Evaluation of a Learning Application Designed to Improve Motivation and Engagement of Students in Higher Education

Max Schlosser, Mona Urban, Duc Tran, Carolina da Rocha Nobre, Peter Kreißig,
Susan Labude, Dominik Breck, Christian Roschke, Marc Ritter, Matthias Vodel
University of Applied Sciences Mittweida, Germany

Abstract

This paper describes the process of conceptual design and prototypical implementation of an application to be used in a higher education context. The main purpose of the app is increasing student motivation in subjects which have a strong tendency towards rote learning. With the help of an evaluation concept, it was shown that the motivation has increased in essential aspects after the use of the app among nine student subjects. Specifically, extrinsic motivation increased by 23 percent, and intrinsic motivation increased by 16 percent. Additionally, satisfaction and attention increased by five percent each.

1. Introduction

Motivation is directly related to learning success and exam results, making it a significant aspect of teaching in higher education institutions [1]. For this reason, when designing teaching content and materials, it is essential to consider student motivation. According to Kember et al., in addition to students' interest, the learning environment provided by the teachers is crucial to maintaining motivation [2].

Past studies have shown that gamified applications have gained significant importance in recent years and are used in various areas of higher education already [3]. Because of their constant presence in the daily lives of many students, mobile applications have proven to be an efficient way to engage students in higher education learning [4] [5]. However, there are still a limited number of solutions aiming to increase student motivation in specific subject areas, particularly when combining memorising facts with understanding core concepts.

Currently, professors at several universities in the state of Saxony (Germany) have noticed that students encounter persistent difficulties in sustaining their motivation to assimilate the learning material. The main reason identified is that the underlying subjects often require them to learn by rote while being presented with outdated and non-engaging learning management systems. Therefore, it is essential to offer students an alternative learning approach that not only provides specific incentives for content repetition but also assists in maintaining their motivation.

2. Methodology

In this study, a mobile application was conceptualised and prototypically implemented to facilitate playful learning through quiz-like game modes. Approaches of user-centred design have been incorporated by conducting qualitative interviews with both lecturers and students who would be directly affected by the introduction of such an application. Their feedback was iteratively incorporated to refine and enhance the app's design. Furthermore, a literature review was conducted to identify the most effective gamification elements for increasing motivation, with special consideration given to ensure a broad reach among students.

By evaluating the application in a real university setting, this work aims to measure the effectiveness of the application in increasing student motivation. Using validated questionnaires and the implementation of two evaluation phases, a systematic investigation will be conducted to capture changes in student motivation as a result of the application.

2.1. Development

During development, the main goal was to create an application that would allow instructors to create course-specific quizzes. Students can then take these quizzes to prepare for lab tests or exams.

Three key factors were identified contributing to an increase in learning motivation through the usage of the app. The first one, found during the requirement analysis, emphasises the need to provide students from participating universities and classes with easy and quick access to the content which they

Table 1. Correlation between HEXAD gamer types and gamification elements

HEXAD Gamer Type [9]	Gamification Element [10] [11] [12] [13] [14]	Impact Intrinsic Motivation [12] [13] [14]	Occurrence in University Setting [10] [11] [14]
Player	All	Significant	Less frequent
Socializer	Multiplayer, Leaderboard	Weak	Less frequent
Philanthropist	None	None	Most frequent
Free Spirit	Leaderboard, Quiz	Significant	Frequent
Achiever	Badges, Progressbar, Avatar	Moderate	Frequent
Disruptor	Leaderboard, Progressbar, Multiplayer	Moderate	Least frequent

need to refresh their knowledge for a specific course. This was achieved by implementing one-time password authorization, accepting only emails from selected universities. A dedicated authentication system not only ensures the access for individual users, but at the same time it can also be checked that no logins from universities not participating in the app take place. After logging in on a new device, a session is automatically saved for the user, so authentication does not require any special effort for further usage. To ensure simple and clear access to the quizzes, a search function was implemented, consisting of three categories. The top-level category represents a subject area, while the subcategories encompass individual study programs. The last category consists of quizzes related to course content or dedicated modules where a quiz contains a collection of dedicated questions. Professors are required to specify all three categories during the creation process, with the latter two being independently manageable by them. For particularly easy access to course-related content, lecturers can generate QR codes to enable swift access to specific quizzes for their students. The codes can be stored on a device as an image file and then integrated into the lesson content. To manually search for categories, subcategories or quizzes, users can also use a search by name. Filter and sorting functions are also provided, which, for example, only display content that has been added to the app by their own university.

The second factor is task value, which involves students being able to directly link the content to the associated class to maintain motivation. Therefore, an editor is available for instructors, enabling them to create quizzes aligned with their class content and gather statistics. These grant an overview of the students' knowledge and provide the opportunity to adapt the course material to the respective class

level. Individual questions can also be easily modified in the editor. File uploads for images that are displayed for the question or associated explanations are also possible. The application supports collaboration between several lecturers who create and edit questions for a quiz together.

The final factor is the incorporation of gamification elements. The app offers quizzes created by lecturers available in three different modes. The first mode, a practice encouraging mode, allows students to play a quiz and repeat questions that were answered incorrectly. In this mode all gamification elements are kept private and not visible to others, creating a safe space that allows room for errors. In addition, in this mode the user can freely choose a so-called "stage size". This indicates how many questions are played in one go before an interim overview of the answers given appears. After each "stage", questions answered incorrectly can be repeated. The second mode serves the purpose of allowing students to assess their knowledge and compare themselves with others. In this mode quizzes are played without the possibility of repetition and selecting a "stage size". Gamification elements achieved in this mode can be seen by other users, fostering healthy competition. While these modes are based on the individual performance of the student, a secondary focus is the competitive experience of a duel game mode. Past studies have shown that competitive mechanics in quiz-like games have a positive impact on student engagement and learning motivation [6]. Hence, the third mode allows students to participate in a quiz duel against each other.

Each quiz mode features three types of questions. Single-choice and multiple-choice questions can be used to present simple selection questions, as many conventional quiz-like applications already do. In addition, an assignment question type is established

in which individual text modules must be assigned to predefined categories using drag-and-drop. All types presented can optionally contain a picture which can be enlarged by interaction. If a question was answered incorrectly, students are provided with an explanation of the correct answer which may also contain an image. This approach bridges rote learning repeated quiz practice with understanding the core concepts of a subject. To enhance learning engagement and motivation, the app incorporates various other gamification elements, such as local leaderboards, badges, XP points and progress. Local leaderboards facilitate a direct comparison among fellow participants within a specific quiz context. These rankings can be filtered according to various gameplay modes, temporal intervals, and user cohorts, such as friends or affiliations with academic institutions. Accomplishments of distinct merit, such as accurate question responses, frequent quiz engagements, or ascent within the ranking hierarchy, may bestow badges upon players that are readily viewable within their profiles. Expanding upon the paradigm of experience points (XP), supplementary progress indicators have been integrated to encompass the act of quiz participation, offering insights into the advancement of holistic learning. These elements have been proven to be particularly motivating for learning apps [7]. The selection of gamification elements to be used was based on a literature review, which involved collecting a total of thirty papers related to gamification, motivation, and higher education. A particular focus of the literature review was on the utilisation of the HEXAD gamer types within the papers and their conducted evaluations. The HEXAD gamer types, also known as the Hexad user types, are a classification system that categorises players of video games into six distinct personality types based on their motivations and preferences for gameplay. This model was developed by Andrzej Marczewski and is often used in gamification and game design to better understand and cater to the diverse motivations of players. Each of the six gamer types is associated with specific traits, preferences, and motivations [8]. By considering this framework during research and the subsequent development of the gamification approach, the most effective gamification elements can be identified, and their effects can be estimated. For this purpose, the prevalent HEXAD gamer types within a university setting were determined, gamification elements that may influence these types were identified, and the potential impact on enhancing their motivation was evaluated [9] [10] [11] [12] [13]. For details on the correlation between gamification elements and their impact, refer to Table 1. The result of this analysis is that the three aforementioned gamification elements, leaderboard, badges, and XP, have been utilised in a manner that appeals to all gamer types except for the

Philanthropist. Special emphasis was placed on the Free Spirit, as this type can be significantly influenced by leaderboards and quiz modes and is also frequently encountered in university settings [7]. The Achiever gamertype also appears frequently, but its influence can only be moderate, while the Disruptor gamer type can be moderately influenced but is the least represented among students. The Player gamertype is also rare, but it can be significantly influenced by any type of gamification element. By considering these correlations, the three gamification elements that are likely to have the most substantial impact were identified, while their number was minimised, aiming to avoid overwhelming the users and diminishing their motivation.

In addition to the core aspects mentioned, the app supports several other elements that are intended to tailor its use perfectly to learning in higher education institutions. One example is the ability to provide a "room quiz" for the course. In this room, students play a given quiz in a closed group. This allows lecturers to analyse the statistics of an individual course specifically, for example to draw conclusions about the level of knowledge or to use a general means of repetition in the lecture. In addition to a label for identification, rooms also support a maximum number of rounds that a student is allowed to play. There is also an option to set a date after which the room can no longer be used automatically. Just like a normal quiz, the system can also be accessed via a QR code provided by the lecturer. It is also possible to add fellow students and other acquaintances as friends in the app. In this way, a student can not only compare themselves directly in certain rankings and access the statistics via their friends' profiles, but also play duels directly against each other. These are not included in the rankings, but rather emphasise shared learning. Also, ensuring a seamless app experience for students with visual impairments was of high priority. Designing with colour blindness in mind from the outset involved restricting the colour palette and incorporating icons or animations. Additionally, the fonts can be increased in size to accommodate users with a visual impairment.

In order to ensure the accessibility of all presented functions, the app provides a main menu with a tab layout at the bottom of the screen. There are four tabs visible to normal users: The home screen, which you reach after starting the app, shows all the quizzes that have not yet been completed alongside a greeting. The history shows an overview of all completed games, which are sorted by individual quiz for clarity. The search tab is based on the categorization system already explained and allows you to specifically find categories, subcategories and individual quizzes. The individual profile can be seen in the last tab that is displayed for

all users. Individual details such as username or avatar can be changed here. At the same time, various analytics and individual badges can be viewed under the user profile. Finally, your own profile includes the view for friends as well as a separate menu to change the app settings. Accounts that have been activated as lecturers in the app also have access to an extra editor tab that allows you to create and manage quizzes and associated quiz rooms. There is a higher-level account type with administration rights. This also sees a sixth tab in which users can be activated as lecturers in the app using their associated login email address. This ensures that individual universities can autonomously manage permissions for teachers who want to use the app. The view of the main menu while an administrator user has opened the home screen is shown in Figure 1.
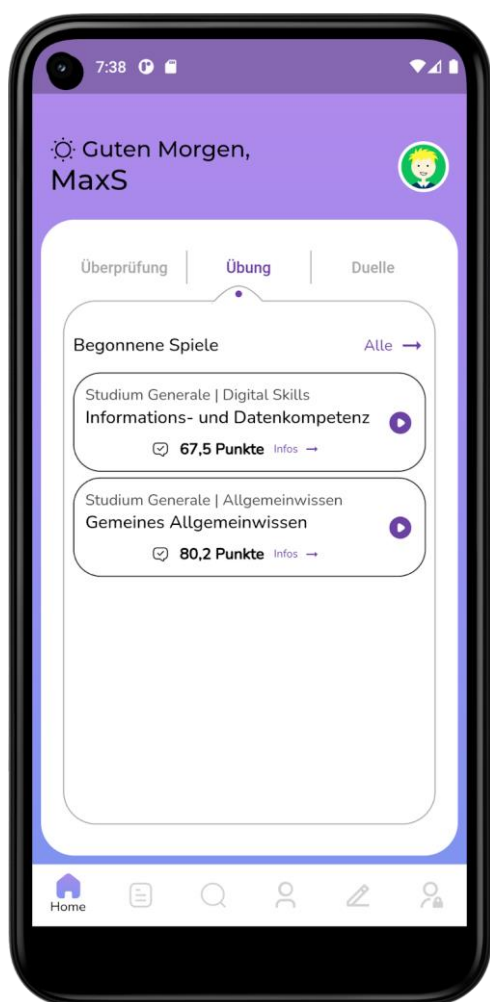

Figure 1. Home screen display in the application

2.2. Evaluation

An evaluation strategy was devised with the aim of measuring the enhancement of motivation of the students who use the app alongside their regular teaching. This included the development of a questionnaire, assessing the current level of motivation consisting of two components. The first component is based on the MSLQ-SF questionnaire, a validated and condensed version of the Motivated Strategies for Learning questionnaire (MSLQ) [15]. The latter was developed to evaluate the motivation, learning behaviours, and learning strategies of college students and consists of eighty-one questions [16]. Only motivation-related questions from the MSLQ-SF were taken into account.

In the second component, the shortened and validated version of the Instructional Materials Motivation Survey (IMMS) was employed to evaluate the motivation generated from the usage of instructional materials and technologies using a total of twelve questions [17]. The original IMMS assesses participants' confidence, attention, satisfaction, and relevance.

To determine and measure a change in motivation levels, the developed questionnaire must be administered to the students on two separate occasions. The questions on motivation were asked using a 6-point Likert scale, where one represented the worst score and six indicated the best score. This approach allowed for well-differentiated results, minimising the tendency for respondents to choose neutral or middle-range options. In addition to the thirty questions on motivation, the questionnaire included questions on age, gender, and personal identification.

The initial evaluation was conducted in an engineering course without the students' knowledge of the developed app. The evaluation was focused on the existing learning platforms and conditions. The timing of the evaluation was relatively early in the semester to determine if the app was having the desired effect of maintaining or increasing student motivation instead of decreasing it.

The second evaluation was conducted at the end of the semester, one and a half months after the initial survey. However, this time there was a one-week interval before filling out the questionnaire, during which the students were asked to explore the app and play quizzes in all modes.

3. Results

A total of nine students successfully completed the evaluation. Of these, eight were male, one was female, and all were aged between 18 and 24. It was found that the current commonly used learning materials resulted in only a moderate to good level of motivation among the participating students.

The results of the second evaluation show that motivation has increased in relevant areas through the use of the developed application. Specifically, the intrinsic and extrinsic goal orientation increased after

the app's usage by 16% and 23% according to the MSLQ-SF questions (see Figure 2). These findings are particularly positive, as previous studies have shown that gamification elements can directly influence these areas of motivation [18] [19] [20].
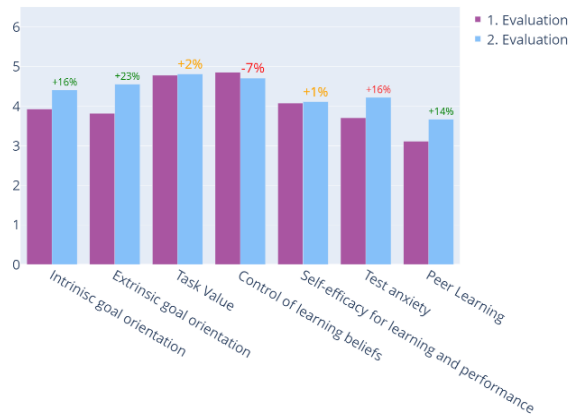

Figure 2. Average rating of the MSLQ questions

Furthermore, the app demonstrated a favourable outcome with a 5% increase in the attention and satisfaction components of the RIMMS (see Figure 3). This indicated that the app retained the students' attention better than previously used materials and learning platforms and that the students were also more satisfied with the app. However, there was a decrease in the relevance component of the RIMMS and a comparatively low increase in the task value component of the MSLQ-SF. This might be because the content provided via the app was derived from a previous semester, possibly affecting its relevance to the students. The decrease in the control of learning beliefs and the increase in the test anxiety component of the MSLQ-SF as well as the decrease in the RIMMS component Confidence are likely due to the fact that the second evaluation was conducted one week before the exam period.
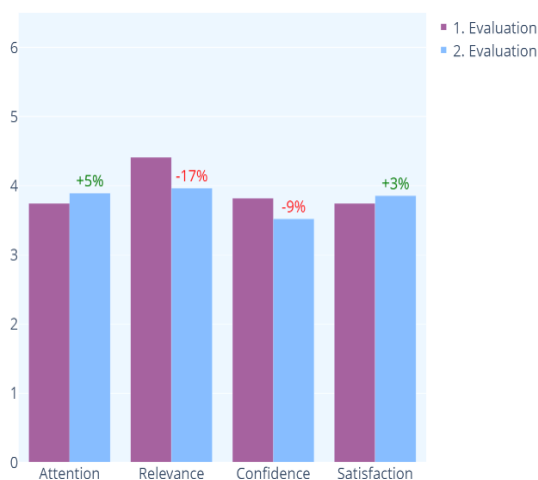

Figure 3. Average rating of the RIMMS questions

4. Discussion

Given the limited number of participants, general conclusions can only be approached with caution. It must also be noted that the time period in which student subjects were able to familiarise themselves with the app was relatively short at one week. The decrease in confidence in particular could be due to the fact that the participants did not have enough time to conscientiously delve into the contents of the app and thus maintain the feeling of having deepened the understanding of the theoretical learning material more securely. It would therefore be worthwhile to test the app in a more extensive scenario and thus be able to make statements about the effects of the app during long-term use. Nonetheless, the findings offer a valuable basis for designing motivational learning environments in online learning contexts.

The survey focused on one specific case of online learning activities, potentially overlooking connections to other online activities that may be linked to the learning preferences and interests of students. However, deliberately limiting the scope of activities allowed for a clear and straightforward design, providing ample opportunities for careful analysis.

5. Conclusion

A prototype version of an app was developed and prepared for public release at universities in Saxony. The app is compatible with the mobile operating systems Android and iOS and can also be accessed via web browser. The evaluation of the developed app demonstrated a significant and positive increase in motivation among engineering students in crucial aspects. This evaluation was conducted on a specific group of individuals and revealed positive trends and tendencies. Nevertheless, to encompass a broader spectrum of students, conducting a continuous evaluation or expanding the study to include a larger and more diverse group of participants would be beneficial. In such cases, it is essential to ensure that, unlike in this evaluation, there is a roughly equal ratio of women and men, and ideally, non-binary individuals are also represented.

Future plans involve expanding the utilisation of the app to over ten universities in Germany. Several lecturers and professors have already expressed an interest in incorporating the app in their teaching. This provides opportunities for more extensive evaluations in the future.

6. References

[1] Liu, O. L., Bridgeman., B., and Adler, R. M. (2012) 'Measuring learning outcomes in higher education: Motivation matters.', Educational Researcher 41.9, pp. 352-362.

[2] Kember, D., Ho, A., and Hong, C. (2010) 'Characterising a teaching and learning environment capable of motivating student learning.', Learning Environments Research 13, pp. 43-57.

[3] Subhash, S., and Cudney, E. A. (2018) 'Gamified learning in higher education: A systematic review of the literature.', Computers in human behavior 87, pp. 192-206.

[4] Bartel, A., and Hagel, G. (2014) 'Engaging students with a mobile game-based learning system in university education.', 2014 IEEE Global Engineering Education Conference (EDUCON).

[5] Pechenkina, E., Laurence, D., Oates, G., Eldridge, D., and Hunter, D. (2017) 'Using a gamified mobile app to increase student engagement, retention and academic achievement.', International Journal of Educational Technology in Higher Education 14, pp. 1-12.

[6] Razali, N., Nasir, N. A., Ismail, M. E., Sari, N. M., and Salleh K. M. (2020) 'Gamification elements in Quizizz applications: Evaluating the impact on intrinsic and extrinsic student's motivation.', IOP Conference Series: Materials Science and Engineering. Vol. 917. No. 1. IOP Publishing.

[7] Aleksic-Maslac, K., Sinkovic, B., and Vranesic, P. (2017) 'Influence of gamification on student engagement in education.', International Journal of Education and Learning Systems 2, p. 012024.

[8] Marczewski, A. (2018) 'Hexad: A player type framework for gamification design.', Dohvaćeno iz Gamified UK; https://www. gamified. uk/user-types (Access Date: 10 June 2023).

[9] Marczewski, A. (2015) 'Even ninja monkeys like to play: Gamification, game thinking & motivational design.'; https://www.gamified.uk/even-ninja-monkeys-like-to-play (Access Date: 12 July 2023).

[10] Fischer, H., Heinz, M. and Breitenstein, M. (2018) 'Gamification of Learning Management Systems and User Types in Higher Education.', 12th European Conference on Game-Based Learning. Academic Conferences and publishing limited, p. 91.

[11] Bovermann, K., Bastiaens, T. (2020) 'Towards a motivational design? Connecting gamification user types and online learning activities.', RPTEL 15, 1. DOI: 10.1186/s41039-019-0121-4 (14 July 2023).

[12] Tondello, G. F., Mora, A., Marczewski A., Nacke, L. E. (2019) 'Empirical validation of the Gamification User Types Hexad scale in English and Spanish', International Journal of Human-Computer Studies, Volume 127, pp. 95-111. DOI: 10.1016/j.ijhcs.2018.10.002 (12 July 2023).

[13] Tondello, G. F., Wehbe, R. R., Diamond, L., Busch, M., Marczewski, A., and Nacke, L. E. (2016) 'The Gamification User Types Hexad Scale.', Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '16). Association for Computing Machinery, New York, NY, USA, 229–243. DOI: 10.1145/2967934.2968082 (12 July 2023).

[14] Şenocak, D., Büyük, K., and Bozkurt, A. (2019) 'Distribution of HEXAD gamification user types and their association with intrinsic motivation in open and distance learning systems.', ICERI2019 Proceedings, IATED, pp. 1011-1017.

[15] Wang, F., Jiang, C., King, R. B., and Leung. S. O. (2022) 'Motivated Strategies for Learning Questionnaire (MSLQ): Adaptation, validation, and development of a short form in the Chinese context for mathematics.', Psychology in the Schools, 2022.

[16] Pintrich, P. R., and De Groot, E. V. (1990) 'Motivated Strategies for Learning Questionnaire (MSLQ)', Database record, APA PsycTests.

[17] Becerra, B. L. G., and Almendra, M. P. R. (2020) 'Measuring student motivation in a statistics course supported by podcast using Reduced Instructional Materials Motivation Survey (RIMMS).', 2020 X International Conference on Virtual Campus (JICV), Tetouan, Morocco, 2020, pp. 1-4.

[18] Buckley, P., and Doyle, E. (2016) 'Gamification and student motivation.', Interactive learning environments 24.6 (2016), pp. 1162-1175.

[19] Razali, N., Nasir, N. A., Ismail, M. E., Sari, N. M., and Salleh, K. M. (2020) 'Gamification elements in Quizizz applications: Evaluating the impact on intrinsic and extrinsic student's motivation.', IOP Conference Series: Materials Science and Engineering. Vol. 917. No. 1. IOP Publishing, 2020.

[20] Sandusky, S. (2015) 'Gamification in Education', The University of Arizona; http://hdl.handle.net/10150/556222 (Access Date: 13 June 2023).