The use of Gamification in Smart Sport Training

Alen Rajšp, Marjan Heričko, Iztok Fister Jr.
Faculty of Electrical Engineering and Computer Science, University of Maribor
Institute of Informatics
Koroška cesta 46, 2000 Maribor, Slovenia
{alen.rajsp, marjan.hericko, iztok.fister1}@um.si

***Abstract**. The objective of this paper is to present the use of Gamification in Smart Sports Training. Gamification is related to the use of game elements in non-game contexts. While Smart Sports Training incorporates the use of wearables, sensors, and Internet of Things devices and or intelligent data analysis methods to improve training performance. Until recently, Gamification was rarely applied to Smart Sports Training.*
In this paper, we designed and proposed a gamified solution for a mobile application that represents a virtual sports trainer.
The architecture of this application is systematically outlined and supported by practical use. Positive aspects of Gamification in Smart Sports Training are depicted.

Keywords. Smart Sports Training, Gamification, mobile application, Android

1 Introduction

People generally want to live good and long lives. This largely depends on a person's physical and mental health. While they do not guarantee happiness, lack of them certainly negatively affects a person's quality of life.

One of the main ways to improve an individual's health is through physical activities and exercises. The World Health Organization recommends at least 150 minutes of moderate-intensity or at least 75 minutes of vigorous-intensity physical activity per week, due to the health benefits such activities provide (World Health Organization, 2018).

Besides the obvious benefits of regular exercise such as increased stamina and strength, numerous others exist. Some of them are reducing the risk of coronary disease, obesity, strokes, risk of some types of cancer, prevention of progressive incapacity and improvement in memory, self-esteem, calmness, mood, and psychomotor functions (Fentem, 1994).

Despite numerous benefits of physical activity, over 25% of the world population is not exercising enough (Bosley, 2018), and 39% of the world population is overweight or obese (Ritchie, 2017). Among the five possible reasons for not exercising irrelevance, unnecessary, negative feelings, too risky, and that it requires too much effort, the latter was found to be the most common (Auweele, Rzewnicki, & Mele, 1997). Lack of effort related to the inadequate motivation of an individual to perform physical exercises (Buckworth & Dishman, 2012).

On the contrary, one activity has no problem prospering and motivating users in the real world. There are more than 2.5 billion people playing video games in the world, and gaming revenue reached 152 billion $ in 2019 (Wijman, 2019). Smartphone usage has also been increasing and is projected to reach 3.5 billion people worldwide in 2020. Video games surely have no problem with the engagement and motivation of their users. They are meant to be played, so why isn't exercising meant to be *played* too? If a highly engaging system exists in video games that make the user engaged and want to play them even more, can the same be done for those who find physical exercise mundane and not engaging? A problem of motivation could be solved by Gamification, which can provide the needed encouragement for exercise (Suh, Wagner, & Liu, 2015).

Capitalizing on these worldwide trends, we propose a smart sports training solution, implemented as a smartphone mobile application. A lot of similar applications indeed already exist and are used by a large number of people. One of the most popular ones Google Fit (Google, n.d.-c), awards you cardio points for performing and recording different activities. It, however, lacks in the planning phase of training and lacks training plans and Evaluation of your results versus the community. MyFitnessPal (MyFitnessPal, n.d.) is another of the more popular apps. It features training plans, nutrition planning, but lacks in the realization phase of training; it does not allow recording the exercises with the device but merely entering them.

Analyzing 32 health and fitness applications identified in (Cotton & Patel, 2019), no application that was identified supported the training in all of its four phases (Planning, Realization, Control, and Evaluation) was found. Completeness of the support for the whole training cycle is an important thing when using an application. It allows an individual to stay within the same ecosystem, which is both convenient and may allow a better quality of training if fully utilized.

Another unforeseeable thing is that in the current 2020 world, it is sometimes better to do something alone. SARS-CoV-2 worldwide pandemic has changed people's lives. Whole communities have been put on lockdowns, and people have been asked to socially distance and reduce close contacts with one another (Lipton & Steinhauer, 2020). This is another great advocate for the establishment of a virtual training application, providing the health/fitness benefits without the need for additional health risks that arise when social distancing is not practiced.

The contributions of this paper are:

- Establishing the need for virtual trainers and presenting the worldwide trends that have created a positive environment for adoption and popularization of such tools.
- A proposal and presentation of how individual game elements could be used in each of the sports training phases.
- Linking Gamification and Smart Sports Training by proposing a Virtual Training Application that supports the user in executing all four training phases

The paper is structured as follows. Section 2 outlines and briefly presents the topics of Smart sports training and Gamification. Section 3 presents the proposal for our gamified smart sports training (running and cycling) mobile application what the application must support in each of the phases of sports training, namely planning, realization, control, evaluation. In Section 4, conclusions are drawn, the benefits and drawbacks of using a proposed training application are presented, the section is continued with, a proposal for future research, where experimental validation of the approach is recommended, and the processing of the data collected by the application with artificial intelligence algorithms.

2 Background

Physical activity and sports are two terms that can, in a broader sense, be used interchangeably. However, sport can also be defined as a formalized, competitive, and physical type of play (Fister, Fister, & Fister, 2019a). Sports training is a process with continuous interaction by an athlete and his/her trainer.

(Fister, Fister, & Fister, 2019b) proposes that sports training is composed of four interconnected tasks/phases, as is shown in **Figure 1**.

The Planning phase refers to the activity in which the trainer prepares the future training plan for the athlete. One training is composed of multiple exercise units.

The Planning phase is connected to the **Realization** phase in which the planned exercises are executed, and the trainer must prepare the necessary equipment, conduct a psychophysical evaluation of the athlete, and monitor and advise the athlete during the training session. The training data that can later be used for analysis is recorded during the training execution. Realization is followed by the **Control** phase, where the execution and performance of the exercises done are compared to the training plan. The **Evaluation** phase refers to the measurement of the athlete's performance. For professional athletes, this refers to the competition performance. The evaluation phase is interconnected with the initial planning phase because the results from the evaluation phase influence future training plans and goals of an athlete.

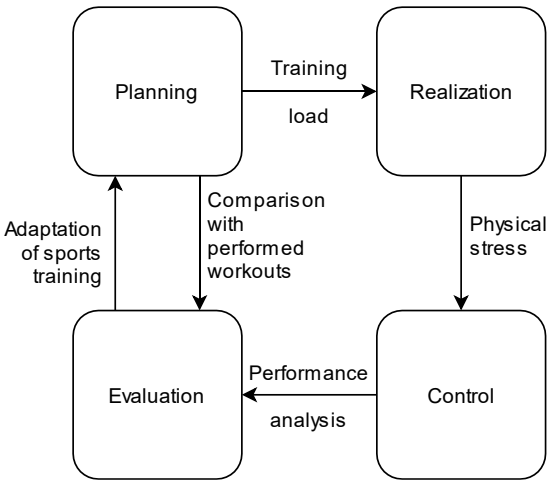

Figure 1 Phases of Sports Training

2.1 Smart sports training

The advances in information technology have bought upon severe changes in the way we do things. On every step of our lives, there have been optimization attempts. We are still far away from general-purpose artificial intelligence, but the fact remains that well defined specialized tasks can be delegated to the machines, and in some iterations, the machines and systems we designed will reach and overtake the ability that was previously only reserved for humans. The technology has also changed the way we train sports and information systems connected with wearable devices have started the evolution in sports as well.

In (Rajšp & Fister, 2020), we proposed the following definition of Smart Sports Training (SST). This is a type of sports training, which utilizes the use of wearables, sensors, and Internet of Things (IoT) devices and or intelligent data analysis methods and tools to improve training performance or reduce workload while maintaining the same or better training performance.

The SST approach is used in various studies, a systematic literature review (SLR) (Rajšp & Fister, 2020) done in 2020 found 109 different studies that implemented the SST methods for training sports. The approach has been used in 32 different sports, both in a team (basketball, soccer, volleyball, etc.) and solo (running, golf, swimming, weight lifting, yoga, etc.) sports.

The implementations of SST do not have to support all the four training phases and may only be used for some specific parts of the training, which is what the majority of SST implementations do. As is shown in **Table 1** found that the majority of SST research is concerned with the Realization phase of SST. Only a few implementations, 39 out of 109, are concerned with the Planning phase of training where the system would aid the user and give him some guidance on how to proceed. The planning phase can be supported by the use of advanced computational intelligence, which adapts to each user or simply by providing generalized exercise plans.

Table 1 Phases of sports training investigated in research identified in (Rajšp & Fister, 2020)

Plann.	Real.	Cont.	Eval.	Σ
39	76	64	45	109

A solution that would support all four training phases of the training could replace the human trainer altogether. To ensure that the application could fully replace the human trainer, it would need to not only aid the user with technical measurements and training plans but also provide a way to engage and motivate the user. This is a key role of a real trainer. We believe such a thing can be done by introducing Gamification to Smart Sports Training.

2.2 Gamification

Due to the popularity of modern computer games, various approaches have been tried to take the popularity of the games and use them in non-gaming applications. A great example of how games can influence behavior is the phenomenon of Pokemon Go, (Althoff, White, & Horvitz, 2016) found, by comparing the step counter values of people over a period of three months, that players playing the game increased their walking activity by an average of 25 % compared to their previous number of steps per day.

The term gamification refers to the use of game design elements in non-game contexts (Deterding, Dixon, Khaled, & Nacke, 2011).

According (Amir & Ralph, 2014) to the Theory of Gamification Effectiveness (TGE), the effectiveness of a gamified system is the extent to which the system is used and contributes to any explicit goals of the system and contributes to the goals of its users. The effectiveness is exhibited in three dimensions of Formative constructs and is influenced by Antecedents, which are factors that cause effectiveness, as shown in Figure 2.

Use relates to the consumption of the system output, which translates to the user participation of the gamified system. Purpose measures if the Gamification contributes to the purpose for which the system was originally designed. The user alignment is the connection between how the goals of the user are aligned with the gamified system.

The factors which influence the system effectiveness are Intrinsic motivation dynamics: feelings of relatedness, autonomy, and competence when using the system. Giving the user abilities to choose his/her own tasks, that are of the adequate difficulty; Extrinsic motivation: points, levels, badges, trophies awarded for completing tasks in the gamified system; Game Mechanics: space, objects (tools), actions and rules that are determined and defined in the system and; Immersive dynamics: providing the narrative and the world that user participates in.

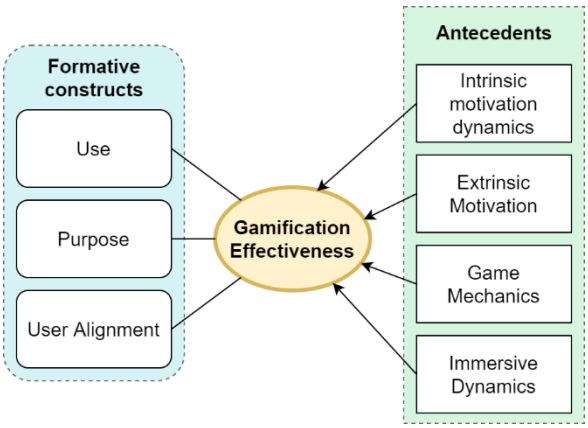

Figure 2 Gamification Effectiveness Theory

In a systematic literature review (Hamari, Koivisto, & Sarsa, 2014) of 25 empirical studies investigating the effects of Gamification in different environments found that its effects were generally positive. The researchers mostly determined that introduction of Gamification to their environments was the right choice to make. The fields where Gamification has been widely used include education, marketing, and social media.

In education, Gamification has been used to increase the students' motivation and engagement (Dicheva, Dichev, Agre, & Angelova, n.d.). In different implementations, personalized avatars, points, ranking systems, levels, virtual goods, and currency have all been implemented. Plugins are readily available to be used on different learning management systems (e.g., on Moodle, A+, Blackboard, etc.).

Marketing has applied point systems in their loyalty programs, giving customers who spend the most cash some additional benefits. In contrast to education, the measured metric in marketing was not the user motivation and engagement but mostly the sales figures resulting from the implementation of such systems (Huotari & Hamari, 2012).

Social media has also leveraged the gamification elements on their platforms (Williams, 2019). To ensure that users fill out their social media profile, they are given rewards in forms of badges or progress bars on how complete their profile is. Badges are also used for completing tasks on social media (e.g., add first ten

friends, send a private message, etc.) all to boost the interaction between users. Web forums and boards use various reputation systems, where users gain or lose points based on the quality of their content (e.g., karma system on Reddit, likes on Facebook, likes on Instagram, etc.).

(Werbach & Hunter, 2012) divided the most used game elements in Gamification into a pyramid of game elements. There the gamification elements are divided on the highest level in Dynamics, Mechanics, and on the lowest level in Components.

The Dynamics are the elements on the highest abstraction level that are not directly entered into the game but are implemented through the use of Game Mechanics and Components. These are constraints, emotions, narrative, progression, and relationships. The Mechanics are the most basic processes that drive the engagement of users in the system. This includes challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns, and win states. To implement the mechanics game components are used; these are the actual functionalities implemented in the system. These are achievements, avatars, badges, boos fights, collections, combat, content unlocking, gifting, leaderboards, levels, points, quests, social graphs, teams, and virtual goods.

Measurable evidence exists on how properly implemented Gamification techniques improve user engagement (Koivisto & Hamari, 2014). But as is always noted and should not be overlooked, the Gamification must aid the users but remain optional. All the functionalities must still be available even if the user does not wish to participate in the gamified part of the solution. A key concept is that playing must be optional, if something is not optional but is mandatory, then it is by definition, not a game (Callois, 2001).

Gamification elements can certainly motivate the user on a short term basis, but he/she may get bored over time. A lot of gamification systems lack the transition to the real-world context. Creating such a context can ensure that the user will keep engaging with and using the system, which is, in a way, always the goal of Gamification (Nicholson, 2015).

3 The architecture of Fitness World - a mobile solution for sport training

The development of a mobile application/solution consisted of the following steps:

- Defining the goals of our application, what needs will our application fulfill and how each of the training phases will be supported
- Selection of gamification elements to be used in each phase of the training
- Android app development on a hybrid platform (for the later possibility of porting the application to iOS ecosystem)
- Testing the application in a controlled environment (currently underway)

All the processes are outlined below in the next subsections. For our proposal to implement a Smart Sports Training solution, we developed a mobile application named **Fitness World**. It was developed using Flutter (Google, n.d.-b) framework. It is a Dart (Google, n.d.-a) language-based framework for developing native apps in both of the mobile phone ecosystems (iOS and Android OS). The backend of the application is based on the Express (Node.JS based) framework ('Express - Node.js web application framework', n.d.).

For the prototype, only the running and cycling sport were supported since they are most easily recorded using mobile phones and using smartwatches, and the application was being tested only on the Android platform.

The application in development aims to replace the human trainer for the non-professional sports enthusiast. This is achieved by providing the athletes with training suggestions, measurements of their sporting activities, and giving the users ability to compete with other users and their peers. While the benefits of human trainers certainly exist, we may not always have access to one.

Gamification was used to increase user engagement and motivation, and game elements (underlined in the following paragraphs) shown in Figure 3 were used.

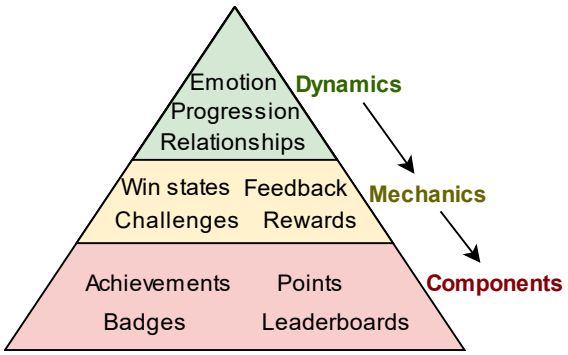

Figure 3 Game elements according to the pyramid of game elements used in the **Fitness World** app

On the most elementary level, the game elements of the game can be reduced to the model shown in Figure 4. The user must first select a training plan to follow, which serves as a challenge that once completed award achievements in the form of badges. The training plans can be sorted by duration, activity types (cycling, running, both) and goal (e.g., preparing for 5000-meter run, half-marathon, marathon, etc.). Training plan progression is done through the completion of activities, those activities also award (activity) points which rank the user on a friend list and global

leaderboards, allowing the user to compare his/her progress and activeness against other users.

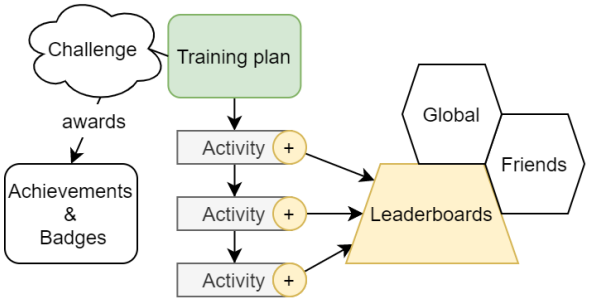

Figure 4 Core game elements in the Fitness World app

Currently, the Fitness World application was tested by the developers and their relatives as a proof of concept, but rigorous user testing will be conducted in the coming months.

3.1 Planning

The first stage of sports training is **planning**. In the first stage, we must determine what the goal of the user is and how soon does he/she need to achieve this. In our case, this may be to train to improve some results or prepare for a specific event. The planning phase is not only concerned with the prepared exercises but can also be related to nutrition planning, which was not addressed in our application. Training plans can be general or adapted to the specific user needs and their abilities. In the application, he/she can choose a specific predetermined training plan based on the competition he/she wants to participate in (e.g., 5k run, half marathon, etc.). Each plan has three difficulty levels based on his/her starting ability, namely beginner, normal, and advanced. This serves as an intrinsic motivation dynamic in the TGE model, giving the user autonomy and allowing him to advance in training with his/her own pace. he/she then receives a daily task that is made of individual exercise sessions that he/she needs to do. From the perspective of game elements, these tasks and the plan serve as challenges (gamification mechanic). The tasks were selected to be of a daily periodicity as they were found (Lally & Gardner, 2013) to be the most suited for encouraging exercise habit formation in users. This happens in 18-254 days.

3.2 Realization

In the **realization** phase, the exercise activities are recorded. The user is provided with a two tabbed screen (Figure 5). On the first screen, he/she can see his/her current sessions stats (activity type, distance, time is taken, current and average speed), and he/she also has the ability to start, pause and finish the activity. The second screen provides him with a map display, where he's currently completed training route is visualized and his/her current speed, time is taken, and distance is displayed.

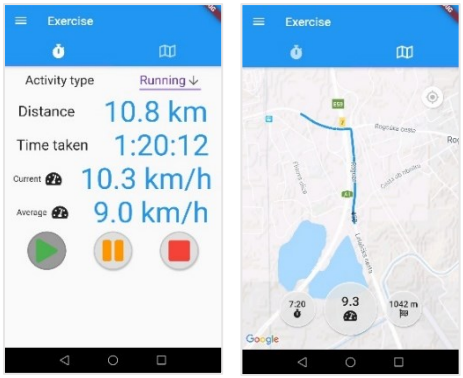

Figure 5 The exercise activity two tabbed screen

In the realization phase, the activities are merely recorded, and the user may complete any of the given daily tasks, the conditions for their completion are evaluated after the end of the exercise session. The map display and the constantly updating screen is created to serve as an link between the real world and the fitness application and functions as an immersive dynamic in the Fitness World.

3.3 Control

In the **control** phase, the user can verify if he/she is completing the determined exercises and accurately following the training plan. Successful completion of the selected training plans awards the users with achievements that are displayed as badges on the achievements screen, as shown in Figure 6. Badges are a simple gamification mechanic that can positively promote user activity and interaction with the system even over longer periods of time (Hamari, 2017).

Achievements and leaderboards also provide the user with the necessary feedback, so he/she can see that his/her actions influence his/her performance within the system.

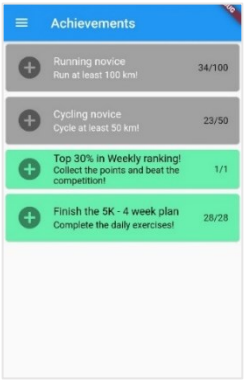

Figure 6 The users' Achievements screen

Every completed activity is also transformed into points that the user collects. The number of points an activity is worth is determined from the duration and

effort the activity required. This means that the points between different users and activity types can, in some way, remain comparable. A great advantage of games over normal sports is that in games, your progress can almost always be quantified while in sports in each training session, the abilities of the person only improve marginally, and the athlete may not notice his/her performance improving. Awarding points gives each exercise a sense of progression and value even if his/her performance is not noticeable yet in his/her real-world observations. Points have been found to positively impact user engagement in multiple studies (Gibbons, 2013), (Iosup, J Epema, & Epema, 2014) in fact (Mekler, Brühlmann, Tuch, & Opwis, 2015) found that merely adding Points and Leaderboard game elements to a higher education course increased user engagement and a ratio of completed exercises. The elements of points, achievements – badges, and leaderboards were implemented as extrinsic motivators in the TGE.

3.4 Evaluation

The points collected serve as a basis for the **Evaluation** of the users' performance on a leaderboard. Two types of leaderboards are provided global, and friend leaderboards, where he/she is competing against his/her added contacts who also use the application, facilitating the use of the relationships Gamification dynamic. He/she can see his place among his friends, as seen in Figure 7 Friends leaderboard display, and can even win by finishing the period first. The leaderboards are generated for both activities combined (the points from running and cycling are summed up) and separately. They are available for a weekly, monthly, and yearly basis. His/her progression in comparison with the previous period is shown (e.g., +20 points compared to last week) next to his/her current score.

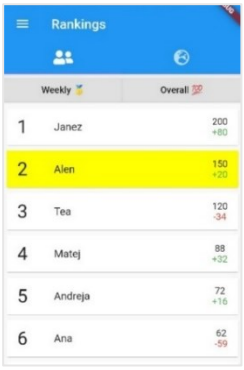

Figure 7 Friends leaderboard display

The user who reduces or ceases his/her exercise activity may quickly fall of first the weekly, then monthly, and at the end yearly Leaderboard. This is done in context with the human body, which also needs constant physical activity to maintain or improve its current fitness level and strength. (McMaster, Gill, Cronin, & McGuigan, 2013) found that the strength levels start rapidly dropping in average after three weeks of ceasing previous regular exercise routine. This shows that the fitness state of an individual will quickly regress if the user adopts a less active lifestyle, and we must be reminded that progress is not permanent.

Because leaderboards may become demotivating as shown in (Souza, Constantino, Veado, & Figueiredo, 2017), the comparison with the global players is made on pie charts. There the user is simply informed what percentage of the users he/she is leading and trailing in his/her activity points for the given sport and period, as shown in Figure 8. It is also much more informative to tell the user that he/she is rated higher than 47 % of individuals than to tell him that he/she is on the place 12451th out of 23410 users.

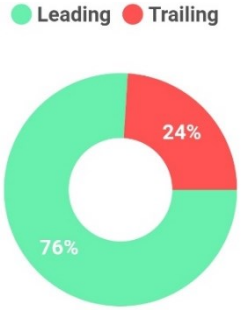

Figure 8 Pie charts displayed on the global leaderboards

The proposed training cycle will allow the user to stay engaged and keep using the application for most of his training routine. The rules on which the users receive points and their ranking in the system, which demands on his/her continuous participation, serve as the game mechanics which the user follows to maximize both his in-app and real-world performance.

4 Conclusion

The field of Smart Sports Training is developing rapidly, and virtual trainers have the ability to enhance or replace human trainers in the future. This is particularly true for the individuals whose goals for exercise are of the non-professional athlete sports training nature. A common problem, as mentioned, is that over a quarter of the world population does not exercise enough. The main reason for their sedentary lifestyles is their lack of effort, which signifies deeper motivational issues.

Gamification as a tool is just the right tool to introduce into the field as its` main effects are increasing user motivation and engagement. We believe this is a vital component that has not yet been properly utilized in the field of Smart Sports Training.

The proposed approach was a demonstration of a Smart Sports Training system based on best practices of Gamification and the Theory of Gamification Effectiveness. The Fitness World application creates an immersive exercise world, which is implemented easily since exercise actions in the real world environment can be readily mapped to actions in the gamified system by the use of smartphones.

We believe it is also important that the only additional equipment the user needs is just a smartphone, which allows for the solution to be used by the widest range of users possible. The current application is developed in a way that can possibly be ported on other systems (e.g., iOS) and can be used by any modern mobile phone. The gamification techniques proposed during each of the four training phases will hopefully motivate the user to exercise more regularly and make exercising a daily routine.

The limitations of the current approach include training plans that will only be limited to training exercises but not nutrition, which is an equally important part of the training routine. No standardized ways on how to rank points in the users of different ages and genders have currently been determined. This is an issue that needs to be addressed so that the ranking (point awarding) system will be fair and allow competitiveness between all the persons exercising according to also their effort and not only fitness abilities.

In the future, the application in development will be tested by real users, and usability analysis will be performed so that the approach proposed approach can be used by the general population. Another possible direction of the research is data analysis of the collected exercise data to develop a system that can generate and propose personalized training plans suited for each individual's abilities and needs.

References

Althoff, T., White, R. W., & Horvitz, E. (2016). Influence of Pokémon Go on Physical Activity: Study and Implications. *J Med Internet Res*, *18*(12), e315. https://doi.org/10.2196/jmir.6759

Amir, B., & Ralph, P. (2014). Proposing a theory of gamification effectiveness. In *Companion Proceedings of the 36th International Conference on Software Engineering* (pp. 626–627).

Auweele, Y., Rzewnicki, R., & Mele, V. (1997). Reasons for not exercising and exercise intentions: A study of middle-aged sedentary adults. *Journal of Sports Sciences*, *15*(2), 151–165. https://doi.org/10.1080/026404197367425

Bosley, S. (2018, September 4). Quarter of world's population 'not active enough to stay healthy' | Society | The Guardian. Retrieved 30 June 2020, from https://www.theguardian.com/society/2018/sep/04/quarter-of-worlds-population-not-active-enough-to-stay-healthy

Buckworth, J., & Dishman, R. K. (2012). Exercise Adherence. In *Handbook of Sport Psychology* (pp. 509–536). Hoboken, NJ, USA: John Wiley & Sons, Inc. https://doi.org/10.1002/9781118270011.ch23

Callois, R. (2001). Man, Play and Games, trans. Meyer Barash. *Urbana: University of Illinois Press*, 58.

Cotton, V., & Patel, M. S. (2019). Gamification Use and Design in Popular Health and Fitness Mobile Applications. *American Journal of Health Promotion*, *33*(3), 448–451. https://doi.org/10.1177/0890117118790394

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining 'gamification'. In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011* (pp. 9–15). https://doi.org/10.1145/2181037.2181040

Dicheva, D., Dichev, C., Agre, G., & Angelova, G. (n.d.). *Gamification in Education: A Systematic Mapping Study*. *Systematic Mapping Study. Educational Technology & Society* (Vol. 18).

Express - Node.js web application framework. (n.d.). Retrieved 12 July 2020, from https://expressjs.com/

Fentem, P. H. (1994). ABC of Sports Medicine: Benefits of exercise in health and disease. *BMJ*, *308*(6939), 1291–1295. https://doi.org/10.1136/bmj.308.6939.1291

Fister, I., Fister, I., & Fister, D. (2019a). *Computational Intelligence in Sports*. *Adaptation, Learning, and Optimization*. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-03490-0

Fister, I., Fister, I., & Fister, D. (2019b). Theory of Sports Training. In *Computational Intelligence in Sports* (pp. 103–119). Springer Verlag. https://doi.org/10.1007/978-3-030-03490-0_1

Gibbons, T. E. (2013). COR: A new course framework based on elements of game design. In *SIGITE 2013 - Proceedings of the 2013 ACM SIGITE Annual Conference on Information Technology Education* (pp. 77–82). New York, New York, USA: ACM Press. https://doi.org/10.1145/2512276.2512292

Google. (n.d.-a). Dart programming language | Dart. Retrieved 5 July 2020, from https://dart.dev/

Google. (n.d.-b). Flutter - Beautiful native apps in record time. Retrieved 5 July 2020, from

https://flutter.dev/

Google. (n.d.-c). Google Fit: Health and Activity Tracking - Apps on Google Play. Retrieved 14 July 2020, from https://play.google.com/store/apps/details?id=com.google.android.apps.fitness

Hamari, J. (2017). Do badges increase user activity? A field experiment on the effects of Gamification. *Computers in Human Behavior*, *71*, 469–478.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does Gamification work? - A literature review of empirical studies on Gamification. In *Proceedings of the Annual Hawaii International Conference on System Sciences* (pp. 3025–3034). IEEE Computer Society. https://doi.org/10.1109/HICSS.2014.377

Huotari, K., & Hamari, J. (2012). *Defining Gamification-A Service Marketing Perspective*.

Iosup, A., J Epema, D. H., & Epema, D. (2014). An experience report on using Gamification in technical higher education CACTUS View project Massivizing Computer Systems View project An Experience Report on Using Gamification in Technical Higher Education. https://doi.org/10.1145/2538862.2538899

Koivisto, J., & Hamari, J. (2014). Demographic differences in perceived benefits from Gamification. https://doi.org/10.1016/j.chb.2014.03.007

Lally, P., & Gardner, B. (2013, May). Promoting habit formation. *Health Psychology Review*. https://doi.org/10.1080/17437199.2011.603640

Lipton, E., & Steinhauer, J. (2020, April 22). Social Distancing for Coronavirus Has a History. Retrieved 12 July 2020, from https://www.nytimes.com/2020/04/22/us/politics/social-distancing-coronavirus.html

McMaster, D. T., Gill, N., Cronin, J., & McGuigan, M. (2013, May). The development, retention and decay rates of strength and power in elite rugby union, rugby league, and American football: A systematic review. *Sports Medicine*. Sports Med. https://doi.org/10.1007/s40279-013-0031-3

Mekler, E. D., Brühlmann, F., Tuch, A. N., & Opwis, K. (2015). Towards understanding the effects of individual gamification elements on intrinsic motivation and performance. https://doi.org/10.1016/j.chb.2015.08.048

MyFitnessPal, I. (n.d.). Calorie Counter - MyFitnessPal - Apps on Google Play. Retrieved 14 July 2020, from https://play.google.com/store/apps/details?id=com.myfitnesspal.android

Nicholson, S. (2015). A RECIPE for Meaningful Gamification. In *Gamification in Education and Business* (pp. 1–20). Retrieved from http://scottnicholson.com/pubs/recipepreprint.pdf

Rajšp, A., & Fister, I. (2020). A Systematic Literature Review of Intelligent Data Analysis Methods for Smart Sport Training. *Applied Sciences*, *10*(9), 3013. https://doi.org/10.3390/app10093013

Ritchie, H. (2017). Obesity. Retrieved from https://ourworldindata.org/obesity

Souza, M. R. de A., Constantino, K. F., Veado, L. F., & Figueiredo, E. M. L. (2017). Gamification in Software Engineering Education: An Empirical Study. In *2017 IEEE 30th Conference on Software Engineering Education and Training (CSEE&T)* (pp. 276–284). IEEE. https://doi.org/10.1109/CSEET.2017.51

Suh, A., Wagner, C., & Liu, L. (2015). The Effects of Game Dynamics on User Engagement in Gamified Systems. In *2015 48th Hawaii International Conference on System Sciences* (pp. 672–681). IEEE. https://doi.org/10.1109/HICSS.2015.87

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business*. Wharton Digital Press.

Wijman, T. (2019, June 18). The Global Games Market Will Generate $152.1 Billion in 2019 as the U.S. Overtakes China as the Biggest Market | Newzoo. Retrieved 3 July 2020, from https://newzoo.com/insights/articles/the-global-games-market-will-generate-152-1-billion-in-2019-as-the-u-s-overtakes-china-as-the-biggest-market/

Williams, H. (2019, January 14). The Gamification of Social Media. Retrieved 4 July 2020, from https://www.meltwater.com/en/blog/the-gamification-of-social-media?redirected-path=%2Fuk%2Fblog%2Fthe-gamification-of-social-media

World Health Organization. (2018, February 23). Physical activity. Retrieved 30 June 2020, from https://www.who.int/news-room/fact-sheets/detail/physical-activity