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Enhancing E-Learning with an Interactice Gamification Analytics Tool
Optimierung von E-Learning mit einem interaktiven Gamification-Analytics-Tool

Master Thesis
Masterarbeit

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<th>Description</th>
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<tbody>
<tr>
<td>AJAX</td>
<td>Asynchronous JavaScript and XML.</td>
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<tr>
<td>API</td>
<td>Application Programming Interface.</td>
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<tr>
<td>CSS</td>
<td>Cascading Style Sheets.</td>
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<td>E-Learning</td>
<td>Electronic Learning.</td>
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<td>FSLSM</td>
<td>Felder-Silverman Learning Styles Model.</td>
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<tr>
<td>GA</td>
<td>Gamification Analytics.</td>
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<tr>
<td>HCI</td>
<td>Human-Computer Interaction.</td>
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<tr>
<td>HTML</td>
<td>Hypertext Markup Language.</td>
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<td>IGAT</td>
<td>Interactive Gamification Analytics Tool.</td>
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<tr>
<td>JSON</td>
<td>JavaScript Object Notation.</td>
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<td>KPI</td>
<td>Key Performance Indicator.</td>
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<td>LA</td>
<td>Learning Analytics.</td>
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<td>LMS</td>
<td>Learning Management System.</td>
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<td>LS</td>
<td>Learning Styles.</td>
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<tr>
<td>MOOC</td>
<td>Massive Open Online Course.</td>
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<tr>
<td>Moodle</td>
<td>Modular Object Oriented Development Learning Environment.</td>
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<tr>
<td>PHP</td>
<td>PHP: Hypertext Processor.</td>
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<tr>
<td>QA</td>
<td>Quality Assessment Question.</td>
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<tr>
<td>RQ</td>
<td>Research Question.</td>
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<td>SaaS</td>
<td>Software as a Service.</td>
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<tr>
<td>SQL</td>
<td>Structured Query Language.</td>
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<tr>
<td>SRQ</td>
<td>Secondary Research Question.</td>
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<tr>
<td>UI</td>
<td>User Interface.</td>
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Abstract

Gamification is the application of game elements in non-game contexts. Current research shows that this approach has the potential to compensate low motivation and engagement in many areas, including e-learning. However, it is currently not clear in which way game elements should be applied to be effective. Gamification analytics is a discipline that deals with monitoring users’ interaction with gamification elements to evaluate and improve gamification implementations. Methods from this field can help to address open questions regarding the design of effective gamification applications. Besides supporting research in this area, gamification analytics can also support teachers and students in the e-learning context, as it provides insights into the influence of game elements on the learning process. Despite this potential, gamification analytics is rarely considered in the e-learning context. To bridge this gap, this thesis presents a gamification analytics tool for the Moodle LMS. This involves developing suitable metrics and designing a dashboard for presenting the analytics results. The tool has been applied in an online course with 38 participants and was evaluated with students, teachers and researchers.
Zusammenfassung

Chapter 1 Introduction

Gamification is a promising concept to address current challenges in e-learning. To ensure that gamification does not influence users in any unintended ways, it necessary to monitor the effects of gamification on the users. This can be achieved by applying techniques from gamification analytics, a field that provides methods for analyzing and improving gamification implementations. However, there is a lack of gamification analytics tools. This thesis aims to address this situation in the e-learning context, by proposing a gamification analytics tool for the Moodle LMS. This chapter motivates the use of gamification analytics in the e-learning context and develops the research questions for this thesis.

1.1. Motivation

A central driver of the success of games is their ability to motivate and engage a wide range of people. Game elements are building blocks that are frequently used in game design to achieve certain psychological effects and construct the mechanics of a game. As playing games is an important part of culture, many game elements have been developed which can strongly influence human behavior and support motivation and engagement. Gamification aims to apply the knowledge and experience from game design in different domains to benefit from its positive influences on human behavior and attitude. This technique has been applied successfully in numerous different areas including education, marketing, healthcare and many more [56].

Gamification is able to address one of the current challenges for e-learning which is keeping students engaged and motivated [3,48]. A barrier for achieving motivation and engagement in e-learning is the lack of personal interaction and relation between teachers, students and among fellow students in e-learning systems [2]. Many e-learning systems do not involve any personal encounters but rely mainly on digital communication. In these learning environments, there are no fixed time schedules for learning that provide an organizational framework for students. Instead, students have to commit a high degree of self-organisation, time management and self-discipline. Most e-learning systems require that the students interact with these systems on a regular basis to achieve the desired learning outcomes.

Applying gamification to education and e-learning is still an active research area. It has been shown in various studies that e-learning can benefit significantly from integrated game elements [59]. However, also negative impacts of gamification in e-learning have been reported in studies [61]. Consequently, one focus of research is determining which factors influence the success of gamification in e-learning and how this can be properly implemented.

Gamification analytics is a field that deals with analyzing the users’ interaction with the incorporated game elements. For this purpose, user behavior data is collected, visualized and evaluated. Since e-learning systems are based on a digital infrastructure, this is
1.2. Objectives of this Thesis

Possible in almost all e-learning applications without restricting or influencing the students in any way. This approach could provide valuable insights into the practical effect and the interplay of game mechanics and help gamification engineers to develop and adapt gamification concepts that influence students in positive ways. Besides supporting research, gamification analytics also benefit students and teachers, as they provide additional gamification feedback and help to understand, how the gamification is used in the learning environment.

However, gamification analytics are only rarely applied because there is a severe lack of tools [25]. Although there are many components for integrating gamification into learning systems, they usually offer no or only rudimentary gamification analytics features. Moreover, there is only little research on methods and metrics for measuring and analyzing gamification interaction data [20].

1.2. Objectives of this Thesis

This thesis aims to address this situation by proposing a gamification analytics tool for the Moodle LMS. For this purpose, the following main research question will be answered:

**RQ**: **How should a gamification analytics tool be designed to be beneficial for students, teachers and research?**

To approach this question, the following secondary research questions need to be addressed:

**SRQ 1**: Which metrics provide meaningful insights into the use of gamification by students?

**SRQ 2**: How can the collected data be presented in a useful way for the different stakeholders?

**SRQ 3**: What is the perception of students, teachers and researchers towards the gamification analytics tool?

1.3. Structure of this Thesis

To root the proposed gamification analytics tool in current research, this thesis investigates the theoretical side and methodology of gamification analytics. The required theoretical foundations are presented in Chapter 2. Building on these foundations, this thesis summarizes the state of the art in gamification analytics research in Chapter 3. We conducted a literature review on research of the gamification monitoring phase and collected suitable metrics for understanding the interaction of students with gamification elements.

Based on the findings these findings, the design and implementation of the gamification analytics tool for the Moodle LMS is presented in Chapter 4. The tool aims to offer comprehensive insights into students’ use of gamification by combining various metrics. It combines methods from statistics and data science in a plugin ready for practical use in e-learning.

The developed gamification analytics tool has been tested in an online university course with 38 participants. To evaluate the tool, semi-structured interviews have been conducted with students, teachers and researchers. The design and the results of this evaluation are presented and discussed in Chapter 5. Chapter 6 summarizes the findings and limitations of this work to draw conclusions for teaching and further research in this area.
Chapter 2 Fundamentals

This chapter presents the basic concepts for this thesis. It discusses the gamification process, explains common game elements and gamification analytics.

2.1. Gamification

As games have been part of the human culture for a very long time, game designers have achieved great progress in developing game elements that are capable of engaging and motivating people. Gamification is the use of game design elements in non-game contexts [13]. The idea is to transfer the positive effects of games to the non-game context to make it fun for the users and therefore support achieving its goals. In the e-learning context this means to increase students’ participation, motivation and productivity by building engagement to achieve better learning.

Gamification has been applied in a wide range of domains like healthcare, marketing, finance, e-commerce, education and many more [56, 64]. There is still active research in understanding how gamification can be implemented most effectively and beneficial for all users.

According to Herzig et. al., the gamification process can be summarized in four phases: [28, 7, 62]

1. A business modeling and requirements phase where the application context is analyzed and its goals are documented.
2. A design phase where the gamification design is developed and tested.
3. An implementation phase where the design is realized.
4. A monitoring and adaptation phase to understand the user interaction with the gamification and adjust design flaws that do not work as intended.

As gamification analytics provides tools and methods for the monitoring and adaptation phase, this phase is the main focus of this thesis. A review of literature regarding this phase is presented in section 3.3.

2.2. Game Elements

Game elements are basic building blocks of games that are combined in the game design process to craft the game mechanics. Each game element has characteristic effects on the player and provide incentives for certain player behavior. As the main concept of gamification is the application of game elements in other contexts to achieve similar effects on the users, this section introduces important game elements for the e-learning context.

Dicheva et al. identified seven game elements that are frequently used for gamifying systems in education [15]:

Diverse and engaging game elements can be used to enhance the learning experience in an e-learning context.
2.3. Gamification Analytics

**Points** can be earned by the players by completing certain activities. They can measure the player progress and capacity and are used to motivate the player to achieve a higher score in the game [22]. They are also used to provide a sense of progress through the game. Therefore, they can be used to reflect the learning progress in educational contexts. They also enable to compare different players and therefore introduce a competitive element and promote interaction between players.

**Badges** are graphical emblems that can be earned by the players. In order to be a desirable reward, their design should be visually appealing and attractive. To earn a badge, players usually have to complete special challenges or achieve a particularly good performance. Badges of a player are often also displayed to his peers to address the need for assertion in a social group. According to Gibson et al., badges are used in educational contexts to incentivize learners to engage in positive learning behaviors, identify progress in learning and content trajectories and to signify and credential engagement, learning and achievement [21].

**Levels** are consecutive stages that the player reaches during the game. They are used to emphasize a sense of progression [52]. In learning contexts, they can help to establish a framework for structuring the course. Usually levels are designed in a way that they are very easy to achieve at the beginning of a game, but become increasingly difficult as the player progresses.

While badges and levels are only discrete indicators, **progress bars** can visualize continuous progress information. Moreover, progress bars address the players on a much more visual level than numbers used to measure points or level progress. They can motivate students who are close to achieving learning goals and sub-goals as well as encourage them when they fall behind [52].

A **leaderboard** is a list which ranks the users based on their progress concerning points, levels or badges. This enables social comparison between players which leads to a competitive dynamic that is driven by the social need for achievement [13]. A common strategy to avoid demotivating players that are ranked at the bottom end of the leaderboard is to display only a certain number of other players which are placed before and after the current player without revealing the players absolute position on the leaderboard.

**Virtual goods and currencies** can be collected or earned during the game. The goal is to create positive reinforce desired player behavior and enhance player interest and engagement [52]. To provide more meaning in acquiring virtual goods and currencies, games often incorporate some mechanics to trade or spend them.

**Avatars** are images that represents the profile of the player. Often, illustrations that fit the theme of the game are used instead of real photos of the player. Avatars can be freely chosen by the users. They are used to maximize the sense of self-involvement by the players [43].

The presented game elements will be used in the proposed plugin for the Moodle LMS. They will serve as foundation for the gamification analytics features.

2.3. Gamification Analytics

Gamification Analytics (GA) describe methods and tools that support gamification designers to monitor the success of gamification projects, to understand a user’s behavior and to adapt gamification designs [27]. As in all software systems, the gamification objectives and user characteristics change over time. A gamification needs to be regularly observed and adjusted over its lifetime. It is important for designers to understand how game elements and their combination address the user motivation to ensure that the gamification achieves a maximum of user engagement [10].
2.3. Gamification Analytics

Gamification Analytics involves finding and implementing metrics that enable comprehensive insights into the user interaction with the game elements in order to be able to draw reasonable conclusions. This includes fixing aspects of the gamification that do not achieve the desired effects on the users as well as optimizing the overall gamification towards its goals. Furthermore, gamification analytics should be able to support the identification of different user types and the resulting variation of effects of the game elements.

To achieve this, gamification analytics apply methods from data science and statistics to gamification data and visualize the results to the different stakeholders. Aside from gamification designers and depending on the use case, GA can also provide useful insights for other stakeholders like system operators, content creators for the system or even the system users themselves.

Gamification analytics techniques are the core of the monitoring and adaptation phase in the gamification project. The importance of monitoring and adapting is highlighted in literature, as the main objectives of gamification and the user needs and behaviors evolve during the lifetime of a software system [37, 27, 51]. Despite most gamification experts recommend a monitoring phase during which system usage is investigated in regular intervals, monitoring and management are often not planned or budgeted for in practice and gamification analytics have not yet received significant attention from academics [51, 27]. This thesis aims to address this in the e-learning domain by proposing a gamification analytics tool for the Moodle LMS.

To conclude, this chapter has introduced the concepts of gamification, most common game elements and gamification analytics. The following chapters will build on these concepts to develop a gamification analytics tool for enhancing gamification in e-learning.
Chapter 3  Related Work

This thesis aims to contribute to overcoming current challenges in e-learning, which are collected in section 3.1. A common approach for addressing these challenges is introducing gamification to e-learning systems. The results of current research on this approach are summarized in section 3.2. Although this research achieved promising results, it turns out that still various attempts to gamify e-learning systems fail. One cause that could contribute to these mixed results is insufficient methodology for assessing gamification effects. This thesis wants to address this issue by introducing gamification analytics to the e-learning context. Therefore, we conducted a literature review of the state of the art in the gamification monitoring phase to build a solid foundation for the proposed gamification analytics tool. This literature review is presented in section 3.3.

3.1. Current Challenges in E-Learning

Despite the manifold benefits of e-learning, there are some challenges that need to be addressed in e-learning systems to address the problems described in the previous section. As e-learning provides much more freedom regarding the time and place for learning, it requires strong motivation and time management skills as well as more responsibility and self-discipline for the learner to keep up with the more free and unconstrained learning process [2, 9].

The introduction of e-learning also leads to a lack of personal interaction and relation between learners and teachers and between fellow students [2, 9]. This contributes to lower engagement and motivation of students and becomes especially challenging in learning environments that involve only distance learning. For example, MOOCs struggle with very high student dropout rates [54].

This shortcoming of personal encounters can lead to negative effects on communication and socialization skills [2]. To compensate for such effects and strengthen exchange between students and teachers, communication tools like discussion forums can be integrated in e-learning systems, but they also depend on active student participation to be effective.

Since all these challenges depend to a certain extent on the motivation and engagement of students in the e-learning system, an important approach to address these challenges is to find ways to increase motivation and engagement for the students. Gamification is a promising approach which has the potential to achieve this.

3.2. Studies on Gamifying E-learning Systems

Since the emerge of gamification, many studies have applied gamification in the educational and e-learning area. This section will discuss the results of literature reviews of these studies to highlight common observations and point out current challenges for research that can be addressed by gamification analytics. Three major literature reviews
have been identified for this section that have been published since 2018: Antonaci et al. reviewed 27 empirical studies on gamifying online learning environments [1]. Rincón-Flores et al. conducted a literature review of 22 empirical gamification studies with focus on MOOCs [57] and Majuri et al. took a broader approach by reviewing 128 empirical studies applying gamification in a education and learning domain [46].

Concerning game elements, Antonaci et al. and Rincón-Flores et al. agree that the most used game elements in e-learning environments are points, badges and leaderboards. The most used e-learning platform was the Moodle LMS followed by HP [1] and Coursera [2] [57].

According to Antonaci et al., studies report that most students have a positive attitude towards gamification and gamification can enhance student collaboration and social awareness [1]. Rincón-Flores et al. found that in the reviewed studies participants where more active, satisfied and motivated in gamified MOOCs.

Concerning students performance in gamified systems, the reviewed studies reported mixed results [1]. Many studies reported that students using gamified systems achieved better scores than the control group [5, 12, 36], but other studies observed no significantly different or worse performance in tests conducted during the study [17, 39]. Regarding MOOCs, studies reported substantially higher course completion rates in gamified courses, although not every study was able to achieve these effects [57]. Majuri et al. agree that the majority of studies reported positive results. Of the 128 reviewed studies, 65 studies had mainly positively orientated findings, 23 studies found null or positive and negative results and 3 studies were mainly negatively orientated. However, the results of qualitative research often indicate very varying experiences of the students. Therefore, the positive results of the majority of studies must be treated with caution when applying gamification in education to make sure that no students are left behind [46].

Regarding engagement, studies reviewed by Antonaci et al. report that students under gamified conditions spend more time on assignments in the e-learning system [23, 40]. While most studies found that motivation and engagement can be significantly increased by using gamified systems [23, 29, 38, 60], some studies have found contradicting results [39, 24].

Rincón-Flores et al. identified several approaches in literature to evaluate the effects gamification had on students: [57]

- **Surveys and Questionnaires** are very frequently used in literature to measure gamification impacts in the e-learning context. When integrated in the e-learning system, they allow collecting much data with low effort. This allows to include all participants in the e-learning system and enables algorithmic data evaluation since all results are available as digital data. The main limitations of these methods are that the results are limited to the subjective views of the participants and valuable information that does not fit into the fixed structure of the questionnaire might get lost.

- **Interviews** with course participants can provide different insights. In contrast to questionnaires, they enable to discover results that do not go in line with the expectations of the researchers and facilitate discovering changing attitudes of the target group. They are more flexible as they allow researchers to adapt questions if necessary to capture useful results. On the other hand, interviews are much more time consuming.
3.2. Studies on Gamifying E-learning Systems

... consuming to run as meetings must be organized with all participants. This allows only for smaller sample sizes compared to quantitative methods. Additional biases can be included by participant selection and social norms.

- **In control vs. experimental group testing** the students are randomly assigned to two versions of a course. Its goal is to measure the impact of a specific change of a gamification or the gamification at whole. This change of interest is integrated in the experimental course and lacking in the control course. This increases confidence that the observed effects are caused by the introduced change and not by any unobserved confounders. This method increases confidence but has to be used in combination with some other method to measure the effects.

- **Data analytics** is taking into account that e-learning systems are digital and thus are able to record various data about the students and their use of the e-learning system. The discipline that deals with measuring, collecting, analyzing and reporting data about learners and their contexts for purposes of understanding and optimizing learning and the environments in which it occurs is called learning analytics (LA) [33]. Since LA is an actively researched area and one aim of gamifying e-learning systems is to boost learning, tools from LA can be used to assess gamification effects on the learning process. Besides the investigation of learning analytics, data analytics techniques can be applied in further areas. The field of Gamification Analytics will be discussed in the next section. For MOOCs, Rincón-Flores et al. highlight the importance of the course completion rate as achieving low dropout rates is currently one of the main challenges in MOOC research.

The applied methods for evaluating the effects of gamification in studies are regularly criticized by reviewers. Dichevat et al. conducted a review of 34 studies in 2015 and concluded that most of the empirical studies do not include a proper evaluation [15]. Their study revealed that there are a lot of publications in the educational field of gamification that only describe game mechanics and dynamics and expand on their possible use in educational contexts, while true empirical research in gamifying learning environments is scarce. Therefore, more substantial empirical research is needed to investigate in particular the motivating effects of using single game elements in specific educational contexts and for particular types of learners [15]. In 2015, Šćepanović et al. examined 8 studies introducing gamification in higher education learning and found that all of these studies relied only on student surveys to identify whether the gamification of course had an impact on student motivation and engagement [58]. Thus, the findings rely only on subjective opinions and emotions of participants. They suggest introducing control and/or parallel groups to address this issue and compensate different surroundings for embedding game elements which lead to varying results.

The more recent literature review by Rincón-Flores et al. indicates that the used methodology for evaluating gamification effects has diversified in recent years: of the reviewed studies on gamifying MOOCs 27.6% used questionnaires and/or interviews, 37.9% used data analytics and 20% investigated the course completion rate. Only 3.4% used control vs. experimental group testing and 10% of the studies did not conduct any evaluation at all [57]. Rincón-Flores et al. point out that gamification in MOOCs should be evaluated objectively and not only under the participants perception and conclude that there is a need to strengthen scientific research in this area. Majuri et. al. identified 28 of 128 studies that applied a controlled experimental study design and only 7 of them examined the effects of one game element at a time [46]. They state that this is an issue that has...
been identified in gamification research on a general level and it is difficult to estimate the effect of each motivational affordance or their interaction on the outcomes and results as controlled study designs are not commonly employed. It should be paid more attention on the study designs to produce knowledge on the effects of isolated elements in educational settings.

To conclude, various literature reviews have shown that gamification can achieve great benefits in the e-learning context. Although most results are promising, it is not fully understood yet which factors influence success or failure of gamification approaches in e-learning as there are various studies that were not able to achieve these benefits. In addition, the methodological approaches of current gamification research are criticized by the reviewers. Reviewers see a need for boosting empirical research in studies measuring the impacts of gamification in learning environments. Besides gathering subjective information by participants, it is important to incorporate objective data in the evaluation and more differentiation between the effects of different game elements is required. In particular, behavioral data of students are rarely collected and analyzed, although these data can provide comprehensive insights into the interaction of students with the gamified systems. Methods and approaches to realize such gamification analytics will be addressed in the next section.

3.3. Literature Review on Gamification Analytics

For capturing the state of the art in gamification analytics, we conducted a literature review of publications dealing with the gamification monitoring phase. This review is based on a systematic literature review conducted by Trinidad et al. in 2018 [62]. Their objective was to analyze the current studies in this field to identify current problems and needs in this area. Since the review by Trinidad et al. only includes literature published until June 2018, we applied the same methodology to also cover most recent publications. The identified papers provide insights into requirements for gamification analytics tools and present implications for applying gamification analytics to e-learning. Additionally, current gamification analytics tools are compared and current problems in the gamification monitoring phase are pointed out.

Methodologically, the literature review is based on the guidelines proposed by Kitchenham et. al. [31, 45], and the systematic literature review process proposed by Calderón et. al. [8] which is visualized in Figure 3.1. Since the literature review by Trinidad et. al. only includes papers up to June 2018, an additional literature identification process has been conducted for this thesis based on their approach covering the period from July 2018 to December 2019.

Trinidad et. al specified two research questions for the review:

- What works focus on the scope of the gamification monitoring process?
- What are the main problems and needs that require to be addressed regarding the monitoring of gamified experiences?

The literature review should identify all papers that deal with the gamification monitoring process, introduce tools for gamification analytics or add value to this field. Therefore, Trinidad et. al. selected inclusion and exclusion criteria that are shown in table 3.1.
3.3. Literature Review on Gamification Analytics

![Diagram of systematic literature review process](image)

Figure 3.1.: Applied process for the systematic literature review (adopted from [62])

<table>
<thead>
<tr>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
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<tbody>
<tr>
<td>• The retrieved study deals with the field of gamification monitoring process</td>
<td>• The retrieved study does not focus on gamification process</td>
</tr>
<tr>
<td>• The retrieved study introduces a tool for supporting the gamification monitoring process</td>
<td>• The retrieved study presents a specific application of gamification but does not deal with the gamification monitoring process</td>
</tr>
<tr>
<td>• The retrieved study adds value to the field of gamification monitoring process</td>
<td>• The retrieved study only has its abstract available and it is not possible to find its full-text</td>
</tr>
<tr>
<td>• The study is written in English</td>
<td>• The retrieved study does not provide the required information clearly</td>
</tr>
<tr>
<td></td>
<td>• The retrieved study is written in a language different from English</td>
</tr>
<tr>
<td></td>
<td>• The retrieved study does not provide information included in other retrieved study or in other digital database (duplicate studies)</td>
</tr>
</tbody>
</table>

Table 3.1.: Inclusion and Exclusion criteria for the systematic literature review (adopted from [62])

The quality of the studies is assessed using three quality assessment questions (QA):

- QA1: Does the study deal with the gamification monitoring process?
- QA2: Does the study introduce a tool for supporting the gamification monitoring process?
- QA3: Does the study allow retrieving the information related to the main problems and needs existing in the road to monitor gamified experiences?

The selected scientific databases are IEEE Xplore, Web of Science, SpringerLink, ACM Digital Library and Scopus. The used search string is "gamification AND monitor". This string was deliberately kept very broad so that no relevant publications were excluded. The initial search from Trinidad et. al. identified 383 papers in the databases. These papers were evaluated against the inclusion and exclusion criteria. Only two of these papers met the criteria and were selected as primary studies.
3.3. Literature Review on Gamification Analytics

Our initial search for literature from June 2018 to December 2019 showed a similar picture. As the search on Springer Link returned 1111 results, only the top 100 papers ranked as most relevant by the search engine were considered. This lead to 337 retrieved papers that were assessed with regard to the inclusion and exclusion criteria. Only one paper fulfilled these criteria and was considered as primary study. The distributions of the retrieved and primary studies are depicted in figure 3.2.

These literature reviews revealed that to the best of our knowledge only three studies exist that deal with the gamification monitor process. These papers are listed in table 3.2. All three quality assessment questions could be confirmed for the two studies identified by Trinidad et. al. while the study from Dichev et. al. [14] does not discuss the main problems and needs for gamification monitoring. The identified studies will be discussed in the remainder of this section.

Heilbrunn et. al. evaluated currently available tools for applying gamification analytics techniques to gamified systems [25]. To be able to compare these tools, they have conducted a prior study to build a framework of requirements for the gamification monitoring process [26]. To identify these requirements, they interviewed 10 gamification experts. The resulting requirements model is organized into five categories:

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**Figure 3.2.**: Retrieved studies and primary studies of the systematic literature review by Trinidad et. al. [62] covering publications until June 2018 (left) and of our literature review covering the period July 2018 until December 2019 (right)

**Table 3.2.**: Primary studies of the systematic literature review by Trinidad et. al. [62] and our literature review
3.3. Literature Review on Gamification Analytics

- **Application KPI modelling** sets the focus on the goals that the gamification should achieve. Key Performance Indicators (KPI) are domain specific metrics that operationalize business goals in context of the gamified application [25]. They are set up to quantify the success of the gamification by domain specific means. Observing undesirable user behavior on this side can be the starting point for further investigations that can improve the quality of the gamification. Despite collecting these data, Heilbrunn et al. emphasize that KPIs should be visualized in a useful way for the stakeholders.

- **Gamification Element Analytics** are the key of understanding how the users interact with the gamification. Observing which components of the gamification work well and which parts are not used very often or only by a specific groups of users can provide important insights into user behavior and lead to major gamification improvements. Game element analytics can be categorized in four subcategories:
  - **Game State Overview**: Gamification Analytics should include some metrics to quickly assess the current state of the gamification. Heilbrunn et al. propose the *gamification feedback rate*, which defines feedback as any state change in the game that is perceived by the user as success, e.g., gaining points and measures the amount of feedback per time. Additionally, Helbrunn et al. recommend *point distributions* and *achievable game elements statistics* for providing an overview of the current gamification state.
  - **Detailed Game Elements Statistics**: In order to be able to deeply analyze gamification flaws and effects, more detailed analytics should be provided. This includes *user distributions on the different game elements states* as well as *temporal statistics* which provide insights into the timing of user interactions. The gamification analytics tool should also provide statistics based on *user characteristics* to be able to adapt the gamification for different audiences.
  - **Alerting**: In the interviews of Heilbrunn et al., gamification experts asked for the possibility to be notified when certain metrics raise above or fall below a certain value.
  - **User Interaction Tracking**: Of the 10 gamification experts, 3 experts requested the ability to see how users interact with game elements in the user interface of the gamified application as this helps to understand visual attractiveness of the game elements.

- **User Groups of Interest** help to reflect different user types that show varying behavior when interacting with the gamification. Several different player types with different preferences and needs concerning game elements have been identified in literature [4]. Similarly, there can be specific types of users from the domain perspective. A gamification analytics tool should incorporate this and enable filtering by user types.

- **Gamification Design Adaptation** describes techniques for testing changes to the gamification design. For this, Heilbrunn et al. recommend the integration of experimental vs. control group testing to conduct experiments (see section 3.1). In addition, gamification designers should also be able to conduct direct changes to the gamification. These should be indicated by change markers in temporal statistics.
3.3. Literature Review on Gamification Analytics

- **Simulation** allows to detect flaws in the gamification design in early design phases without requiring users to test the system. For these simulations, historical data can be used or data can be generated. The results of the simulation should be explorable in the same way the gamification can be assessed.

Each of the requirements can be evaluated using a four level scale with the categories *not fulfilled*, *partially fulfilled*, *mostly fulfilled* and *fulfilled* depending on the extend to which these requirements are met. The categorization of requirements is visualized in figure 3.3.

![Requirements model for gamification analytics (adopted from [25])](image)

The presented requirements model can now be used to assesses the currently available tools for integrating GA in a gamification project. Calderón et. al. state that there are two approaches for implementing monitoring of gamification strategies: using a general-purpose gamification platform or creating self-built solutions [7]. While gamification platforms with integrated monitoring tools do not require any implementation effort for enabling monitoring support, they also limit the analysis to the available tools. Furthermore, using such a system leads to a dependence to the gamification platform provider if no open software is used. On the other hand, implementing self-built solutions is complex and expensive.

Heilbrunn et. al. identified two commercial gamification platforms that provide gamification monitoring support:

- **Bunchball** is a cloud-based gamification platform that offers gamification solutions to improve customer loyalty and online engagement as a Software as a Service model (SaaS). It can be integrated in several enterprise engines such as Jive. Bunchball incorporates several basic monitoring features like predefined gamification-related reports and a user segmentation feature. These monitoring capabilities fulfill one of the 22 gamification analytics requirements proposed by Heilbrunn et. al. [25].

- **Gigya** is part of the “SAP Customer Data Cloud” and mainly targets the gamification of online communities. It embeds some analytics that provide a set of predefined reports which accordingly focus on social metrics. It offers progression reports for levels and missions but does not show the amount of badges the users have earned. It partly fulfills one of the requirements by Heilbrunn et. al. [25].
### Figure 3.4: Summary of supported requirements by current gamification analytics tools

<table>
<thead>
<tr>
<th>Requirement</th>
<th>MEdinCEP-Gam</th>
<th>BUNCHBALL</th>
<th>GIGYA</th>
<th>DELTADNA</th>
<th>GAMEANALYTICS</th>
<th>GAMEHUD</th>
<th>HONEYTRACKS</th>
<th>UPSIGHT</th>
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<td>Application KPI monitoring</td>
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<td>R1: Definition of Custom KPIs</td>
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<td>R2: Definition of Pattern Based KPIs</td>
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<td>R3: Definition of KPI Goal Values</td>
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<td>R4: Dashboard</td>
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<td>R5: Change Markers</td>
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<td>R6: Goal Markers</td>
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<td>Game Element Analytics</td>
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<td>R8: Point Distributions</td>
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<td>R9: Achievable Game Elements Statistical Overview</td>
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<td>R10: User Distribution on Game Element State</td>
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<td>R11: Temporal Statistics</td>
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<td>R12: User Characteristics</td>
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<td>R21: User Interaction Tracking for Game Elements in the User Interface</td>
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<td>R14: Experiment Result Analysis</td>
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<td>R15: Direct Design Adaptation</td>
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<td>User Groups of Interest</td>
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<td>R17: Definition Based on Cluster Analysis</td>
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Number of Supported Requirements: 10

Not fulfilled, Partially fulfilled, Mostly fulfilled, Fully fulfilled
3.3. Literature Review on Gamification Analytics

Heilbrunn et al. also investigated how game analytics tools that mainly target monetization of free-to-play games can be adopted for gamification analytics. The examined platforms are DeltaDNA, GameAnalytic, GameHud, HoneyTracks and Upsight [25]. They are designed as SaaS-solutions and therefore can be integrated in any environment where a SaaS-model is acceptable with some effort. While not being designed for use in gamification these tools offer a wider range of monitoring features. The gamification analytics requirements supported by these tools are depicted in figure 3.4. Heilbrunn et al. conclude in their review of gamification monitoring tools that none of the currently existing solutions support the majority of the requirements and therefore do not offer sufficient support for assessing the gamification design in the monitoring and adaptation phase.

Calderón et al. developed the tool MEdit4CEP-Gam at the University of Candiz that holistically supports the gamification process and automates controlling and monitoring of gamification strategies [7]. They introduced a graphical editor that provides a high-level representation of the gamification strategy design and its monitoring. This platform enables the design of analytics to monitor the gamification experience. The editor supports defining metrics to measure user behavior during the gamification experience and KPIs. This system also enables obtaining overviews and statistics about the game elements and components related to the gamification strategy. It is able to send automatic reports via e-mail and communicate with end users about their performance. It fulfills 10 of the 22 requirements proposed by Heilbrunn et. al. [7].

This review of currently available gamification analytics solutions shows that there is currently a severe lack of tools that support the gamification monitoring process. All of the gamification analytics tools were embedded in a fixed gamification system and cannot be reused in other gamification environments. The discussed game analytics tools can be adopted to fulfill gamification monitoring purposes to some degree, but are not designed for this purpose. An overview of all tools with regard to the fulfilled gamification analytics requirements is shown in figure 3.4.

Concerning the integration of gamification analytics to e-learning environments, teachers should be involved in the gamification design process, as the design of the course and gamification design needs to be coordinated to develop synergies. Therefore besides supporting gamification designers, gamification analytics tools should be accessible and beneficial for teachers. Often, there are no external gamification experts involved in the gamification design, but the gamification is developed entirely by the teachers themselves. Therefore, it is important that teachers have tools available to assess the students interaction with the game elements and are able to identify flaws that hinder learning as well as analyzing gamification aspects that work particularly well for the course. These tools should be designed in a way that they can be intuitively used by teachers and are not only intelligible to gamification experts.

As the main purpose of applying gamification to e-learning environments is to promote learning by engaging and motivating students as well as supporting communication and collaboration, key performance indicators (KPIs) that assess the learning success of students should be considered. Learning analytics is the research discipline that deals with measuring, collecting, analyzing and reporting data about learners and their contexts for purposes of understanding and optimizing learning and the environments in which it occurs [33]. Therefore, learning analytics also deals with identifying and analyzing such KPIs in the learning domain, that are able to provide useful insights in effects on learning of integrated gamification systems. However, as they do not consider any gamification
data but only assess the state and development of learning in the e-learning environment, they only cover some part of gamification analytics in the educational context. Therefore, additional analytics that are specifically related to game elements are important [32].

Dichev et. al. point out some similarities between gamification and learning analytics: both rely on learners’ generated data, both generate some feedback and both target enhancing learning/educational outcomes [14]. This suggests that combining learning analytics with gamification can be beneficial for both fields. As learning analytics can provide KPIs for gamification analytics, gamification monitoring can also provide indicators that help understanding the learning process.

To investigate the intersections between gamification analytics and learning analytics, they implemented e-learning platform that facilitates the process of gamifying academic courses or other activities. They point out that the majority of analytics dashboards supports teachers and not much attention has been put into developing dashboards for learners and by examining how learners interact with the gamified environment. However, both learning analytics and gamification analytics are able to provide feedback that can help both learners and teachers throughout the learning process to maximize learning opportunities. Therefore, they implemented a learning analytics dashboard for teachers as well as a dashboard for students. These dashboards used timelines as key aspect of the feedback process. Despite various learning analytics metrics, the dashboards also included some game element statistics like number and category of awards acquired and virtual currency obtained and high/low/mean points. This design was evaluated in a usability study with 15 participant and in three university courses with positive results.

In conclusion, this literature review examined various aspects of gamification analytics to capture the state of the art in this field. The gamification monitoring phase has not been investigated much in current research, therefore there are no established frameworks besides the requirement model by Heilbrunn et al. that can serve as a foundation for gamification analytics applications. Furthermore, there is little evidence regarding the significance and relevance of proposed metrics for supporting the gamification analytics process in literature. Only 3 studies could be identified in the review which deal with the gamification monitoring phase. Thus, there is a strong need to strengthen research in this area. In addition, there is an unsatisfied demand for tools that support the gamification monitoring phase. The available tools often cover only very basic metrics and do not provide sufficient insights in the user interaction with gamified components.

To conclude, there are still many challenges and open questions regarding gamification analytics. Still, this literature review provided valuable insights into this discipline that can be incorporated in the design of a gamification analytics tool for e-learning.
Chapter 4 Design and Implementation

This chapter proposes a gamification analytics plugin for the Moodle LMS. The tool should support teachers, gamification designers and researchers to understand students’ interactions with gamified elements in the learning environment. After introducing the e-learning system and gamification solutions available in this environment, this chapter presents design and implementation of our plugin Interactive Gamification Analytics Tool (IGAT).

4.1. Moodle and Gamification

The Moodle LMS is an open learning management system which is freely available to use under the general public license. It is widely adopted in higher education for blended learning, distance learning and flipped classroom systems as well as in the cooperate learning area [11, 35]. There are over 100,000 registered Moodle LMS installations with over 170 million users worldwide [50]. As a gamification analytics plugin tailored to this system could benefit a wide range of learning applications, Moodle LMS was chosen as platform for the gamification analytics plugin.

The Moodle LMS is written in PHP and designed with a modular architecture to be easily extendable. A Moodle LMS installation consists of courses that students can join or be added to. A course consists of several activities which represent the provided learning resources. The available activities include an assignment system, quizzes, discussion forums, wikis and downloadable learning material. Additionally, other items such as calendars or recent activity overviews can be added next to the course activities in so called blocks. There are already some gamification solutions available for the Moodle LMS which will be presented in remaining subsections of this section.

4.1.1. Badges

The Moodle LMS natively supports a badge system for students. Badges can be created by teachers by providing the badge name, description, image file and additional metadata to the system. It is possible to define multiple criteria when this badge should be awarded automatically to the students or award the badges manually. The automatic badge award system includes awarding badges on course completion, activity completion, competence acquisition or if the student owns a specific set of other badges. Students can view their badges in a table on a site that is reachable via the course navigation menu.

[1] https://moodle.org
4.1. Moodle and Gamification

The badge system of the Moodle LMS is fully compatible with Open Badges 2.0, which allows students to use their badges outside the Moodle LMS installation to show that they have acquired certain skills.

4.1.2. Level Up! Plugin

Level Up! is a plugin for the Moodle LMS which enables adding advanced gamification features to the Moodle course. It was developed by Frédéric Massart and is available under the GNU general public license. It adds experience points (XP), levels and a leaderboard to the course. The teacher can specify rules how points can be earned based on Moodle events, activities and resources. Boolean operators can be used to combine several conditions to more complex rules (see figure 4.1). The required points for each level can also be adapted by the teacher. Furthermore, the plugin has a basic protection system to avoid cheating. Concerning the user interface, this plugin is realized as moodle block and displays the students’ level and points as well as links to the level overview and leaderboard pages next to the course material. The block includes an image representing the level, a progress bar displaying the students’ current points in relation to the points required for the next level and a list of recent point awards. Additional features like more flexible rules, more customization options, and mobile app support are available in the commercial version Level Up! Plus.

---

Figure 4.1.: Teachers’ interface for defining rules how to earn points in the course

2 https://openbadges.org
3 https://levelup.plus
4.2. Gamification Analytics Tool Design

Our gamification analytics tool builds on these gamification plugins for Moodle to integrate gamification analytics features. This tool combines all game elements in a students view to make analytics on game elements easily accessible and comparable. The analytics results are displayed in a teachers view. The integration into the course is realized by a Moodle block, as this is the most suitable plugin type to add new UI elements to a course. In Moodle, blocks are too small to fit the whole IGAT user interface, therefore the block just contains basic information and links to additional pages containing the students and teachers views. A general overview of the design concept is given in figure 4.2 and these components will be discussed in detail in this section.

4.2.1. Gamification Design

As gamification analytics is based on the underlying game elements, the gamification environment needs to be specified. The IGAT plugin is based on the Moodle badge system and the Level Up! plugin introduced in section 4.1. These two systems combined provide a wide range of game elements that can be customized by the teacher to fit the course. The supported game elements in the tool are therefore points, levels, badges, a leaderboard and progress bars. The badges system and Level Up! plugin provide the implementation of the game logic as well as the user interface for teachers to create and customize the gamification. However, the user interfaces for students of these two systems are located on different places in the Moodle user interface, as the badges system introduces a new link to the course main navigation menu and the Level Up! plugin is realized as block. This can introduce some bias to gamification measurement, as these placements could be perceived differently well by the students. Therefore, a new dashboard for students has been created combining the game elements of both systems. This also allows gathering additional data concerning the student interaction with this dashboard that might allow further insights in perception of game elements by the students.

4.2.2. Student View and Integration in the Course

The student dashboard consists of four tabs: progress, badges, leaderboard and settings.
4.2 Gamification Analytics Tool Design

The progress tab provides an overview on the students progress in the gamification. This includes the current points, level and badges. The overall progress is depicted in a progress bar displaying the ratio of completed levels and acquired badges and the total number of levels and badges. This progress bar serves as game element to further motivate the user to progress in the course. The level overview shows the current level and its description as well as a list of all available levels and the points required to achieve them. A point overview shows the current points, the points required for the next level and a progress bar visualizing this ratio. Next to this overview, a statistics box informs the students about the percentage of students in the course that are in a higher level, in a lower level and at the same level as the current student. To enable students to progress in the gamification, another module displays ten random activities that the student can take to earn more points. These are regenerated each time the student loads the dashboard. To complete the overview of the students’ progress in the gamification tab, a preview of the images of acquired badges along with a link to the badges tab is displayed. The progress tab is depicted in figure 4.3.

While the progress tab only contains small preview icons of the users’ badges, the badges tab provides the full overview of all achieved and available badges. It is shown in figure 4.4. The badges are displayed with larger images, full name, badge description and a statistic of the percentage of students in the course that have achieved the badge. For
4.2. Gamification Analytics Tool Design

Figure 4.4.: Badges tab of students view

already achieved badges, the issue date is stated and for badges that are still available the criteria for earning the badges are listed.

The leaderboard tab consists of a table of students which are ranked by their current points. Next to their rank, name and points score, also the students level and small icons for the students badges are displayed. By default, the leaderboard displays only 5 students below and above the rank of the current student and hides the absolute position to avoid demotivating players at the end of the leaderboard. However, the student can change this in the settings tab to view the full leaderboard or completely hide the leaderboard tab from the students view. He can also choose to hide his full name, but this also hides the names of all other students for the student. The leaderboard tab is displayed in figure 4.5.

The gamification block on the course main page next to the learning materials contains links to the progress tab, the badges tab and the leaderboard tab. These links contain a visual appealing icon and some teaser texts that indicate the required points for the next level, the next place on the leaderboard or the actions needed to earn a badge. These elements should offer an incentive for the students to open the students view and get further details. The block also removes the badges link in the Moodle navigation and the Level Up! block should be set to be hidden. Then, all information concerning the gamification state is provided only at one central place in the students view.

When the student has reached a new level or achieved a new level, a popup is displayed on top of the course main page that informs the student about his new achievement. This
4.2. Gamification Analytics Tool Design

Figure 4.5.: Leaderboard tab of students view set to display the whole leaderboard

should ensure that the student is regularly reminded of the gamification and visits the
students view regularly.
This gamification frontend for the students provides a solid foundation for gamification
analytics.

4.2.3. Gamification Analytics Design

For gamification analytics, Heilbrunn et. al. have developed five categories (see section
3.3) that will be addressed in this section to propose the design of the gamification ana-
lytics capabilities for IGAT.
The first category deals with Key Performance Indicators \( \text{KPI} \). Applied to e-learning, \( \text{KPI} \)
should measure the learning success. Assessing the students performance is an integral
part of teaching and therefore well researched. Especially grades existed long before the
use of digital technologies for learning. Concerning e-learning, assessing the students
learning based on data is an integral part of research in learning analytics. For Moodle
LMS several plugins are available that introduce learning analytics \[44, 16\]. The Moodle
LMS also supports some learning analytics features natively \[49\]. Therefore, this area is
very well explored in contrast to gamification analytics and will not be considered in the
context of this work. Thus, no learning analytics features are integrated into IGAT.
4.2. Gamification Analytics Tool Design

The second category of GA requirements by Heilbrunn et. al is Gamification Elements Analytics. Concerning the available game elements for the Moodle LMS, the following metrics have been chosen for the gamification analytics tool:

Game Element Analytics

The Game Element Analytics deal with distribution and states of the available game elements.

- The gamification feedback rate proposed by Heilbrunn et. al. measures the number of state changes in the gamification per day that the student perceives as success. These state changes include gathering points, achieving badges and reaching levels. For this metric, only days the student is active in the course are considered. This metric should indicate to the teacher, if enough feedback is provided by current gamification configuration.

- The points distribution provides insights into the students’ progress in the gamification. This metric is visualized in a bar chart with equally sized bins of experience points on the x-axis and number of students in these point ranges on the y-axis. The exact bin size is calculated based on the gamification configuration.

- In contrast to the uniformly distributed bins of the point distribution, levels are often designed in a way that the first levels only require few points for advancing to motivate players and reaching higher levels requires more effort and becomes increasingly difficult. Therefore, a level distribution is provided in addition to the point distribution which visualizes how many students have reached each available level. This is also realized as bar chart and allows assessing the difficulty of the current level configuration.

- In addition, the badges distribution plots the number of students who have achieved the available badges on a bar chart. This supports evaluating the design of badges in the course and their reception by students.

- Complementary to level distribution, the average days it took for students to reach each level are presented as a bar chart. The days are measured after the first gamification event invoked by the user. This statistic should enable further insights in the effects of the level design and allow to find fitting level difficulties.

- The average days to reach badges works similar but is applied to enable further insights in the badge design.

Gamification Dashboard Analytics

To enable further insights into the student interaction with the students view, the following Gamification Dashboard Analytics metrics are realized:

- The gamification page views metric measures how often the students visit each of the four tabs of the students view. This line chart plots all dates since the course started on the x-axis and the number of page views for each tab on the y-axis. This should allow to reflect whether points, badges and the leaderboard are relevant for students and detect changes in user behavior. The IGAT block next to the learning materials contains direct links to each tab of the three game elements to avoid noise caused by students opening one page just to switch to another tab.
4.2. Gamification Analytics Tool Design

- In addition to the page views, the average page viewing duration is measured for each tab. This is the time the student stays on the page between opening it and leaving the page. This metric is visualized as a bar chart for easy comparison between the tabs.

- To provide more insights on how the student browse the students view, a gamification dashboard subsequent pages graph has been added. This graph shows which pages students move to when they leave a tab on the students view. The nodes of this graph include the four available tabs, a moodle node for students leaving to another page in the Moodle LMS outside the students view and a external node for students leaving to another website or closing the browser. The directed edges between these nodes are labeled with the percentage of all students coming from this tab that are leaving to the destination this edge points to.

- The leaderboard visibility settings bar chart shows what settings the students have chosen concerning the leaderboard visibility. As described in section 4.2.2, students can choose to view the full leaderboard, only five places above and below their position or completely hide the leaderboard tab. Analyzing which settings have been chosen by the students can provide insights in the students perception of the leaderboard.

- Similarly, the leaderboard anonymity settings chart shows what proportion of students has chosen to hide their full name in the leaderboard.

In all visualizations of the gamification dashboard analytics, the same colors are used for each students view tab, to support the readability of the provided diagrams.

The third requirement category for gamification analytics by Heilbrunn et. al. is User Groups of Interest. In learning, students have different strengths and preferences in the ways they take and process information [19]. To conceptualize these differences, various learning style models have been developed [34, 42, 47]. One of the most often used learning style model has been proposed by Felder and Silverman [18]. According to the Felder-Silverman Learning Styles Model (FSLSM), students can have preferences for one of two categories in four dimensions: [19]

- **Sensing** learners are concrete thinkers and practical orientated while **intuitive** learners prefer thinking abstract and are oriented toward theories and underlying meanings.

- **Visual** learners prefer visual presentations of learning material while **verbal** learners prefer written or spoken explanations.

- **Active** learners prefer learning by trying things out while **reflective** learners prefer thinking thinks through.

- **Sequential** learners have a linear thinking process and learn in small incremental steps, while **global** learners have a holistic thinking process and learn in large leaps.

There is ongoing research at RWTH Aachen University on applying the FSLSM to gamification of virtual learning environments [65]. The main idea is that students with different learning styles are effected differently by game elements. The research aims to investigate the connection between the FSLSM and gamification in detail.
4.2. Gamification Analytics Tool Design

To contribute to this field, [IGAT] includes the possibility to filter each gamification analytics metric by learning style. This feature is based on a learning style questionnaire for the Moodle LMS [30]. This questionnaire can be integrated as a Moodle activity and contains 40 questions for students for identifying preferences on each of the four dimensions. The design of the learning style filters of [IGAT] is depicted in Figure 4.6 and consists of a slider for each learning styles dimension. These sliders allow to select a range of scores of the learning style questionnaire. This filters the GA metric in a way that only students who achieved a score in the selected range are included.

The fourth requirements category proposed by Heilbrunn et al. is Gamification Design Adaptation. Experimental vs. control group testing or A/B testing are the core requirements in this area. [IGAT] does not implement any specific functionalities regarding these techniques. However, they are easily realizable by dividing students between two Moodle courses with identical learning materials and comparing the gamification analytics provided by [IGAT]. Cloning courses in the Moodle LMS is possible by using the backup and restore features. Using this approach, the requirements for gamification design adaptation can be fulfilled with some effort.

The last requirement category for gamification analytics by Heilbrunn et al. is Simulation. The Level Up! plugin and badge system by the Moodle LMS differ considerably regarding their software architecture and have not been designed in a way that allows simulating gamification use. Therefore, simulation support could not be realized within the scope of this thesis.

To summarize the gamification analytics design for the proposed gamification analytics tool, the fulfillment of requirements by Heilbrunn et al. is depicted in Table 4.1. The design is able to meet 17 of the 22 requirements at least partially when adequate learning analytics tools are used in combination.

4.2.4. Teachers View

The metrics described in the last section are displayed in a gamification analytics dashboard for teachers and gamification designers on the teachers view tab. This dashboard is divided in three tabs: the first tab contains all metrics related to students interaction with the students view, the second tabs contains all metrics referring to game elements and the third tab contains links to the gamification configuration sites of the Level Up! plugin and the Moodle badge system. The gamification dashboard analytics tab is depicted in Figure 4.7. The metrics are displayed in the same order as they were presented in section 4.2.3. The only exception is the average days to reach level chart which is inserted directly after the level distribution to support comparing these two measurements. As the [IGAT] block hides the badges link and the Level Up! block should be also hidden,
4.3. Implementation

The design introduced in the prior sections was implemented during this thesis. A general overview on the plugin structure is shown in figure 4.8. The backend code is organized in three categories: libraries contain the backend logic for interfacing with moodle and the gamification components as well as communicating with the database. Renderers provide user interface components and views use them dynamically to build the frontend. All design configurations are contained in a central stylesheet and client-side logic is realized via two scripts for logging data on the students dashboard and displaying gamification analytics graphs. IGAT was mainly programmed in [PHP] as this is the language which is used by the [Moodle LMS] to realize the server backend. Additionally, [HTML] was used for the frontend markup and [CSS] was used to realize the design. The dynamic elements on the plugin frontend were realized using [JavaScript] and [SQL]. This following sections provide a detailed description of the implementation of this plugin.

4.3.1. Software Architecture

The overall architecture is dictated by the structure of [Moodle] blocks which is based on an object-oriented approach [53]. The [IGAT] plugin consists of the following directories and files:

<table>
<thead>
<tr>
<th>Requirement</th>
<th>IGAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application KPI monitoring</td>
<td></td>
</tr>
<tr>
<td>R1: Definition of Custom KPIs</td>
<td>LA</td>
</tr>
<tr>
<td>R2: Definition of Pattern Based KPIs</td>
<td>LA</td>
</tr>
<tr>
<td>R3: Definition of KPI Goal Values</td>
<td>LA</td>
</tr>
<tr>
<td>R4: Dashboard</td>
<td>LA</td>
</tr>
<tr>
<td>R5: Change Markers</td>
<td>LA</td>
</tr>
<tr>
<td>R6: Goal Markers</td>
<td>LA</td>
</tr>
<tr>
<td>Game Element Analytics</td>
<td></td>
</tr>
<tr>
<td>R7: Feedback Rate</td>
<td>↑</td>
</tr>
<tr>
<td>R8: Point Distributions</td>
<td>↑</td>
</tr>
<tr>
<td>R9: Achievable Game Elements Statistical Overview</td>
<td>↑</td>
</tr>
<tr>
<td>R10: User Distributions on Game Element State</td>
<td>↑</td>
</tr>
<tr>
<td>R11: Temporal Statistics</td>
<td>↑</td>
</tr>
<tr>
<td>R12: User Characteristics</td>
<td>↑</td>
</tr>
<tr>
<td>R21: User Interaction Tracking for Game Elements in the User Interface</td>
<td>↓</td>
</tr>
<tr>
<td>R22: Alerting</td>
<td>↓</td>
</tr>
<tr>
<td>Game Design Adaptation</td>
<td></td>
</tr>
<tr>
<td>R13: Experiment Creation</td>
<td>↓</td>
</tr>
<tr>
<td>R14: Experiment Result Analysis</td>
<td>↓</td>
</tr>
<tr>
<td>R15: Direct Design Adaptation</td>
<td>↓</td>
</tr>
<tr>
<td>User Groups of Interest</td>
<td></td>
</tr>
<tr>
<td>R16: Definition Based on Criteria</td>
<td>↑</td>
</tr>
<tr>
<td>R17: Definition Based on Cluster Analysis</td>
<td>↓</td>
</tr>
<tr>
<td>R18: Definition Based on Manual Selection</td>
<td>↓</td>
</tr>
<tr>
<td>R19: Filtering of Overviews by User Groups</td>
<td>↑</td>
</tr>
<tr>
<td>Simulation</td>
<td>R20: Simulation and Result Analysis</td>
</tr>
</tbody>
</table>

Table 4.1.: Evaluation of IGAT design regarding the requirements proposed by Heilbrunn et. al. [26] (↑ Fulfilled, ↗ Mostly fulfilled, ↘ Partly fulfilled, ↓ Not fulfilled, LA Fulfilled by applying suitable learning analytics tools)

a configuration tab is necessary to still provide access to the gamification settings. For teachers and managers, the gamification analytics dashboard is linked in the IGAT block next to the learning materials.
4.3. Implementation

Figure 4.7.: Dashboard analytics tab with the first two metrics in the IGAT teachers view

Figure 4.8.: General implementation structure of the IGAT plugin
4.3. Implementation

- **block_igat.php**
  This is the main class of the plugin. It is responsible for generating the block that is displayed next to the learning materials. It shows suitable links for the current user to the *students* and the *teachers view*. It also handles displaying the popup notifications.

- **dashboard.php**
  This file is the entry point for the student dashboard. After setting up a new page in the Moodle LMS, it includes the `view/view_dashboard.php` file which generates the four dashboard tabs.

- **analytics.php**
  Similarly, this file is the entry point for the gamification analytics dashboard. It initializes the page and includes `view/view_analytics.php` which handles the generation of the analytics dashboard itself.

- **ajax.php**
  This file provides the backend for all dynamic requests that are sent to the server with JavaScript.

- **style.css**
  This file contains the style sheet for the user interface of the plugin.

- **classes/**
  This directory contains all classes that realize the plugin’s features.

- **view/**
  This directory contains the files that establish the HTML structure of the pages created by this plugin and loads renderer classes for displaying the individual components.

- **amd/**
  All JavaScript code for the dynamic elements of this plugin is stored in this directory.

- Some files and folders required for configuration, documentation and distributing resources.

The core functionality is implemented in the classes. An overview of all classes and their functionality is provided in table 4.2.

4.3.2. Accessing Gamification and Learning Styles Data

To process gamification data, an interface to the *Level Up!* plugin and the Moodle badge system had to be created. As all gamification information is stored in the database by the gamification components, most information could be directly read from the corresponding tables. Also the calculation of gamification analytics metrics could be implemented in SQL queries. This has great performance advantages over loading all data to be accessible in the PHP script as especially the log tables can become very large over time. Using SQL, it was still possible to calculate the desired metrics within milliseconds.

The following tables are accessed for calculating gamification analytics:

- **block_xp**: This table contains general information on the students’ points and levels.
### Table 4.2: Overview of classes of the IGAT plugin

<table>
<thead>
<tr>
<th>Class File</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>block_igat.php</td>
<td>IGAT block generation and popup notifications</td>
</tr>
<tr>
<td>classes/lib/igat_badges.php</td>
<td>Library for accessing the Moodle badge system</td>
</tr>
<tr>
<td>classes/lib/igat_capabilities.php</td>
<td>Library for checking rights of a user in Moodle LMS</td>
</tr>
<tr>
<td>classes/lib/igatLearningstyles.php</td>
<td>Library for accessing the data on students learning styles of the LS questionnaire</td>
</tr>
<tr>
<td>classes/lib/igat_notifications.php</td>
<td>Library for managing level and badge achievement notifications</td>
</tr>
<tr>
<td>classes/lib/igat_progress.php</td>
<td>Library for accessing data from the Level Up! plugin</td>
</tr>
<tr>
<td>classes/lib/igat_ranks.php</td>
<td>Library for loading the students' rank and generating the leaderboard</td>
</tr>
<tr>
<td>classes/lib/igat_statistics.php</td>
<td>Library that implements the gamification analytics metrics</td>
</tr>
<tr>
<td>classes/lib/igat_usersettings.php</td>
<td>Library for managing user settings</td>
</tr>
<tr>
<td>classes/renderer/analytics_components_renderer.php</td>
<td>Renderer for displaying charts and components for gamification analytics</td>
</tr>
<tr>
<td>classes/renderer/analytics_config_renderer.php</td>
<td>Renderer for displaying elements of the gamification analytics config tab</td>
</tr>
<tr>
<td>classes/renderer/badges_renderer.php</td>
<td>Renderer for displaying elements of the gamification dashboard badges tab</td>
</tr>
<tr>
<td>classes/renderer/game_elements_analytics_renderer.php</td>
<td>Renderer for displaying game elements analytics</td>
</tr>
<tr>
<td>classes/renderer/gamification_dashboard_analytics_renderer.php</td>
<td>Renderer for displaying gamification dashboard analytics</td>
</tr>
<tr>
<td>classes/renderer/progress_renderer.php</td>
<td>Renderer for displaying elements of the gamification dashboard progress tab</td>
</tr>
<tr>
<td>classes/renderer/ranks_renderer.php</td>
<td>Renderer for displaying elements of the gamification dashboard ranks tab</td>
</tr>
<tr>
<td>classes/renderer/usersettings_renderer.php</td>
<td>Renderer for displaying elements of the gamification dashboard settings tab</td>
</tr>
<tr>
<td>forms/usersettings_form.php</td>
<td>Class required by Moodle [form API] for the settings on the gamification dashboard</td>
</tr>
<tr>
<td>classes/event_processor.php</td>
<td>Responsible for processing Moodle events and generating gamification notifications</td>
</tr>
</tbody>
</table>
4.3. Implementation

- **block_xp_log** or **local_xp_log** (when Level Up! Plus is installed): A log entry is created in these tables every time a user earns points.

- **block_xp_config**: This table contains information on the current level configuration of the gamification.

- **badge**: This table contains information on all available badges in the Moodle LMS installation.

- **badge_issued**: This table holds the assignments of badges to students.

The Moodle core library file badgeslib.php was used additionally for accessing badges information.

For the average days to reach level metric, the exact time of leveling up for each level and each student was needed. As this information is not available in the database, an auxiliary table **block_igat_levelup_log** was created. The level-up-event provided by the Level Up! plugin was used to log this information.

Another challenge was incorporating students’ learning styles into the analytics, as this information was also not available in the database. Instead, the learning styles questionnaire plugin provided functions for calculating students’ learning styles from their answers to the questionnaire during runtime. As the direct results of the questionnaire were needed in the database to create SQL joins, a second auxiliary table **block_igat_learningstyles** was created where the results of the learning style questionnaire are saved to.

When a student reached a new level or achieved a badge, an additional notification was shown by the IGAT block to the student. To generate these notifications, Moodle events provided by the Moodle badge system and the Level Up! plugin were used to save a notification to the **block_igat_notifications** table. When the user visits the course main page the next time, the IGAT plugin notices that a notification is available and displays it to the student.

4.3.3. Measuring Gamification Dashboard Interaction Data

To provide statistics on students’ interaction with the students view, an analytics component has been developed in JavaScript. When the student opens a tab, the current time is stored in a variable. Once the page unloads, a JavaScript beacon is send to the server, containing the url, page loading and unloading time, destination if a link was clicked and course id. This data is stored in the table **block_igat_dashboard_log** and can be used for generating analytics.

The form elements on the settings tab in the students view are realized using the Moodle form API. They are stored in the table **block_igat_usersettings** and can be accessed from there for displaying the correct leaderboard and for analytics.

4.3.4. Analytics Visualization

The visualization of the gamification analytics metrics was realized using the JavaScript library chart.js. This library is capable of displaying various chart types in a responsive design. Data can be provided as JSON and can be dynamically changed. A bar chart created with chart.js for IGAT is depicted in figure 4.9.

---

4 https://www.chartjs.org
4.3. Implementation

![Chart showing average days to earn badge](chart.png)

**Figure 4.9:** Gamification analytics metric visualized with chart.js

The JSON inputs for the graphs are generated by the PHP backend from the results of the SQL queries implementing the metrics. The JSON code is embedded directly in the page when a gamification analytics tab is opened. When the user filters the data, an AJAX request is sent to the server and a new JSON code with applied filters is returned and transferred to chart.js. This way, it is possible to filter and update the charts without regenerating the whole page.
Chapter 5 Evaluation

The developed gamification analytics plugin has been evaluated to address the research questions posed at the beginning of this thesis. The evaluation investigates to which extent the plugin is beneficial for students, teachers and research (RQ) by assessing if the proposed metrics provide meaningful insights in students’ use of the gamification (SRQ 1), evaluating if the presentation of data is useful for all stakeholders (SRQ 2) and capturing the perception of students, teachers and researchers towards the gamification analytics tool (SRQ 3).

5.1. Evaluation Method

To approach this evaluation, appropriate evaluation methods have to be selected. There are two main aspects that this evaluation should address: on one side, we want to assess the design of the plugin regarding the interaction with all stakeholders (SRQ 2, SRQ 3). The evaluation should identify the aspects of the design that succeed in achieving their desired effects as well as highlight shortcomings of the design and point out directions on how these could be improved. The field of Human-Computer Interaction (HCI) research has developed methods that are appropriate for addressing these questions. On the other side, the evaluation should assess the usefulness of the applied gamification analytics metrics for understanding the gamification effects on students to identify and adapt gamification design flaws (SRQ 1). Some methods from HCI research like usability studies and time diaries are too focused on specific aspects to provide insights concerning this area.

One considered evaluation method is the conduction of user surveys. Surveys allow to collect data from a large number of participants relatively easy. Lazar et al. state that they are particularly useful for getting an overview of a population but struggle to provide deep, detailed data [41]. In addition, surveys are build on fixed questionnaires and may not allow to explore different directions that have not been considered in the questionnaire design. Therefore, a survey might not be able to provide sufficiently detailed answers to the research questions.

Semi-structured interviews aim to bridge the gap between the fully structured questionnaires where it is not possible to deviate from the planned questions and unstructured interviews that flow completely free and respond to general topics rather than to specific questions [6]. This technique allows to explore new directions that arise during the interview without loosing reference to the questions that the interview should approach. Semi-structured interviews can provide sufficiently detailed insights regarding all research questions. Therefore, semi-structured interviews have been conducted to evaluate the developed gamification analytics tool and address the research questions of this thesis.
5.2. Evaluation Design

In addition, data collected by the gamification analytics plugin regarding students interaction with the students view can provide further perspectives on students perception of the IGAT plugin. Since this plugin was applied in a practical course, these results are considered as well in this evaluation.

5.2. Evaluation Design

To build a foundation for the evaluation of the gamification analytics tool, this plugin has been applied in an e-learning course with 38 participants. The data collected and displayed by the tool could be used in semi-structured interviews to be assessed by teachers and researchers. The data also enabled some first insights regarding the students perception of the gamification dashboard for students’ which have been complemented by semi-structured interviews with students participating in the course. The results obtained in this process can be used to draw meaningful conclusions regarding the research questions.

5.2.1. Evaluation Context

The developed gamification analytics tool was applied in a programming course for students in computer science. As part of a module on web technologies, the course aimed to teach students the fundamentals of JavaScript. The course lasted for four weeks and did not include any face-to-face learning. Instead, the lessons were provided as video lectures. To get hands-on experience in JavaScript, programming assignments called "Coding Challenges" were offered. Additionally, the students could test their knowledge in quizzes and tests.

The gamification was based on experience points that could be earned by watching lecture videos, answering questions hidden in the videos and completing the additional tests. By collecting experience points, the students could progress through seven levels and unlock some rewards like more time for tests or additional material. They could also collect seven badges for completing coding challenges. The gamification block was embedded next to the course material and allowed participants to enter the students view containing the overview of points and badges as well as the leaderboard. Popup notifications were shown on the course main page once the student has reached a new level or earned a new badge.

5.2.2. Study Groups

Regarding the number of participants, literature in usability studies suggests that 5 [63] to 7 [53] participants should be involved. Even though this evaluation is not conceptualized purely as an usability study, it aims to achieve similar insights regarding the interaction of stakeholders with the system. Therefore, these numbers were used as a guideline for the number of participants.

To evaluate the gamification analytics features, semi-structured interviews with six teachers were conducted. All of them were focused on teaching in higher education. They were involved in conducting lectures, seminars or practical courses at RWTH Aachen University. Three of the teachers are involved in researching and teaching in the field of learning technologies, while the other three teachers are teaching in chemistry, engineering and mathematics. Since no gamification experts were available for interviews, the e-learning researchers were asked to assess the contribution to research of this
5.2. Evaluation Design

The teachers interviews aimed to collect data regarding the selected metrics and their general perception of the developed plugin. They started with some warm-up questions about teachers’ subjects, their present and past courses and their familiarity and experience with e-learning, gamification, learning analytics and the Moodle LMS. This was followed by an introduction to the JavaScript course and the gamification analytics plugin on a computer that was accessible during the interview. After the introduction, they were allowed to freely interact with the plugin interface to answer the following questions. The main part of this interview addressed the metrics available in the teachers view. For each metric, the participant was asked to describe what it measures and how data is collected. The teachers were asked if the visualization of each metric is appropriate and what conclusions can be drawn from it. The teachers then were asked to evaluate the usefulness of this metric for assessing and improving the gamification. As the leaderboard anonymity and visibility settings metrics are very similar and the points/levels/badge distribution and average days to reach level/earn badge are the same metrics applied to different game elements, they were discussed in combination to avoid unnecessary repetition. The interviews concluded with some closing questions to summarize their opinion and address additional aspects that have not been covered yet. The full questionnaire for these interviews is attached in Appendix B.

The student interviews should examine the perspective of the students on the IGAT plugin. They are part of ongoing research regarding personalized e-learning using gamification (see section ??) [65]. These interviews addressed how students’ motivation and engagement are is influenced by the game elements in the JavaScript course. These interviews included several questions on their perception of the plugin and their perception of the student dashboard which allow conclusions regarding SRQ1 and SRQ2. The questions of the interview that are relevant for this thesis are listed in Appendix C.
5.3. Results

5.3.1. Metrics evaluation

Regarding SRQ 1 and SRQ 2 the teachers and researchers were asked to assess the conclusions that each metric can provide regarding the students’ interaction with the gamification and the metric’s visualization. For reference, the gamification dashboard analytics tab is depicted in figure 5.1.

Gamification Page Views

The gamification page views metric was immediately understood by all participants. The teachers reported that this metric is useful for comparing which game elements the students are interested in and which game elements are not relevant to students. It is also useful for assessing the development of students interest in the gamification during the course. The visualization was evaluated as adequate by four participants, two participants would prefer a stacked bar chart, as line charts suggest a process and this metric only collects discrete data. It was also pointed out, that this data should be correlated to the overall student activity in the Moodle course, to be able to draw useful conclusions. Therefore, looking at gamification tab views in general was evaluated as useful by five of six participants, but additional context on the overall students activity should be provided.

Average Page View Duration

The average page view duration metric was correctly understood by all teachers. The bar chart showed an average of 263 seconds for the leaderboard view duration, while the duration for the other tabs was below 70 seconds. Two participants supposed that students had this page open in the background for regularly checking their rank while learning. It was pointed out that also providing the median and the upper and lower quartile would enable more insights. Another way to improve the value of this metric would be recording the duration of mouse activity on this page instead of just measuring how long the tab is open. The teachers reported that the observations of the gamification page views metric are confirmed by this metric, but it does not provide any additional insights. Two of the participants found the confounders to strong to draw any useful conclusions.
5.3. Results

Figure 5.1.: First four metrics of the gamification dashboard analytics tab
5.3. Results

Student Dashboard Subsequent Pages

The gamification dashboard subsequent pages graph was assessed as an advanced metric by the teachers. Thou all participants were able to correctly describe what is depicted in this graph, it took some time for them to understand this metric. The graph was described as "confusing" by two participants because of the high number of edges. There were some suggestions for improving the readability of this visualization: the edges of the graph and the data values could be colored, the thickness of the edges could be changed based on the data and it would be helpful to be able to filter nodes. Another suggestion was providing 3-tuples of the most frequent paths instead of using a graph, as this visualization is too complex for teachers. One participant concluded that additional reinforcements for visiting the other tab pages should be integrated. Three participants reported that this metric can be used to learn if the students browse the students view in a particular order and found this metric interesting while two participants did not find this metric useful. It was also pointed out, that this metric is more useful for gamification designers than for teachers.

Leaderboard Visibility and Anonymity Settings

The leaderboard visibility and anonymity settings metrics were clear to four participants, two participants needed help for drawing the connection to the students chosen settings. It was observed that none of the students decided to hide the leaderboard or chose to be displayed anonymous to other users. This lead teachers to the conclusion that the leaderboard was relevant for students and the students were willing to participate in the gamification, although it might be possible that some students were not aware of these settings. They suggested that the default value should be marked or no default value should be used at all but the user should be prompted to specify its settings before accessing the students dashboard. One participant expressed interest in having information on how the settings have been changed over time. Overall, these metrics were evaluated as useful, as they provide insights in the students attitude towards the gamification.

Gamification Feedback Rate

The gamification feedback rate had to be explained to some extend to all participants. Even though, there was some text defining the feedback rate, it was not clear what counts as a "gamification reinforcement". Therefore, additional explanation should be provided with this metric. It was pointed out, that it is necessary to have an in-depth understanding of the gamification and available course material to be able to assess this number. The visualization could help on this by summarizing at which places in the course feedback is provided by the gamification. One participant suggested plotting the gamification reinforcements as a time series and categorized by game element instead of providing only one number. Although the implementation of the feedback rate was criticised by the participants, the participants agreed that assessing gamification reinforcements can be useful to determine if the gamification provides enough feedback to the students.
5.3. Results

Points, Levels and Badges Distribution

The points distribution, badges distribution and badges distribution metrics were fully understood by all participants. Teachers reported that these metrics allow to get an overview of the current state of the gamification and assess the difficulty of levels and badges. One participant concluded that these data mainly raise questions for further research, as these metrics alone are not sufficient for answering why distributions deviate from their desired form. Concerning the visualization, the participants pointed out that an pie or doughnut chart would also be appropriate and would help to relate the data to the population size. The metric was rated explicitly as useful by four out of six participants.

Average Days to Reach Level and Earn Badge

The analysis of all data lead to the conclusion that many students first started working in this course once the course was released, then fell inactive for some time and finished the course once the end of the course was near. This introduced some bias to the average days to reach level and average days to earn badge metrics. Nevertheless, participants were able to conclude how long it takes for students to gain momentum in the course. The metrics would also allow conclusions on the level and badge difficulty if the students were active more constantly. One participant interpreted these data as an indicator that the gamification did not achieve the desired engagement and therefore considered this metric as useful. Another participant pointed out that he would be more interested in a statistic when students achieve the badges and levels. The visualization was understood well by all participants.

5.3.2. Conclusions on Teachers and Researchers Perception of the Gamification Analytics Tool

The evaluation allows several conclusions regarding SRQ 3 with respect to teachers and researchers, which refers to their perception of the developed plugin. Most participants found that the existing metrics covered all aspects of gamification, but pointed out that many metrics should be extended to provide a clearer picture of students’ gamification interaction (see section 5.3.1). Two participants rated the gamification dashboard analytics as more useful for the gamification developers, while the game elements analytics are also interesting for teachers.

With regard to the value for research, the three participating researchers in the learning technologies domain especially highlighted the use in the pre-analysis phase, as there are currently some confounders that needs to be isolated and the provided metrics are not detailed enough. This should be addressed in further work.

Concerning the integration of an export feature, there was a clear split between educational researchers an the other teachers: while other teachers thought it would be sufficient to just export the diagrams as image files, some researchers would like to be able to export the raw data for further analysis. The teachers would use exported graphics for reports, archiving and comparing past and current courses.

The overall layout structure of the teachers view was intuitive to use for all participants. One teacher pointed out that the form of visualization should change more frequently to keep the viewers interest. Three participants reported that the labeling text on the axis of the diagrams was too small. Although most metrics were clearly understood by the participants, some metrics required additional explanation during the interview and should therefore be described in more detail on the teachers view. It was also suggested.
5.3. Results

to display more information on the context like the required points for each level in the levels distribution or the population size in the diagrams.
The learning style filters were considered interesting by all participants, but the interface for selecting a range of applicable learning styles in the filter was not clear to most teachers. One participant stated it would be sufficient to just have two buttons for each learning style dimension, e.g. having just an "active" and "reflective" button that filters the diagrams to display the corresponding data.

Of the six interviewed teachers, five had a positive attitude towards the general concept of gamification for learning. One of them was sceptical at the beginning of the interview, if applying game elements to learning environments can influence students behavior in a positive way but concluded after examining the gamification analytics that gamification works better than he expected. One teacher from mathematics expressed that gamification is not well applicable for supporting teaching in mathematics, as the e-learning environments in this domain often only provide downloadable learning material and assignment management. This opinion was confirmed by reviewing the collected data in the analytics dashboard, therefore this participant evaluated the gamification analytics tool as useful. Other participants agreed that prerequisite for applying gamification and gamification analytics to an e-learning course is that the platform uses a rich variety of e-learning features and not only serves as a download portal for learning materials.

To conclude, overall the teachers had a positive attitude towards the proposed gamification analytics tool. One participant expressed that it is inevitable to apply such a tool when integrating gamification in an e-learning system, as it is necessary to reflect on how gamification affects learning. Another teacher stated that applying such tools also helps to reflect on the provided learning material and course design and therefore also contributes to these areas. For research, the tool can provide explorative insights but should be refined to exclude confounders and deliver more in-depth results.

5.3.3. Students’ Interaction and Perception of Gamification Dashboard

To evaluate the students’ perception of the students view, five interviews have been conducted. Additionally, the collected data of students’ interaction with the dashboard was analyzed.

Most students had an overall positive perception of the gamification and its integration in the course. Students reported that they perceived the layout structure of the students view as clear and well-structured.

The collected page view data showed, that the leaderboard tab is most interesting for students while the other tabs were visited significantly less. Also, the students spend much more time on the leaderboard compared to the other tabs. The importance of the leaderboard was underlined by the interviewed students, two of them explicitly stated that the leaderboard was important to them. Another student stated that when looking at the leaderboard, he looked at his point count and the difference to the next highest position. The conclusion that achieving this progress was manageable served as a motivator for continuing learning.

The progress and badges tabs have not been visited by students as frequently. As the main reasons for this, students reported that they were not aware of their existence or these tabs were not interesting enough. One student stated that he was not able to know what badges are available until he earned them. On the progress tab, especially the progress bars did not achieve their desired objective to further motivate students. Another reason for not visiting other tabs could be that the experience points, level and badges of the student were all visible on the leaderboard.
5.4. Discussion

Concerning the settings tab, 15 of the 38 students participating in the course switched the leaderboard visibility setting to show the whole leaderboard. This indicates that the settings tab was visited by a larger group of students, although two of the interviewed students reported that they were not aware this tab exists. None of the students had completely hidden the leaderboard nor hidden their full name on it. This indicates that the leaderboard and the introduced competition aspect was perceived positively, although some of the students participating in the course might have not been aware of this choice. One student reported that he was not aware of the entire students view until the first gamification popup appeared. This indicates that the placement of the IGAT block on the right side next to the course’ learning materials does not sufficiently capture the students attention. This also indicates that the notification popups are quite important. These were perceived positively and students reported that they often visited the students view after such a popup appeared. However, students expressed that notifications should appear dynamically in the moment and on the page the badge or level was achieved, not just when the course main page is visited.

In conclusion, the students view was evaluated positively by students, especially the leaderboard was perceived very well. However, some parts of it had little impact. Especially the progress tab has not been used very frequently. Also, in general the links leading to the gamification dashboard need to be placed more prominently and notification feedback should be provided at the moment the student reaches a new level or earns a badge. Despite this room for improvement, the students view contributed to motivating students while collecting data for gamification analytics at the same time.

5.4. Discussion

The evaluation has shown that the selected metrics are appropriate for assessing the students interaction with the provided game elements. However, evaluation results suggest that several improvements of the gamification analytics should be realized to unfold its full potential. Initially, the displayed metrics should be enriched to provide more accurate insights. The metrics currently showing an average should also include mood, median and upper and lower quartiles. Also, additional information for properly evaluating statistics should be provided, e.g. the total number of students visiting the course on the gamification page views chart and default values for settings should be highlighted. In addition, the analytics dashboard should provide more information on the metric itself and possible confounders to avoid any misunderstandings as well as support drawing correct conclusions. This could be realized with a help system that can be accessed directly from each metric. More context on assessing the analytics results could also be provided by integrating some learning analytics metrics into the teachers view. Concerning the individual metrics, teachers have suggested various small improvements that should be realized.

Regarding the students dashboard, two layout improvements should be addressed. To avoid that students do not recognize the links to the students view, a larger module could be placed on the course front page directly on top of the learning materials. However, this is not supported by the current block system of Moodle LMS and therefore would require some larger modifications of the system. Also, displaying immediate popup notifications once a student reaches a new level or earns a badge is difficult to realize, as Moodle event handlers are not supposed to directly create any user interface elements.

This evaluation also assessed the perception of different stakeholders on the proposed tool. Students and teachers had an overall positive attitude towards the developed tool.
5.4. Discussion

besides some suggestions that should be addressed. Researchers requested more detailed visualizations and adaptations of the metrics that reduce present confounders. Aside from improving the metrics, it should be noted that also in the current design, confounders can be addressed by applying A/B-testing with two courses, which is supported in the Moodle LMS by duplicating the course and dividing the participants between the two versions. A limitation of this study is that no gamification experts were available for interviews. However, in most situations in practice the gamification will be most likely designed and assessed by teachers along with the course and not by external gamification experts.

In conclusion, this evaluation was able to provide diverse insights into the main research question how a gamification analytics tool should be designed to be beneficial for students, teachers and research.
Chapter 6 Conclusion and Outlook

This thesis has explored the application of gamification analytics in the e-learning context. Gamification has the potential to address many challenges in e-learning, such as the lack of motivation and engagement caused by the absence of personal communication and relation. However, it is still not fully understood which factors influence the success of gamification, as there are some studies that report negative results.

One integral part of this research is assessing the impacts of gamification on students. Four different approaches on how gamification is evaluated in literature have been identified. Despite variety in these methods, most studies in this area just rely on surveys, questionnaires or interviews to assess students interaction with game elements.

A field that can provide more perspectives to the evaluation of gamification in e-learning environments is gamification analytics. Only very little attention has been paid to the gamification monitoring phase, although experts emphasize its importance. Our literature review identified only three studies that deal with the gamification monitoring process. One reason for the infrequent adaption of gamification analytics is a lack of tools. The few available gamification analytics tools are often part of closed gamification platforms and provide only few metrics for assessing the gamification.

To address this issue, a gamification analytics tool for the Moodle LMS has been developed. It is based on established gamification solutions for the Moodle LMS and provides insights into the interaction of students with gamified elements in the learning environment. It includes various metrics on students’ activity on the gamification dashboard as well as statistics on the different game elements. All metrics can be filtered by students learning style to reflect differences in students’ perception and personality. With minor effort, it is also possible to conduct experimental vs. control group studies. Despite the benefits of applying gamification analytics, much attention should be paid to the design of the course and learning material, as this also has a significant impact on students engagement and motivation as gamification will not be able to compensate a lacking didactic concept.

The proposed gamification analytics tool was used in a JavaScript course with 38 participants. To evaluate the benefits and shortcomings of this tool, semi-structured interviews were conducted with five students and six teachers. The students had an overall positive perception of the developed gamification dashboard. The teachers were able to draw meaningful conclusions from the presented analytics. Additionally, teachers developed various ideas to further improve the analytics, as some metrics should be expended to provide deeper insights.

To conclude, this thesis showed that gamification analytics can be very valuable for assessing gamification effects on students in the e-learning context. The developed gamification analytics tool for the Moodle LMS makes these benefits easily accessible for educators. Also, this thesis lays a foundation for further research in this area.
6.1. Limitations and Future Work

This work was subject to some limitations regarding the developed tool and regarding the evaluation that need to be pointed out. The implementation phase was carried out under tight time constraints, as the course start date was fixed and the software had to be fully implemented and tested before that date. Therefore, not all requirements identified in literature could be realized. In addition, the Moodle LMS system architecture and the used plugins came with some limitations. Thus, it was not feasible to implement features like e.g. simulation during this project. Also, the gamification is restricted to the game elements introduced by the Moodle badges system and the Level Up! plugin. Learning analytics were mostly excluded from the scope of this work, as there is much active research and there are more available tools in contrast to gamification analytics. However, the IGAT plugin would benefit from a direct learning analytics integration into the teachers view, as this would provide more context and more sophisticated insights into the students interaction with the virtual learning environment.

In the evaluation, no gamification experts were available for interviews. Additionally, only three researchers in the learning technologies field have participated. Raising these numbers would have provided more reliability, however it was still possible to achieve significant results concerning the gamification analytics tool.

As this thesis highlights, applying gamification analytics can benefit gamified systems in many ways. Therefore, much more attention should be paid by researchers to this area. Since the topic of gamification analysis is still largely unexplored in the e-learning context, there are many aspects that should be considered in further research. There are still open questions concerning incorporating different user characteristics in gamification in the educational context. The relation between Felder-Silverman Learning Styles and player types in gamification is currently researched at RWTH Aachen University [65]. In addition, it is unclear to which extend gamification effects are influenced by other factors like gender. Further evidence is needed in this area and results should be incorporated into the gamification analytics plugin.

During evaluation, teachers pointed out various needs concerning the available metrics in the IGAT plugin. The gamification analytics dashboard revealed general tendencies concerning the students’ gamification interaction but extending these metrics could allow more detailed insights. Concerning key performance indicators for e-learning, results from the learning analytics field should be considered, as this discipline has investigated how students performance can be assessed in digital learning environments in detail. Therefore, it is recommended to use the proposed tool in combination with available learning analytics solutions and the tool could be expanded to incorporate metrics from the LA field in future work.

Another interesting aspect that can be explored in future work is making gamification analytics accessible for students. The IGAT plugin integrated some statistics into the students view to contribute to students motivation, but this implementation was only very basic. Expending on this could also encourage students to reflect on gamification as a tool.

To sum up, there are still many approaches to be explored in the gamification analytics field. This is not just limited to the educational area, but also extends to gamification research in general. However, current results already show that gamification analytics is a very powerful tool that can contribute to the success of a gamification project to a large extend.
Appendix A Bibliography


A. Bibliography


A. Bibliography

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Appendix B Questionnaire for Semi-Structured Interviews with Teachers

Warm Up
1. What is your subject and which courses do you teach?
2. Do your current and past courses involve any e-learning components? Which one?
3. Have you used Moodle before? How familiar are you with Moodle? If not, what other learning platform have you used?
4. What is your experience with student’s activities in Moodle? Which do they use very frequently and which one are not used very often? (Do they actively participate in discussion forums? Do they turn in their assignments early?...)
5. Did you use learning analytics tools before to investigate such questions?
6. Do you know the concept gamification?
   ⇒ If not, explain concept
7. Have you worked with gamified learning systems before? Which one? Which Game Elements?
8. What is your opinion of gamification? Do you like the idea?

Introduction
Show gamified javascript course to teacher and IGAT plugin:
- Short overview of javascript course
- Student dashboard: show all game elements
- Gamification Analytics Dashboard: just show different tabs, no explanation of available metrics
- Very brief explanation of learning styles

Gamification Analytics
The teacher can freely explore the gamification analytics dashboard while answering the following questions.
Gamification page views

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding
2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?
3. What conclusions can you draw from this metric?
4. Is this metric useful assessing and improving the gamification?

Average page views duration

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding
2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?
3. What conclusions can you draw from this metric?
4. Is this metric useful assessing and improving the gamification?

Gamification dashboard subsequent pages

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding
2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?
3. What conclusions can you draw from this metric?
4. Is this metric useful assessing and improving the gamification?

Leaderboard visibility and anonymity settings

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding
2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?
3. What conclusions can you draw from this metric?
4. Is this metric useful assessing and improving the gamification?

Gamification Feedback Rate

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding
2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?
3. What conclusions can you draw from this metric?
4. Is this metric useful assessing and improving the gamification?
Points, levels and badge distribution

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding

2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?

3. What conclusions can you draw from this metric?

4. Is this metric useful assessing and improving the gamification?

Average days to reach levels and average days to earn badge

1. What do you think is shown here? How is it measured?
   ⇒ Explain metric, if wrong understanding

2. Do you like the visual representation of this statistic? Is it clear? Would you like to have a different visual representation of these data?

3. What conclusions can you draw from this metric?

4. Is this metric useful assessing and improving the gamification?

Closing Questions

1. Do you think that the used metrics cover all important aspects of the gamification? Is anything missing?

2. Do you like layout structure of the gamification analytics dashboard? Is it possible to find what you are looking for quickly? Would you change anything about the arrangement of the statistics?

3. Do the learning style filters provide valuable insights?

4. How would you assess your insights into the gamification of the JavaScript course? Have you been able to draw useful conclusions to improve the gamification?

5. Would you like to be able to export the data? What would you use this exported data for?

6. So, after seeing this tool, what is your attitude towards gamification? Would you use this tool for your own courses?

7. How would you assess the value for gamification/e-learning research of the gamification analytics tool?

8. What is your general opinion of this tool? Do you have anything to add?
Appendix C Questionnaire for Semi-Structured Interviews with Students

This questionnaire only contains questions that are relevant for this thesis. These interviews were part of research concerning personalized e-learning using gamification and therefore also included additional questions regarding this area.

General Questions

1. Can you tell me how often you accessed the Introduction to JavaScript course?
2. What was the main reason for your access?
3. How many hours did you spend on the Course on a weekly basis?
4. During that time, what did you do?

Badges

1. Can you tell me how the badges were awarded and what was their purpose?
2. Have you earned any badges in the course?
   Yes:
   a) Do you know how or when did you earn a badge?
   b) Can you recall any specific emotion or feeling you had when you earn a badge?
   c) During the course, did you have any intention to earn a badge?
   d) So in general, what is your opinion on badges as a tool to enhance learning and boost engagement?
   e) Would you like to see badges in other courses?
   f) Would you like to change anything regarding badges?
   No:
   a) Can you tell me why?
   b) Do you think the badges are too difficult or not interesting?
   c) What is your general opinion on badges as a tool to enhance learning and boost engagement?
   d) What can be changed in the badge system to make you interested in using it and collecting badges?
Levels and Experience Points (XP)

1. Can you tell me how experience points and levels were organized in the course?
2. What was the purpose of collecting experience points and leveling up?
3. During the course, did you collect any XP?
   Yes:
   a) Can you tell me how you collected the experience points?
   No:
   a) Can you tell me why?
   b) What can be changed to make you interested in collecting points?
4. Did you level up?
   Yes:
   a) How did you feel when you leveled up?
   b) Did you seek for any specific level? What level and why?
   No:
   a) Can you tell me why?
   b) What can be changed to make you interested in levelling up?
5. There was a possibility to see levels and experience of other students in the course, have you visited the leaderboard?
   Yes:
   a) Why? In which way leaderboard was important/valuable to you?
   b) In your opinion, is the system of levels and leaderboard a good addition to the learning?
   c) What do you like about levels and experience points?
   d) What did you not like?
   No:
   a) Why?
6. Would you like to change anything related to levels / leaderboard?

Gamification Progress

1. Have you visited this progress bar tab?
   Yes:
   a) Can you tell me what information you looked for?
   b) Would you consider a progress bar being a good feedback to students learning?
   c) Do you think progress bars can help students reflect on their learning?
   d) What do you like about progress bar?
   e) What did you not like?
   No:
   a) Why?
IGAT Plugin

1. What did you like about the design students dashboard?
2. What should be improved?
3. What do you think about the gamification block next to the course material?
4. How did you perceive the notification popups?

Closing Questions

1. When did you visit the gamification dashboard? Before taking a learning action or after? Or when the system notifies you?
2. Why did you visited the gamification dashboard?
3. Do you think this idea/concept can enforce students to be more active and engaged?
4. Do you find any other mechanism more successful?
5. Would you consider gamification being a positive addition to the course regarding motivation and engagement?
6. What is your general opinion, what did you like and what did you not like?
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Gottschlich, Dirk Manuel 348336

Name, Vorname Matrikelnummer (freiwillige Angabe)

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