explains in detail the prepared supporting materials that were used during the study to present to participants and help them in the immersion and brainstorming to obtain in-depth insights and opinions. These materials were tested during the pilot study and enhanced according to participants' comments as mentioned in the previous section. All the supporting materials are shown on this link [https://drive.google.com/drive/folders/1sQ\\_kQq\\_HOTg1l6RrSo0py8F6J01iVlbV?usp=share\\_link](https://drive.google.com/drive/folders/1sQ_kQq_HOTg1l6RrSo0py8F6J01iVlbV?usp=share_link).

### 1) PRESENTATIONS

In the study, two presentations were presented to the participants shown in the shared drive. The first one was an introduction to gamification and learning in general. The second presentation contained a slide for each unexplored element with an example, mockup, real-life example, and/or scenario to make it clear for the participants so they can share their opinions and feedback on a well-based understanding of those elements.

### 2) IMMERSION SCENARIOS

Scenarios are described as "stories about people and/or their activities." Scenarios can be presented in a variety of ways, including text, storyboards, video mock-ups,

written prototypes, and more. Instead of depending on the researcher's technical language, they enable imagining future work circumstances to allow people to experience how developing designs may impact work practice. Using scenarios in participatory design approaches enables context, needs, and requirements to be discussed. They may also be used as a means of communication amongst different stakeholders from various backgrounds throughout the session.

Thus, several specific scenarios designed for utilizing specific game elements were designed to immerse users and allow them to imagine their utilization and discuss opinions and enhancements. For example, in an element called Branching choices: Merging the eight different learning styles to create different branching choices for students not only to succeed but also to achieve excellence as shown in Figure 2. There might be more than a way to pass like choices between exams and projects. For example, if a student is Intuitive, he shall have a written exam from 80% and a practical exam from 20% while if he is Active, the practical exam shall be from 70% and written from 30% [30]; [10].

### 3) TASKS

The table of tasks was made with the inspirations of [46] and [35] as supporting material for the focus group session. In [46], the tasks shown concerning each learning style were based on the Felder and Silverman learning styles. They showed activities like Practical tasks, visual and essay questions, conceptual solutions, and issues. While in [35], Prensky's Study showed activities and learning techniques used in educational computer games. For example, feedback, Goal-oriented learning, Task-based learning, Coaching, and Intelligent tutors. Finally, in [35] there was Learning from mistakes because of different people's characteristics.

### 4) QUESTIONS AND ACTIVITIES

Each participant was given a set of questions. It was divided into three parts. Part 1 contained demographics and their opinion on studying and what can be improved. Part 2 contained general questions about gamification and learning. Finally, part 3 had questions related to unexplored elements, where for each unexplored game element, brainstorming and discussion took place. Then, each participant had to match the suitable learning task that can be motivated by this element from their opinion. Each participant had to suggest separately according to his/her opinion why this element best suits this task or how it can be used to enhance this task's motivation, satisfaction, and enjoy-ability.

Finally, they give their opinion on the scenario design and provide more ideas or examples on the tasks that are motivated by this element. A sample from the questions is shown in Figure 3 while the rest of the questions and tasks used exist in the shared folder in addition to some sample answers from the participants' responses.

## 5.4. STUDY RESULTS

In this section, the study results are described in detail. Depending on the participant's results, Table 3 was created as shown below to get the average of all personality types and learning styles to ensure full coverage of all learning styles and for each cross-section (Total of each learning style of this personality type/existing number of this personality type) to create Table 3. For the sake of the success of this study, the researchers have chosen a threshold of 2.25 that gives the full coverage for all learning styles by having at least one taken in a column. This criterion allowed the researchers to take moderate and strong learning styles values that affect

the performance of the students as the mild data do not have a major effect on the students' performance, which means that the student with mild effect can do well in the two opposite learning styles like active-reflective or visual-verbal or sequential-global or sensor- Intuitive.

However, if a student is strong in visual, he/she will have problems or face difficulties with verbal intake. The results are put in a table format, where each table represents a single personality type. The top row represents the personality type, the second row shows the top-most learning styles related to this personality type according to the threshold taken in Table 3, and the results of the exams were presented in Table 2. While the left column shows the learning tasks. Finally, the cross-sections present the elements that motivate this task in addition to its matching learning style and personality trait.

#### 5.4.1. NEUROTICISM PERSONALITY TYPE

In this study, the participants who were high in **NEUROTICISM** personality type in the focus group have relations with learning styles (Active, Visual and Sensor) based on the results of the BFI-S and FLS questionnaire. They preferred/choose the elements that shall increase their motivation for each of the 12 tasks in the learning context as shown in Table 4.

**The most appropriate unexplored elements** that motivate the learning tasks from the point of view of Neuroticism and their Learning styles are for example: In Virtual economy and Access he/she suggested tasks like essay questions, but why?

**AS A SUMMARY** This person is visual, so he is having a hard time studying essay questions that is why he is trying to find a way to make himself more motivated to study those kinds of questions. Also, he/she wants access to those kinds of questions to help him/her with those kinds of questions that are hard for visual learners. But in practical tasks, they preferred physical rewards because they are related to real-life practices, and rewards will make students motivated as they gain more challenges.

While in anarchy participants suggested tasks were like learn from mistakes, but why?

This person wants an opportunity to learn from his/her mistakes without deduction in marks. He/she wants perfection in their work as well. They just want to know what is wrong to fix it and start over.

Sharing knowledge / Caretaking/ Gifting / Collect and Trade he/she suggested tasks, practical assignments, experiments, and practical tasks as he/she needs more help with those tasks from others. Social pressure: In this element, the conscientiousness personality type has chosen only one task for which the participant gives his opinion. This personality type always feels pressured by others' performance.

Here, the researchers can say that the more those tasks that have relation to others' performance increases the more this person's performance decreases. That is exactly why this person did not like to choose the leaderboard and social pressure at all.

#### 5.4.2. CONSCIENTIOUSNESS PERSONALITY TYPE

Participants who were high in the **CONSCIENTIOUSNESS** personality type in the focus group have relations with learning styles (Reflective, Verbal, Sequential and Sensor)

based on the results of the BFI-S and FLS questionnaire. They preferred/chose the elements that shall increase their motivation for each of the following 12 tasks in the learning context as shown below in Table 5.

**The most appropriate unexplored elements** that motivate the learning tasks from the point of view of Conscientiousness and their learning styles are for example: In Access, he/she suggested tasks like conceptual solutions, but why?

**AS A SUMMARY** This personality type has problems understanding conceptual solutions that is why he/she needs access from the question bank to fulfill his/her eagerness of knowledge to understand it well. That is why they mentioned it in meaning / purpose and they cannot figure out why they are taking this kind of task. Sharing knowledge / Caretaking/ Gifting / Collect and Trade he/she suggested Tasks Practical assignments, experiments and Practical tasks as he/she needs more help with those tasks from others.

Social pressure: In this element CONSCIENTIOUSNESS personality type have, chosen only one task, which is Student gives his opinion. This personality type always feels pressured by others performance.

Here we can say the more those tasks that has relation to others performance increases the more this person performance decreases. That is exactly why this person did not like to choose the Leaderboard and Social pressure at all.

#### 5.4.3. EXTROVERSION PERSONALITY TYPE

Participants who were high in **EXTROVERSION** personality type in the focus group have relations with learning styles (Active, Visual, & Intuitive) based on the results of the BFI-S and FLS questionnaire. They preferred/chose the elements that shall increase their motivation for each of the following 12 tasks in the learning context as shown below in Table 6.

**The most appropriate unexplored elements** that motivate the learning tasks from the point of view of Extroversion and their learning styles are for example: If the student gives his opinion, he/she suggested tasks like creativity tools, but why?

**AS A SUMMARY** This personality type likes outgoing and social interaction so they want various ways to show their opinion. While in task with multiple steps they mentioned meaning / purpose as they tend to be assertive because this personality wants to be sure of what is the purpose and why to take all the steps that will be taken out. Since this personality is gregarious, they like Tutoring others however they like to take the credit as well like physical rewards or to be a part of the development tools or innovation platform.

In practical assignments, experiments or tasks common elements were mentioned for the active and visual personalities like Development tools / Innovation platform / Creativity tools / Certificate / Investment / Learn / New skills.

Here the researchers can say that those tasks that have a relation to teamwork and dealing with others to achieve and gain new information and leveling up.

#### 5.4.4. AGREEABLENESS PERSONALITY TYPE

Participants who were high in the **AGREEABLENESS** personality type in the focus group have relations with learning styles (Active, Visual, Global and Sensor) based on the results of the BFI-S and FLS questionnaire. They preferred/chose the elements

that shall increase their motivation for each of the following 12 tasks in the learning context as shown below in Table 7.

**The most appropriate unexplored elements** that motivate the learning tasks from the point of view of Agreeableness and their learning styles are for example: In Investment, he/she suggested tasks like practical assignments, experiments, tasks, and learn from mistakes, but why?

**AS A SUMMARY** This personality type is optimistic as they believe that by investing time, effort, emotions, or money, they will get value and gain from those tasks to evolve more.

#### 5.4.5. OPENNESS PERSONALITY TYPE

Participants who were high in **OPENNESS** personality type in the focus group have relations with learning styles (Reflective, Visual and Intuitive) based on the results of the BFI-S and FLS questionnaire. They preferred/chose the elements that shall increase their motivation for each of the following 12 tasks in the learning context as shown below in Table 8.

**The most appropriate unexplored elements** that motivate the learning tasks from the point of view of Openness and their learning styles are for example: In Creativity tools, he/she suggested ten Tasks where it can be used like practical assignments, experiments, tasks, student gives his opinion, questions with visual elements, essay questions, conceptual solutions, tutoring others, class surveys, learn from mistakes, and gathering data, but why?

**AS A SUMMARY** This personality type is Intelligent and Imaginary. They like to think out of the box so this element will give them a way to put their own fingerprint in the normal boring learning tasks. Even though only three tasks were related to visual-only like conceptual solutions, class surveys, and practical tasks, the rest was common for all learning styles.

#### 5.4.6. THREATS TO VALIDITY

There are three main threats to validity in this study:

1. The participants were given scenarios for the unexplored elements that contained examples of detail of usage in the learning system. This could have influenced the quality of the participants' responses, especially in the area regarding giving more ideas. To minimize this effect, the study moderator constantly advised the participants to think out of the box and generate their ideas. Besides, the moderator always gave the pros and cons of the scenario to motivate participants to share their opinions and evolve with new ideas as reached in the final version.
2. One of the threats was the risk of 'group think' and the group dominators in the focus group. That was put into consideration, the study moderator always encouraged them to provide their opinions in addition to the use of supporting materials and documents. With the questions to be filled all participants were able to give their opinions and there were no passive participants.
3. A common threat to validity in focus groups studies is whether all the participants understood the questions as intended. This issue was addressed by explaining and exemplifying each question with a slide in a presentation. Also, all questions went through a pilot study and iterative revisions with two research members to ensure clarity.

## 6. ONTOLOGY IMPLEMENTATION OF GAMIFIED LEARNING

In this section, the design of the structure of the ontology is explained. The ontology will serve as a model of gamification in learning environments, and a guideline for the design of the gamified learning environment for software engineers [16]. The ontology will help software engineers to fill this gap of gamification with clear guidelines developed from a previous research [12] and the focus group study. Previous research papers on gamification and ontology usually presented the most used and well-explored game elements.

However, the proposed ontology provides 4-dimension aspects (personality, learning style, tasks, and elements) in the same study as shown in Figure 4.

### 6.1. CLASS HIERARCHY

Figure 5 shows the main class Learning\_Gamification and the five main subclasses derived from it in the ontology. Learning\_Gamification is used to define a new structure for gamification in learning that was devised from the participatory design study. This structure combines several new dimensions that the engineers will use to enhance the current gamified learning apps.

There are five sections, which are PersonalityTrait, Elements, LearningStyle, Materials, and Tasks as shown in Figure 5. Also, each main class has a group of sub-classes as provided in Figure 6. For example, the main class Materials have sub classes like (Attendance, Research, ...).

### 6.2. OBJECT PROPERTIES

The classes will not be sufficient in providing information. A collection of object properties, in addition to the taxonomy, was created to explain the relationship between the classes and is used to construct the rules that regulate the constitution of each class and is shown in Figure 7. These relations and rules reflect the results reached from the focus group study that was conducted and explained in the previous section. They are also helpful joins for query processing.

According to [16], "Web Ontology Language (OWL) Properties represent relationships between two classes. Properties may have a domain and a range specified. Properties link classes from the domain to classes from the range". The OWL domains and ranges are used as 'axioms' in reasoning, not constraints as shown in Table 9.

For example:

1. Each domain "PersonalityTrait" has object property "HaveLearningStyle" and range "LearningStyle". It means that any personality type may have more than one learning style.  
*Ex. Neuroticism has active, sensor, and visual learning styles.*
2. Each domain "Elements" have object property "IsSuitableFor" and range "Tasks". It means that any Element may be suitable for more than one Task.  
*Ex. Certificate element is suitable for tasks like practical tasks and practical experiments.*
3. Each domain "Elements" has object property "IncreaseMotivationOf" and range "PersonalityTrait". It means that any Element may have more than one

personality type that increases its motivation.

*Ex. Element Fixed Reward Schedule increase motivation of Neuroticism personality trait.*

### 6.3. CLASS RULES

After describing the class and object property hierarchies, this section demonstrates how to use them to define the rules that govern class usage.

For example, the element Creativity\_Tools increases the motivation of personality trait Neuroticism, which has learning styles active, sensor, visual, and prefer tasks like visual questions. On the other hand, the same element Creativity\_Tools increases the motivation of the personality trait Conscientiousness, which has learning styles reflective, sensor, sequential, verbal, and prefer tasks like conceptual issues, practical experiments, and practical tasks with this element that is shown in Figure 8.

That illustrates that elements can motivate different personalities but learning styles and tasks must be put into consideration to provide the best results.

### 6.4 SAMPLE INSTANCES

In this section, an example of a scenario implementation is explained through a running case. First, some of the instances of the ontology are shown in Figure 9.

While in Figure 10, Sensor\_C that is related to consciousness is described using tasks that this learning style prefers and which are the mandatory components for providing this learning style specification that conforms to the rule defined by the ontology.

On the other hand, Figure 11 illustrates the graph representation of a personality type instances neuroticism and their relations with some classes, showing distinct coloring for the different object properties used.

Finally, Figure 12 illustrates a query and sample output for the personality traits and learning styles that were implemented using SPARQL Query Language to extract information from instances. The query asked for the personality trait and the learning style and a sample of the output is shown under the query that shows conscientiousness and its learning styles and neuroticism and its learning styles.

In the current research, the ontology acts as the rule engine component for utilizing the four dimensions of the focus group study (personality, learning style, tasks, and elements) to be used. It is a way to formalize the guidelines adopted from the study so that the engineers can use them easily. Finally, providing an ontology design that firmly stands by the study results and design rules offers validation on how well the ontology accomplishes its anticipated tasks. The ontology file is shared on the drive in this link [https://drive.google.com/drive/folders/1sQ\\_kQc\\_HOTg1l6RrSo0py8F6J0iVlbV?usp=share\\_link](https://drive.google.com/drive/folders/1sQ_kQc_HOTg1l6RrSo0py8F6J0iVlbV?usp=share_link).



## 7. THE GAMIFIED E-LEARNING FRAMEWORK

A final contribution to the literature is supporting the research outcomes with an enhanced framework for gamification in learning as illustrated in Figure 13.

This engineering framework provides a standard way for engineers to design gamified learning systems. This framework shows the basic components and the relationships between them.

It incorporates management of user types, gamification in learning, courses, management of learning system, and the ontology models used to store, retrieve, and reuse information. Also, it provides a view of the dependencies between them. Finally, it shows the new artifacts that were developed and presented in this paper that are highlighted in yellow.

The framework presented in Figure 13 is based on the previous framework proposed in [46]. It provides augmented components used to enhance the model according to the focus group study that was conducted.

According to [46] gamified courses should increase student motivation, engagement, and provide an atmosphere in which students are proactive, motivated, and express a positive attitude toward learning. However, the researchers believe that more dimensions should be considered to enhance students' experience and that is why the big five-personality trait as a questionnaire and a component is added to the framework in the management of user types. The management of the Big five personality traits is beside the management of Learning styles that contain the FLS questionnaire in addition to the unexplored elements (unexplored game mechanics and unexplored game dynamics) that are studied in depth in the focus group study. They are added to the gamification of the learning block to help software engineers focus on the unexplored elements that are important for many users in learning applications.

Adding to that more tasks and materials mentioned in [35] are added to the framework because they were not mentioned by Nadja et.al. The tasks and materials components are added to the course design block to be taken into consideration while the software engineer is designing the learning application. The yellow arrow coming out from materials and tasks components is fed into the ontology depending on each course design. On the other hand, the two yellow arrows coming from the management of user types and gamification of learning blocks are bidirectional arrows. They are used to guide system designers on how to apply a personalized system that adapts the gamification elements based on user types and learning styles in the tasks of the different courses. Personality traits, learning styles, material, tasks, and elements are added to the ontology in addition to their mapping that is reached through the researchers' study as shown in Figure 13 and many components are fed to the ontology for validation.

The researchers believe that this framework shall guide software engineers in their future designs to create more usable personalized systems where users could benefit the most from them and achieve mastery as well in learning and, in addition, to detect the users who are not put into consideration in the platform or system. In learning, this will help give more attention to the students that are either losing performance, demotivated, or having a decline in their system loyalty. In the researchers' opinion, merging all those factors shall reduce gamification risks and switch gamification to excel in the new era.

## 8. CONCLUSION

This paper focused on experimenting with unexplored gamification elements in addition, to the mappings between Player types, Big Five personality traits, and learning styles that showed the partially and neglected users in the gamified learning context. The researchers' findings shall redirect researchers, software engineers, and lecturers to focus more on alternative ways in teaching or in designing apps in different ways to give more opportunities for all types of users to enhance long-term motivation. Furthermore, providing individualized instructions is not the goal of teaching and learning but a more balanced personalized way shall maximize their learning.

In addition, the second part of this paper focused on an in-depth focus group study and its supporting materials, that helped in reaching a new conclusion regarding applying game elements in learning. This study looked at the learning system from four different dimensions to cover the vital factors to enable all students regardless of their differences whether it is personality or learning style to achieve better in academic and learning systems.

The resulting detailed user profiles provide detailed guidelines to software engineers when designing gamified learning systems using the elements that were explored in our study. Also, implementing these results through an ontology will help software engineers in extracting important knowledge using automated means during the development of learning systems.

The final contribution to the literature is the enhanced gamified e-learning framework. This engineering framework provides a standard way for software engineers to analyze, design, and implement personalized gamified learning systems. This framework shows the basic and added components and the relationships between them. It also incorporates the new ontology model used to store and retrieve information.

**Table 1**  
Focus Group Sessions

Gender	Male	Female	Time Taken
Pilot study	0	3	150 minutes/each pilot
Focus group session # 1	6	2	120 minutes/session
Focus group session # 2	5	2	120 minutes/session
Total	11	7	690 minutes

**Table 2**  
Heat Table of Personality Types and Learning Styles of Participatory Design Study

Openness	Conscientiousness	Extroversion	Agreeableness	Neuroticism	Active	Reflective	Sensing	Intuitive	Visual	Verbal	Sequential	Global
6	6	3.33	7	4.33	1	0	7	0	3	0	0	1
5.67	4.67	4.67	5.67	3.33	5	0	11	0	9	0	0	5
6	4.33	4.33	4.33	2.67	1	0	9	0	11	0	3	0
5.33	4.33	3.67	6.33	5.67	9	0	9	0	11	0	3	0
7	6	4.33	6	1.67	5	0	3	0	5	0	3	0
7	5.33	5.33	5.67	4.33	0	5	0	9	5	0	3	0
5.67	6.67	2.67	6	5	0	5	9	0	0	5	7	0
6.67	6.33	6.67	6	3.33	7	0	0	3	7	0	1	0
6	5.67	5	6.33	3.33	3	0	0	5	7	0	7	0
6	5.57	3.33	5.67	1	0	1	1	0	3	0	0	3
6.67	5.67	4	6.33	1	0	9	0	1	7	0	1	0
6.33	4.67	6	5.33	3.67	5	0	0	9	9	0	3	0
6.33	5.67	6	7	6.67	0	3	1	0	5	0	1	0
7	5.67	5	5.33	5	0	3	0	5	1	0	1	0
7	5.33	2.33	6	3.67	0	5	0	1	3	0	0	1

**Table 3**  
Heat Table of Personality and Learning Styles Threshold

	Active	Reflective	Visual	Verbal	Sequential	Global	Sensor	Intuitive
Neuroticism	4.5	1.5	8	0	2	0	5	0
Extroversion	6	0	8	0	2	0	0	6
Conscientiousness	0	5	0	5	7	0	9	0
Agreeableness	2.25	0.25	5.5	0	1.75	2.25	4.75	1.25
Openness	1	3.6	5.3	0	1.8	0.16	2	2.6

**Table 4**  
The Elements that Motivate Tasks with Neuroticism and Learning Styles

Learning Styles		NEUROTICISM		
		Active	Visual	Sensor
1	Practical assignments, experiments	√	√	√
			Development tools / Innovation platform / Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards	
		Learn/ New skills		
2	Student gives his opinion	√	√	√
		Anonymity/ Light touch / Branching choices / Social pressure / Fixed Rewards		
3	Question with visual elements	√	√	√
			Fixed Rewards / Random Rewards / Time-Dependent Rewards / Scarcity	
		Creativity tools		
4	Essay questions	√	√	√
			Virtual economy / Access / Boss Battle / Social pressure / Random Rewards / Time-Dependent Rewards / Strategy / Investment / Scarcity / Learn / New skills	
		Fixed Rewards		
5	Task with multiple steps	√	√	√
			Curiosity/ Mystery box/ Exploration/ Easter eggs Fixed Rewards / Random Rewards / Time-Dependent Rewards	
		Boss Battle		
6	Conceptual solutions	√	√	√
			Development tools / Innovation platform / Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards	
		Curiosity/ Mystery box/ Exploration/ Easter eggs		
7	Practical tasks	√	√	√
			Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards / Learn / New skills	
		Physical rewards / Certificate / Investment		
8	Conceptual issues	√	√	
			Boss Battle / Fixed Rewards/ Random Rewards/ Time-Dependent Rewards	
9	Tutoring others	√	√	√
			Development tools / Innovation platform / Social discovery / Social pressure / Social Status / Fixed Rewards / Random Rewards / Time-Dependent Rewards	
		Sharing knowledge / Care taking / Gifting / Collect and Trade / Leaderboard and Social pressure / Signposting		
10	Class surveys	√	√	√
			Anonymity/ Light touch / Access / Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards	
		Branching choices		
11	Learn from mistakes	√	√	√
			Anonymity/ Light touch / Anarchy / Development tools / Innovation platform / Fixed Rewards / Random Rewards / Time-Dependent Rewards	
		Scarcity		
12	Gathering Data	√	√	√
			Development tools / Innovation platform / Social discovery / Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards / Signposting	
		Strategy		

Table 5  
The Elements that Motivate Tasks with Conscientiousness and Learning Styles

Learning Styles		CONSCIENTIOUSNESS			
		Reflective	Verbal	Sequential	Sensor
1	Practical assignments, experiments	√	√	√	√
		Lottery / Meaning / Purpose / Sharing knowledge / Care taking/ Gifting / Collect and Trade / Boss Battle / Certificate Creativity tools / Fixed Rewards / Random Rewards			
2	Student gives his opinion	√	√	√	√
		Social pressure			
3	Question with visual elements	√	√	√	√
		Scarcity			
4	Essay questions	√	√	√	√
		Boss Battle			
5	Task with multiple steps				
		N. A			
6	Conceptual solutions	√	√	√	√
		Meaning / Purpose / Access / Investment / Learn/ New skills			
7	Practical tasks	√	√	√	√
		Lottery / Sharing knowledge / Care taking/ Gifting / Collect and Trade / Boss Battle / Certificate / Creativity tools / Fixed Rewards / Random Rewards			
8	Conceptual issues	√	√	√	√
		Creativity tools			
9	Tutoring others	√	√	√	√
		Physical rewards / Signposting / Strategy			
10	Class surveys	√	√	√	√
		Lottery / Anonymity / Light touch			
11	Learn from mistakes	√	√	√	√
		Physical rewards			
12	Gathering Data	√	√	√	√
		Lottery / Anonymity / Light touch			

**Table 6**  
The Elements that Motivate Tasks with Extroversion and Learning Styles

EXTROVERSION				
Learning Styles		Active	Visual	Intuitive
Tasks				
1	Practical assignments, experiments	√	√	
		Physical rewards / Development tools / Innovation platform / Certificate / Curiosity / Mystery box/ Exploration / Easter eggs / Creativity tools / Fixed Rewards / Signposting / Strategy / Investment / Learn / New skills		
2	Student gives his opinion	√	√	√
		Vote / Voice / Certificate / Branching choices / Social Status / Fixed Rewards / Time-Dependent Rewards / Strategy / Investment		
		Creativity tools		
3	Question with visual elements	√	√	√
		Certificate / Random Rewards / Investment / Learn / New skills		
		Virtual economy / Development tools / Innovation platform / Curiosity / Mystery box / Exploration / Easter eggs		
4	Essay questions	√	√	
		Physical rewards / Certificate / Curiosity / Mystery box / Exploration / Easter eggs / Branching choices / Investment / Learn / New skills / Consequences / Loss Aversion		
5	Task with multiple steps	√	√	√
		Lottery / Development tools / Innovation platform / Certificate / Creativity tools / Learn / New skills / Time-Dependent Rewards / Signposting / Strategy / Flow and Strategy / Investment / Consequences / Loss Aversion		
		Meaning / Purpose		
6	Conceptual solutions	√	√	
		Lottery / Certificate / Creativity tools / Branching choices / Fixed Rewards / Strategy / Investment		
7	Practical tasks	√	√	√
		Development tools / Innovation platform / Creativity tools / Branching choices / Investment / Learn / New skills		
		Certificate / Consequences/ Loss Aversion		
8	Conceptual issues	√	√	
		Development tools / Innovation platform / Certificate / Creativity tools / Fixed Rewards / Investment		
9	Tutoring others	√	√	√
		Lottery / Certificate / Social Status / Investment		
		Physical rewards / Development tools / Innovation platform		
10	Class surveys	√	√	√
		Certificate / Time-Dependent Rewards / Investment		
		Development tools / Innovation platform / Branching choices		
11	Learn from mistakes	√	√	√
		Physical rewards / Certificate / Social Status / Random Rewards / Investment / Scarcity		
		Lottery / Virtual economy		
12	Gathering Data	√	√	√
		Certificate / Curiosity/ Mystery box / Exploration / Easter eggs / Social Status / Time-Dependent Rewards / Investment		

**Table 7**  
The Elements that Motivate Tasks with Agreeableness and Learning Styles

Learning Styles Tasks		AGREEABLENESS			
		Active	Visual	Global	Sensor
1	Practical assignments, experiments	√	√	√	√
			Physical rewards / Virtual economy / Development tools / Innovation platform / Anarchy / Meaning / Purpose / Sharing knowledge / Care taking / Gifting / Collect and Trade / Learn / New skills / Fixed Rewards	Branching choices	Physical rewards / Learn / New skills
				Boss Battle	
			Access		
		Investment			
2	Student gives his opinion		√	√	
			Physical rewards / Anonymity / Light touch		
			Vote / Voice		
3	Question with visual elements		√	√	√
			Vote/ Voice / Development tools / Innovation platform / Sharing knowledge / Care taking / Gifting / Collect and Trade / Learn / New skills / Curiosity / Mystery box / Exploration / Easter eggs	Creativity tools	Physical rewards
			Branching choices		
4	Essay questions	√	√	√	√
			Virtual economy / Anonymity/ Light touch / Development tools / Innovation platform / Anarchy / Time-Dependent Rewards	Lottery / Flow and Strategy	Physical rewards
			Access		
		Meaning / Purpose / Branching choices / Creativity tools			
5	Task with multiple steps	√	√	√	√
			Anonymity / Light touch / Certificate / Branching choices		Physical rewards / Learn / New skills
		Development tools / Innovation platform			
6	Conceptual solutions	√	√	√	√
				Curiosity / Mystery box / Exploration / Easter eggs	Learn/ New skills
		Meaning / Purpose			
7	Practical tasks	√	√	√	√
			Anonymity / Light touch / Certificate / Curiosity / Mystery box / Exploration / Easter eggs	Anarchy	Lottery / Virtual economy / Creativity tools
			Access		
			Learn / New skills		
		Physical rewards / Development tools / Innovation platform / Boss Battle / Branching choices / Time-Dependent Rewards / Signposting / Investment			
8	Conceptual issues	√	√	√	√
			Certificate		Certificate

Table 7: Cont.

		AGREEABLENESS			
Learning Styles Tasks		Active	Visual	Global	Sensor
		9	Tutoring others	√	√
			Sharing knowledge / Care taking / Gifting / Collect and Trade / Learn/ New skills / Random Rewards	Vote / Voice / Fixed Rewards	Physical rewards / Certificate
			Meaning / Purpose		
			Virtual economy		
			Creativity tools / Signposting		
10	Class surveys	√	√	√	√
			Anonymity / Light touch / Sharing knowledge / Care taking / Gifting / Collect and Trade	Certificate	Lottery
			Meaning / Purpose		
			Virtual economy / Fixed Rewards		
11	Learn from mistakes	√	√	√	√
			Anonymity / Light touch	Learn / New skills / Signposting	
			Fixed Rewards		
			Investment		
12	Gathering Data		√	√	√
			Physical rewards / Virtual economy / Anonymity / Light touch	Learn / New skills / Investment	Physical rewards / Creativity tools
				Certificate	
			Meaning / Purpose		



**Table 8**  
The Elements that Motivate Tasks with Openness and Learning Styles

Learning Styles Tasks		OPENNESS		
		Reflective	Visual	Intuitive
1	Practical assignments, experiments	√	√	√
		Anonymity/ Light touch/ /Anarchy / Meaning / Purpose	Sharing knowledge / Care taking / Gifting / Collect and Trade / Certificate / Curiosity / Mystery box / Exploration/ Easter eggs / Social pressure / Leaderboard and Social pressure / Consequences / Loss Aversion / Signposting / Investment / Scarcity	
		Physical rewards / Development tools / Innovation platform / Access / Flow and Strategy		
		Virtual economy / Anonymity / Light touch / Boss Battle / Learn/ New skills / Creativity tools / Branching choices / Time-Dependent Rewards / Strategy / Social Status		
2	Student gives his opinion	√	√	√
			Curiosity/ Mystery box/ Exploration / Easter eggs / Social pressure / Leaderboard and Social pressure / Fixed Rewards / Consequences / Loss Aversion / Strategy / Flow and Strategy	Anonymity/ Light touch / Social Status
		Physical rewards / Virtual economy		
		Development tools / Innovation platform / Boss Battle		
		Learn/ New skills		
Access / Sharing knowledge / Care taking / Gifting / Collect and Trade / Meaning / Purpose / Certificate / Creativity tools / Branching choices / Signposting / Investment				
3	Question with visual elements	√	√	√
		Sharing knowledge / Caretaking / Gifting / Collect and Trade	Virtual economy / Meaning / Purpose / Social pressure / Leaderboard and Social pressure / Consequences / Loss Aversion / Signposting / Strategy / Flow and Strategy / Investment/ Scarcity	
		Development tools / Innovation platform		
		Access / Learn / New skills		
Anonymity / Light touch / Creativity tools / Branching choices / Social Status / Fixed Rewards				
4	Essay questions	√	√	√
		Sharing knowledge / Care taking / Gifting / Collect and Trade / Boss Battle	Meaning / Purpose / Certificate / Social discovery / Social pressure / Leaderboard and Social pressure / Consequences / Loss Aversion / Signposting / Investment	Lottery / Anonymity / Light touch / Development tools / Innovation platform
		Physical rewards / Virtual economy/ Access/ Learn/ New skills / Strategy		
		Creativity tools / Branching choices / Fixed Rewards		
5	Task with multiple steps	√	√	√
		Anonymity / Light touch	Virtual economy / Meaning / Purpose / Certificate / Social pressure / Leaderboard and Social pressure / Fixed Rewards / Random Rewards/ Time-Dependent Rewards / Consequences / Loss Aversion / Signposting / Strategy / Investment	Lottery / Physical rewards / Anonymity / Light touch / Social discovery
		Development tools / Innovation platform / Access / Flow and Strategy		
		Learn / New skills / Branching choices / Social Status / Scarcity		
6	Conceptual solutions	√	√	√
		Sharing knowledge / Caretaking / Gifting / Collect and Trade	Virtual economy / Certificate / Creativity tools Fixed Rewards / Time-Dependent Rewards / Consequences / Loss Aversion / Signposting / Strategy	Lottery / Anarchy / Social discovery
		Social pressure / Leaderboard and Social pressure		
		Anonymity / Light touch / Access / Investment		
Physical rewards / Development tools / Innovation platform / Learn / New skills / Boss Battle / Curiosity / Mystery box / Exploration / Easter eggs / Branching choices / Social Status / Random Rewards / Scarcity				

Table 8: Cont.

		OPENNESS		
Learning Styles	Tasks	Reflective	Visual	Intuitive
		7	Practical tasks	√
		Meaning / Purpose	Sharing knowledge / Care taking/ Gifting / Collect and Trade / Certificate / Creativity tools / Social discovery/ Social pressure / Consequences / Loss Aversion / Signposting / Flow and Strategy / Investment	Anonymity / Light touch
			Lottery / Leaderboard and Social pressure	
		Access		
		Physical rewards / Virtual economy / Development tools / Innovation platform / Learn / New skills / Boss Battle / Curiosity / Mystery box/ Exploration / Easter eggs / Branching choices / Social Status / Time-Dependent Rewards / Strategy / Scarcity		
8	Conceptual issues	√	√	√
			Meaning / Purpose / Sharing knowledge / Care taking / Gifting / Collect and Trade / Boss Battle / Curiosity / Mystery box / Exploration / Easter eggs / Leaderboard and Social pressure / Fixed Rewards / Random Rewards/ Time-Dependent Rewards / Consequences / Loss Aversion / Signposting / Investment	Physical rewards
			Virtual economy /Social pressure / Scarcity	
		Anonymity / Light touch / Access / Learn / New skills / Strategy		
9	Tutoring others	√	√	√
		Anonymity/ Light touch	Lottery / Boss Battle / Certificate / Curiosity / Mystery box / Exploration / Easter eggs / Branching choices / Social pressure / Leaderboard and Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards / Consequences / Loss Aversion / Signposting / Investment	Anonymity / Light touch / Anarchy / Social discovery
			Flow and Strategy	
		Access / Learn / New skills		
		Virtual economy / Development tools / Innovation platform / Sharing knowledge / Care taking/ Gifting / Collect and Trade / Creativity tools / Strategy		
10	Class surveys	√	√	√
		Meaning / Purpose	Vote/ Voice / Development tools / Innovation platform / Anarchy / Boss Battle / Curiosity / Mystery box / Exploration / Easter eggs / Creativity tools / Branching choices / Social discovery / Social pressure / Leaderboard and Social pressure / Consequences/ Loss Aversion / Signposting Flow and Strategy / Scarcity	Anonymity / Light touch / Investment
		Access / Learn/ New skills / Strategy		
		Virtual economy / Fixed Rewards/ Random Rewards/ Time-Dependent Rewards		
11	Learn from mistakes	√	√	√
		Investment	Certificate / Curiosity / Mystery box / Exploration / Easter eggs / Branching choices / Social discovery / Leaderboard and Social pressure / Fixed Rewards / Random Rewards / Time-Dependent Rewards / Signposting / Flow and Strategy	Anonymity / Light touch
		Virtual economy / Social pressure / Consequences / Loss Aversion		
		Learn / New skills		
		Physical rewards / Access / Development tools / Innovation platform / Access / Boss Battle / Creativity tools / Social Status / Strategy / Scarcity		
12	Gathering Data	√	√	√
		Anarchy / Meaning / Purpose / Investment	Leaderboard and Social pressure / Consequences / Loss Aversion	Anarchy
			Certificate / Signposting	
		Anonymity / Light touch / Flow and Strategy		
		Physical rewards / Virtual economy / Development tools / Innovation platform / Access / Sharing knowledge / Care taking / Gifting / Collect and Trade / Learn / New skills / Boss Battle / Curiosity / Mystery box / Exploration / Easter eggs / Creativity tools / Branching choices / Social Status / Fixed Rewards/ Random Rewards / Time-Dependent Rewards / Strategy / Scarcity		

Table 9  
Object Properties' Domain and Range

Object Property	Domain	Range
IsEquivalentTo	All_Materials	Materials
HaveLearningStyle	PersonalityTrait	LearningStyle
IncreaseMotivationOf	Elements	PersonalityTrait
IsStronglyRelated	Tasks	Materials
IsSuitableFor	Elements	Tasks
PreferTask	LearningStyle	Tasks

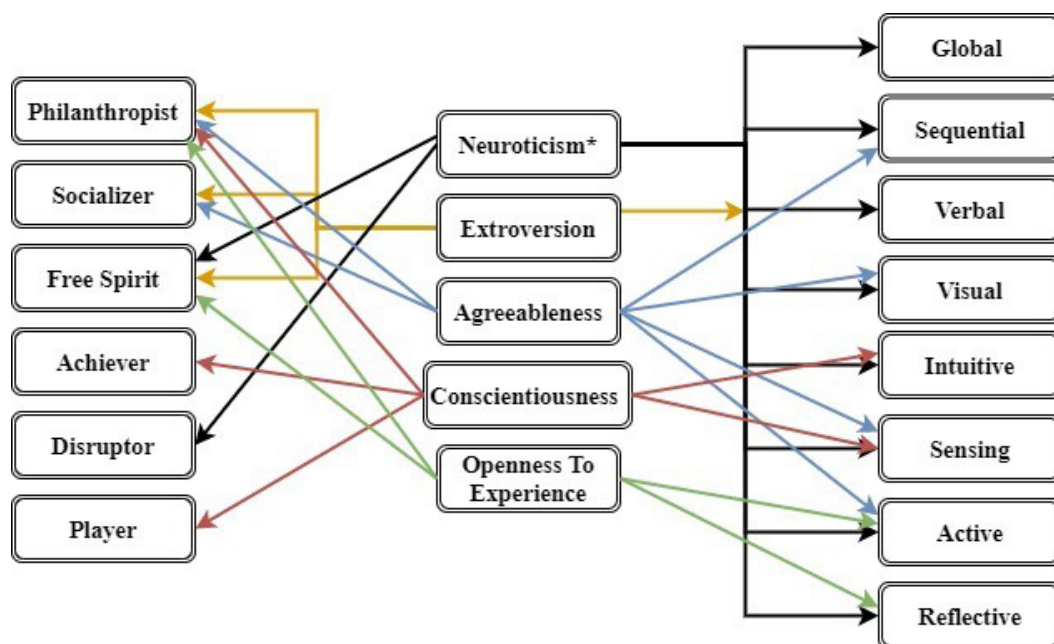


Fig. 1. Mappings between gamification player types, big five personality traits, and learning styles [12].

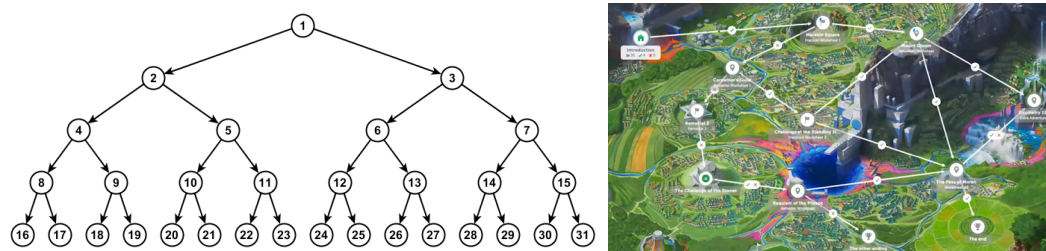


Fig. 2. Examples of branching choices in the immersion scenarios [30].

**Curiosity/ Mystery box/ Exploration/ Easter eggs:**

14. Would you like to invest time, explore, and search for new things (special codes, special behavior combinations) to unlock a mystery box or to earn an Easter egg?

- Yes
- No
- Other (please specify)

Which task best suits this element and why? (you can choose more than one)

1	2	3	4	5	6	7	8	9	10	11	12
---	---	---	---	---	---	---	---	---	----	----	----

Fig. 3. A sample from the participatory design study questions.

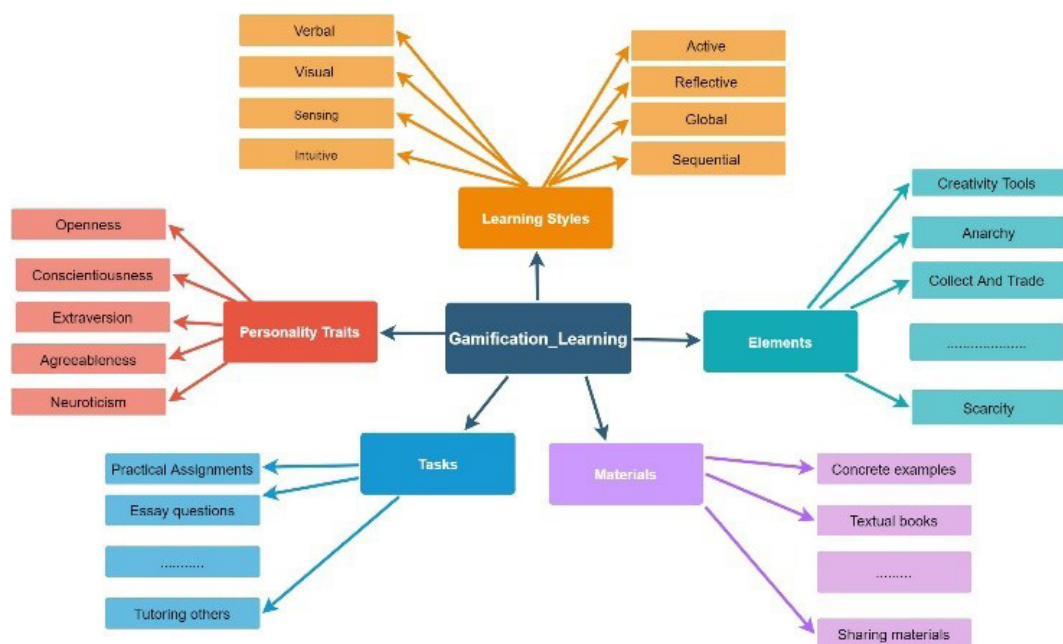


Fig. 4. The main five classes of Gamification learning ontology.

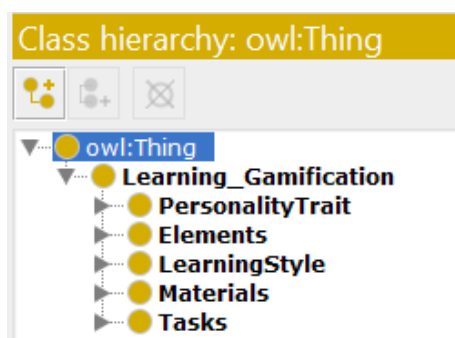


Fig. 5. A collapsed view of the implemented Ontology Class Hierarchy.

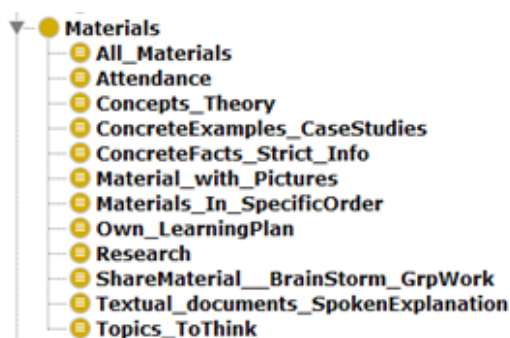


Fig. 6. A detailed view for the "Materials Types" class.

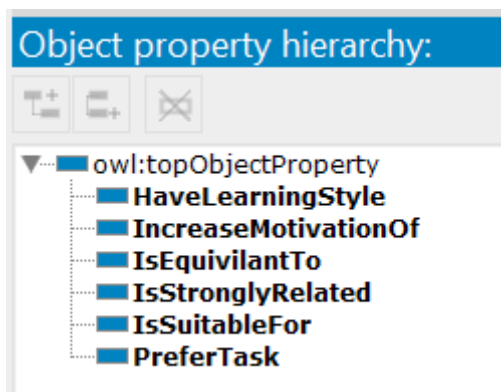


Fig. 7. A detailed view for the object properties.

**Description: Creativity\_Tools**

Equivalent To +

- **Creativity\_Tools**  
 and (((HaveLearningStyle **some**  
 (Active or Sensor or Visual))  
 and (IncreaseMotivationOf **some** Neuroticism))  
 and (PreferTask **some** Visual\_Question))
- **Creativity\_Tools**  
 and ((HaveLearningStyle **some**  
 (Reflective or Sensor or Sequential or Verbal))  
 and (IncreaseMotivationOf **some** Conscientiousness))  
 and (PreferTask **some**  
 (Conceptual\_Issues or Practical\_Experiments or Practical\_Tasks))

Fig. 8. The rule description for one of the elements "Fixed Rewards".

**Individuals:**

- ◆ I\_BF\_Agreeableness
- ◆ I\_BF\_Conscientiousness
- ◆ I\_BF\_Extraversion
- ◆ I\_BF\_Neuroticism
- ◆ I\_BF\_Openness
- ◆ I\_E\_Certificates
- ◆ I\_E\_Social\_Status
- ◆ I\_E\_Virtual\_Economy
- ◆ I\_LS\_Active
- ◆ I\_LS\_Global
- ◆ I\_LS\_Intuitive
- ◆ I\_LS\_Reflective
- ◆ I\_LS\_Sensor
- ◆ I\_LS\_Sequential
- ◆ I\_LS\_Verbal
- ◆ I\_LS\_Visual
- ◆ I\_TK\_Class\_Surveys
- ◆ I\_TK\_Conceptual\_Issues
- ◆ I\_Tk\_Essay\_Questions
- ◆ I\_TK\_Learn\_from\_Mistakes
- ◆ I\_TK\_Practical\_Experiments
- ◆ I\_TK\_Practical\_Tasks
- ◆ I\_TK\_Tutoring\_Others

Fig. 9. An illustration of some instances of ontology.

**Rules:** ◆ I\_LS\_Sensor\_C — [http://www.semanticweb.org/waelg/ontologies/2020/2/untitled-ontology-28#I\\_LS\\_Sensor\\_C](http://www.semanticweb.org/waelg/ontologies/2020/2/untitled-ontology-28#I_LS_Sensor_C)

Individual Annotations Individual Usage

Usage: I\_LS\_Sensor\_C

Show: this different

Found 10 uses of I\_LS\_Sensor\_C

- ◆ I\_BF\_Conscientiousness
  - ◆ I\_BF\_Conscientiousness HaveLearningStyle I\_LS\_Sensor\_C
- ◆ I\_LS\_Sensor\_C
  - ◆ I\_LS\_Sensor\_C Type Sensor
  - ◆ I\_LS\_Sensor\_C PreferTask I\_TK\_Practical\_Experiments
  - ◆ I\_LS\_Sensor\_C PreferTask I\_TK\_Practical\_Tasks
  - ◆ Individuals: I\_LS\_Sensor\_C

**Description: I\_LS\_Sensor\_C**

Types +

- Sensor

Same Individual As +

Different Individuals +

**Property assertions: I\_LS\_Sensor\_C**

Object property assertions +

- PreferTask I\_TK\_Practical\_Experiments
- PreferTask I\_TK\_Practical\_Tasks

Data property assertions +

Negative object property assertions +

Negative data property assertions +

Fig. 10. Sensor learning style and its object property assertions.

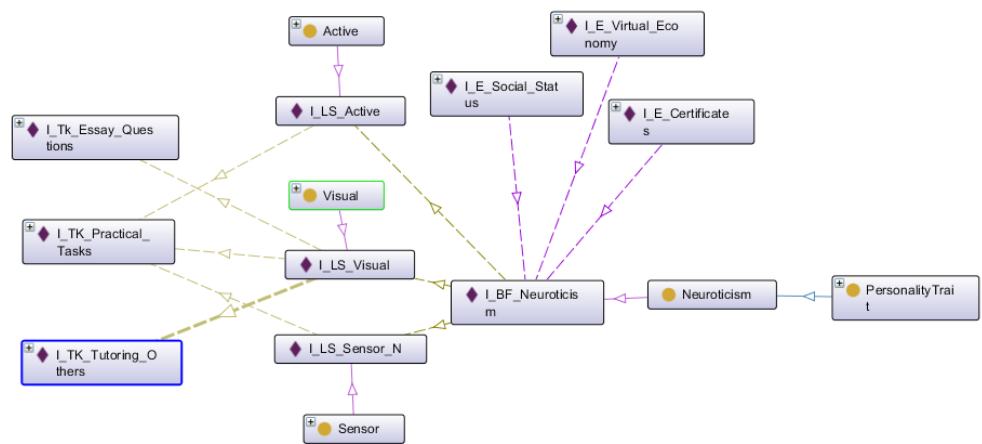


Fig. 11.A graph representation of Neuroticism personality type.

**Snap SPARQL Query:**

```

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX OL: <http://www.semanticweb.org/waelg/ontologies/2020/2/untitled-ontology-28#>

SELECT distinct ?BF ?LS
WHERE
{
    {?E OL:IncreaseMotivationOf ?BF}
    {?BF OL:HaveLearningStyle ?LS}
    {?LS OL:PreferTask ?T}
    {?E OL:IsSuitableFor ?T}
}
ORDER BY ?E ?BF ?LS ?T
    
```

**Execute**

?BF	?LS
OL:I_BF_Conscientiousness	OL:I_LS_Reflective
OL:I_BF_Conscientiousness	OL:I_LS_Sensor_C
OL:I_BF_Conscientiousness	OL:I_LS_Sequential
OL:I_BF_Conscientiousness	OL:I_LS_Verbal
OL:I_BF_Neuroticism	OL:I_LS_Active
OL:I_BF_Neuroticism	OL:I_LS_Sensor_N
OL:I_BF_Neuroticism	OL:I_LS_Visual

Fig. 12. A SPARQL Query example for extracting information.

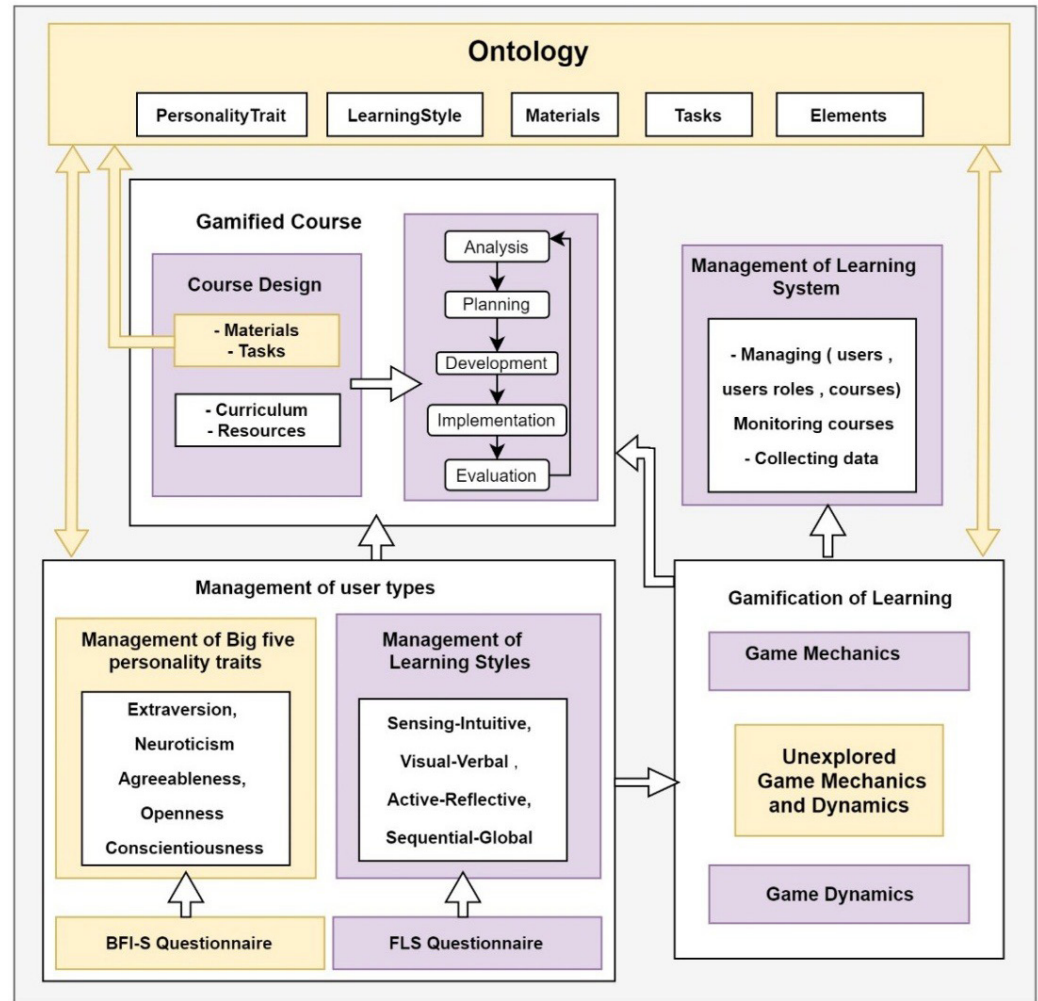


Fig. 13. Model of gamification in learning based on big five personality traits, students learning style, unexplored elements, and ontology.

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