Smart Learning Environments

RESEARCH

Open Access

Gameful education: a study of Gamifiter application's role in promoting physical activity and active lifestyle

Michal Vorlíček[1], David Prycl[2], Josef Heidler[3,4], Manuel Herrador-Colmenero[5*], Jitka Nábělková[6], Josef Mitáš[1], Erica Hinckson[7], Sandra Mandic[7,8] and Karel Frömel[1]

*Correspondence:
mhc@ugr.es

[1] Institute of Active Lifestyle, Faculty of Physical Culture, Palacký University, 771 11 Olomouc, Czech Republic
[2] BALUO Application Centre, Faculty of Physical Culture, Palacký University, 771 11 Olomouc, Czech Republic
[3] Faculty of Education, Jan Evangelista Purkyně University in Ústí Nad Labem, Ústí nad Labem, Czech Republic
[4] Research Unit of Active Living, Department of Sports Science and Clinical Biomechanics, The Faculty of Health Sciences, University of Southern Denmark, Odense, Denmark
[5] La Inmaculada Teacher Training Centre, Sport and Health University Research Institute (iMUDS), University of Granada, Granada, Spain
[6] Institute of Education and Social Studies, Faculty of Education, Palacký University, 771 11 Olomouc, Czech Republic
[7] School of Sport & Recreation, Faculty of Health and Environmental Sciences, Auckland University of Technology, 1010 Auckland, New Zealand
[8] AGILE Research Ltd, 6012 Wellington, New Zealand

Abstract

This study addresses the issue of insufficient physical activity (PA) among youths. The emergence of gamified interventions, such as Gamifiter web portal, offers a novel approach to promoting healthy habits and increasing intrinsic motivation for PA. Gamifiter engages users in virtual challenges linked to daily step counts and progress on a digital map, aiming to enhance PA and physical literacy. Involving 107 pupils (12–13 years old), the intervention utilized Garmin VívoFit trackers, with the Gamifiter portal providing individual PA reports, challenges, and interactive educational applications. Results showed a significant increase in daily step counts indicating the positive impact of Gamifiter on PA levels. Attitudes Towards Educational Reality questionnaire and incomplete sentence test results revealed pupils' positive perceptions, high motivation, and satisfaction with Gamifiter. Teachers also praised Gamifiter for promoting PA and literacy, although some desired more customization options. The study emphasizes the potential of gamified interventions to effectively promote a healthy lifestyle. Positive attitudes and increased PA suggest that gamification can be a valuable tool in motivating and engaging pupils in physical activities, fostering a foundation for a healthier lifestyle. In conclusion, Gamifiter's success in motivating pupils to engage in higher levels of PA highlights its potential as a useful tool for promoting a healthy lifestyle. Future studies with larger sample sizes and longer follow-up periods are recommended to better understand the sustained impact of gamified interventions on health among youths.

Keywords: Intervention, Gamification, Education, Motivation, Physical literacy, Children

Introduction

According to the World Health Organization (WHO), 81% of adolescents do not do enough physical activity (PA)(WHO, 2023), and in the Czech Republic only 58% of Czech children and adolescents meet the PA guidelines (Gába et al. 2022). The lack of PA is associated with the risk of cardiovascular diseases, obesity, diabetes, and certain types of cancer (Poitras et al. 2016; Warburton & Bredin, 2017).

Rapid development of technology brings new approaches to increase PA and promoting healthy lifestyle has emerged through gamified interventions (Lu et al. 2013). The gamification mean that participants are involved in an adventure to achieve a goal (in this context healthy habits improvement), where game elements have an utilitarian purpose (Pérez-López, 2020). These interventions utilize game elements such as points, budges, leaderboard, and social interaction to achieve intrinsic motivation to enhance PA and overall health (Roman et al. 2015; Romeo et al. 2019; Ryan & Tanaka, 2014).

Gamified interventions have gained popularity (Beemer et al. 2019; Mora-Gonzalez et al. 2020; Saucedo-Araujo et al. 2020). Gamified interventions can be effective in increasing PA, reducing sedentary behavior, and improving overall fitness among children and adolescents (Hsu & Chen, 2018; Johnson et al. 2016; Mazeas et al. 2022; Sardi et al. 2017) but they may be influenced by factors like age, gender, and individual preferences (Bort-Roig et al. 2014; Sailer et al. 2017). These findings are in line with the self-determination theory, which suggests that increasing motivation (intrinsic) can lead to increased PA (Deci & Ryan, 2000).

Gamification can be used to promote active transportation (AT), which are walking, running, cycling, or other forms of human-powered movement from place to place (Chillón et al. 2014). AT can reduce sedentary time and increase PA (Cooper et al. 2012; Kek et al. 2019; Khan et al. 2021). Gamified interventions can be useful in promoting PA and AT as part of broader programs to support a healthy lifestyle (Cugelman, 2013), as it can be an effective tool for increasing AT and promoting sustainable travel modes (Coombes & Jones, 2016; Harris & Crone, 2021; Wang et al. 2022).

Research gap and study objectives

Despite the growing interest, there is not a technological tool that gamified the AT with a clear success to increase the PA levels. Additionally, in the previous researches in this line that effectiveness for increasing AT (Coombes & Jones, 2016; Harris & Crone, 2021; Wang et al. 2022) did not analyzed its impact on PA levels. Hence, it is necessary to study the effects on PA and AT of a gamification developed with a technological tool. Therefore, we designed a tool "Gamifiter" to enhance PA and encourage AT. Gamifiter engages users in virtual challenges, tied to their daily step counts and progress on a digital map. The primary goal of this study is to evaluate the utility and effectiveness of the software in enhancing physical activity (PA), active transportation (AT), and physical literacy among adolescents in Czech primary schools. Additionally, the study aims to capture teachers' perspectives on the effects and usability of this tool. The intervention is grounded in established academic concepts, providing a scientifically supported foundation for gamified approaches in promoting these outcomes. The research questions are articulated to assess both the direct impact on student behaviors and the perceived value from the educators' viewpoint.

Materials and methods

Participants

A total of 115 pupils and their parents (or a legal guardian) from the seventh grade of four different schools and regions of the Czech Republic (city/region: Olomouc/Olomouc, Březová/Karlovy Vary, Dvůr Králové nad Labem/Hradec Králové, Opava/

Moravian-Silesian) were invited to participate in research and sign a written informed consent. From those who agreed to participate (n = 107), 100 pupils (52% girls; age range between 12.1 and 13.2 years old) were registered in the system. The protocol was approved by the Ethical commission of Faculty of Physical Culture, Palacký University (reference number: 38/17 from May 2017).

The course of the intervention and the Gamifiter portal

All participants received fitness trackers Garmin VívoFit 4 (Grimes et al. 2022; Lavelle et al. 2022) to monitor their PA. Participants were asked to wear the tracker on the non-dominant wrist from waking up to going to bed. The tracker data was synchronized and graphically represented within the individual PA reports provided by Gamifiter. The Gamifiter portal comprises a web platform and PA challenges. The web platform offers individual reports on PA within the context of current recommendations, allowing for comparisons of PA levels at the group, class, and school levels. The portal displays interactive PA data through dashboards (i.e., step counts, comparisons with recommendations, weekly walking profiles) which can be filtered and selected across different timeframes (i.e., days, weeks, and years) (Fig. 1).

The challenges (Fig. 2) in portal are interactive educational applications driven by the PA of pupils and teachers. The portal displays ongoing and completed challenges, allowing pupils and teachers to access real-time data that is continuously synchronized. This motivates individuals to engage in PA by participating in various types of challenges, where they can interact with the application to view their data and additional statistics (percentage contribution of their PA to the challenge/class, individual rankings within the challenge/class, and the percentage of pupils participating in the challenge/class). Additionally, the portal highlights the top 10 pupils participating in the challenge and ranks the classes involved.

Within the intervention, pupils engaged in various challenges aimed at motivating them to move and acquiring knowledge in the subjects of geography and history. For example, they were challenged to complete a race across Europe (Fig. 2A) as quickly as possible, collecting steps and virtually visiting different cities while learning interesting

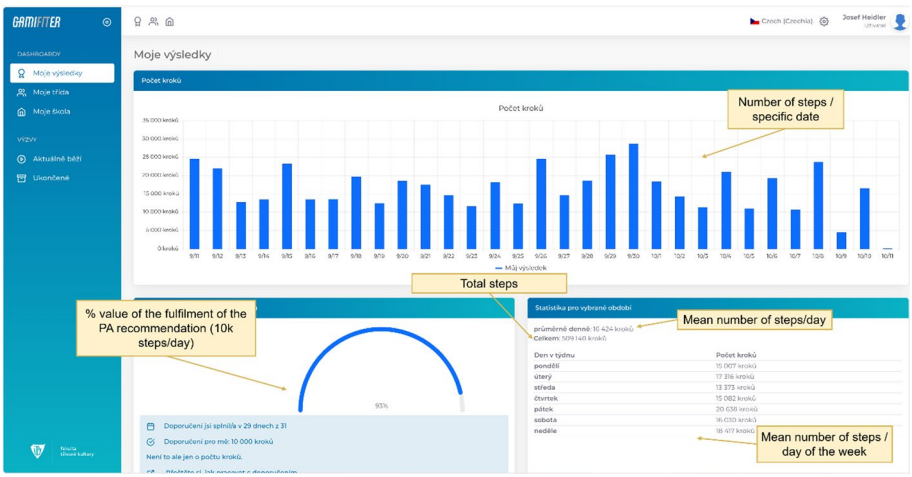

Fig. 1 Individual PA report from Gamifiter portal

Fig. 2 Physical activity challenges: different approaches to visualizing class step competition data

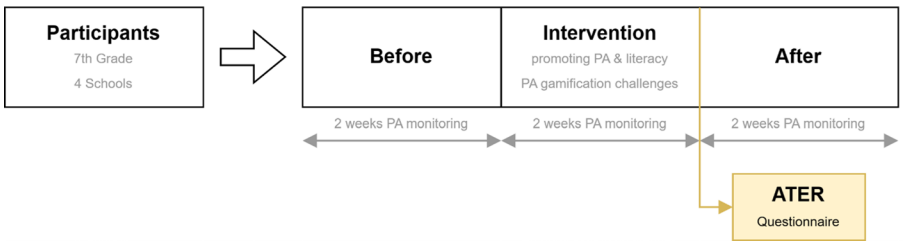

Fig. 3 Project flow chart

facts about them. Another challenge was to identify a picture based on a gradually revealed picture (Fig. 2B) as they accumulated steps, or they attempted to recognize an image that progressively came into focus (Fig. 2C) with increasing steps.

Assessment of the effect on the number of steps

Overall, PA (number of steps from midnight to midnight) and the number of steps before school (from midnight to eight in the morning = beginning of school). Three periods were compared (Fig. 3), each lasting 14 days (i.e., before, during, and after the intervention). Based on the results of the Shapiro–Wilk test, data were not in a normal distribution. Therefore, comparison of these periods was analyzed using non-parametric Wilcoxon test. Effect size was calculated using the Common Language Effect Size (CLES) (Vargha & Delaney, 2000).

Assessment of attitudes towards gamified interventions

The Attitudes Towards Educational Reality (ATER) questionnaire (Chráska, 1998) was used to assess the attitudes of the pupils towards Gamifiter and its perceived load (Chráska, 2003). By making successive modifications and conducting factor analyses, a two-dimensional form of the semantic differential was designed, which is convenient for assessing the concepts of "educational reality" (Vašťatková & Chvál, 2010). The indicators

selected to assess pupils' attitude towards the Gamifiter included "Movement", "Competition" and "Tasks". Each indicator was assessed using 10 scales composed of contrasting adjectives. Five scales measured the evaluation factor, while the remaining five scales measured the energy factor. The evaluation factor represented a measure of "good" or "bad" while the energy factor indicated the extent to which the indicator was associated with effort or difficulty. The indicator evoked a feeling in the pupils, which was recorded on a seven-point scale. The selection of indicators was based on their appropriate representation of the attitude object.

We complemented the semantic differential method with a verbal projective method-the incomplete sentences test phrased with two positive and two negative charge sentences, which was a separate tool apart of ATER questionnaire. Pupils were given several sentences to complete: "I liked…, I appreciate most…, It would be better if…, I would recommend…". The responses were indicative of attitudes, beliefs, motivations, or other mental states. This technique has the advantage of encouraging respondents to reveal their hidden feelings (i.e., wishes, desires, fears, and attitudes) (Holaday et al. 2000). We evaluated the results related to the semantic space indicators (i.e., Movement, Competition, and Tasks in the application). We conducted sorting at the first and second order. In the first-order sorting, a matrix of individual real contents related to the semantic space indicators was processed. In the second-order sorting, the contents of statements were grouped into categories. The resulting categories represent the counts of sentences with a positive and negative charge.

Results

Intervention effect on physical activity and active transport (steps)

In the two-week period prior to the launch of the class competition in the Gamifiter, pupils (age: 12.7 ± 0.5 years old; weight: 51.3 ± 11.8 kg; height: 157.6 ± 9.5 cm; body mass index (BMI) 20.9 ± 4.3) took an average of 9,149 steps/day and 1,377 steps by 8 a.m. (before the start of school). During two-week Gamifiter intervention averages increased by 25% in total (11,463 steps/day) and by 38% (1,899 steps) in the time before school (Fig. 4). The increased number of steps during the intervention period (see Fig. 4), was higher than before ($p = 0.001$) and after ($p = 0.003$) intervention periods. This increase in the number of steps is shown also in the time before school (all, $p = 0.001$). No differences were found between before and after intervention periods in the number of steps per day and in the period before the school (all, $p > 0.05$).

Pupils' subjective evaluation of the intervention

The survey about the attitudes towards gamified interventions was completed by 82% of pupils. Gamifiter achieved the best results in supporting physical literacy as pupils through the intervention a) learned why PA is important, b) what the health recommendations for daily step count are, and c) got an idea of how challenging it is to take 10,000 steps (82%, 88% and 83% agreed, respectively). Gamifiter motivated 88% of respondents to be physically active and 80% perceived the wearables as "user-friendly". Half of the pupils perceived the intervention to promote classroom relationships and team spirit, and 62% would like to get their own fitness tracker based on this experience. Overall,

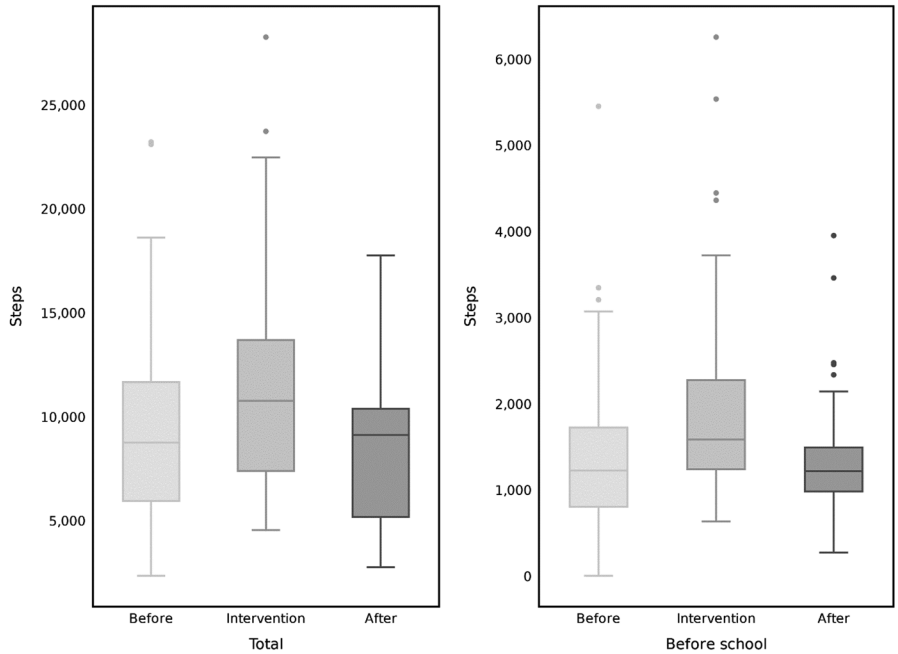

Fig. 4 Visualization of the number of steps within the observation periods

37% of pupils agreed that Gamifiter was a useful tool for learning in other classes (e.g., Geography) and one-fifth of pupils did not feel comfortable if classmates could see their quantified PA results.

Evaluation of the application – ATER questionnaire survey of attitudes

To evaluate the results of the ATER questionnaire, arithmetic means were calculated for the indicators: Movement, Competition and Tasks. Pupils ($n=84$) rated these indicators in terms of both energy and evaluation. The means of all indicators were plotted in a two-dimensional space, labelled by the energy factor axis and the evaluation factor axis. Figure 5 illustrates how the individual indicators are perceived in comparison to the others, it is the semantic space of indicators in the rating and energy factor. The measured indicators are marked in the semantic space, where the individual coordinates of the space are a factor of evaluation and energy. The position of the indicator on the relevant axis is determined by the average value calculated from the individual adjective scales assigned to the given factor. This analysis provides a clear idea of the mutual position of individual concepts. Based on the indicator means, we inferred the overall attitudes of the pupils towards the Gamifiter application (evaluation factor: 4.9; energy factor: 3.2).

The results indicate that pupils perceived the concept of "Movement" and "Competition" in the application most positively. They perceived "Tasks" in the application as more demanding and rated it less positively compared to the concepts of "Movement" and "Competition" in the application. When pupils perceived "Tasks" in the application as

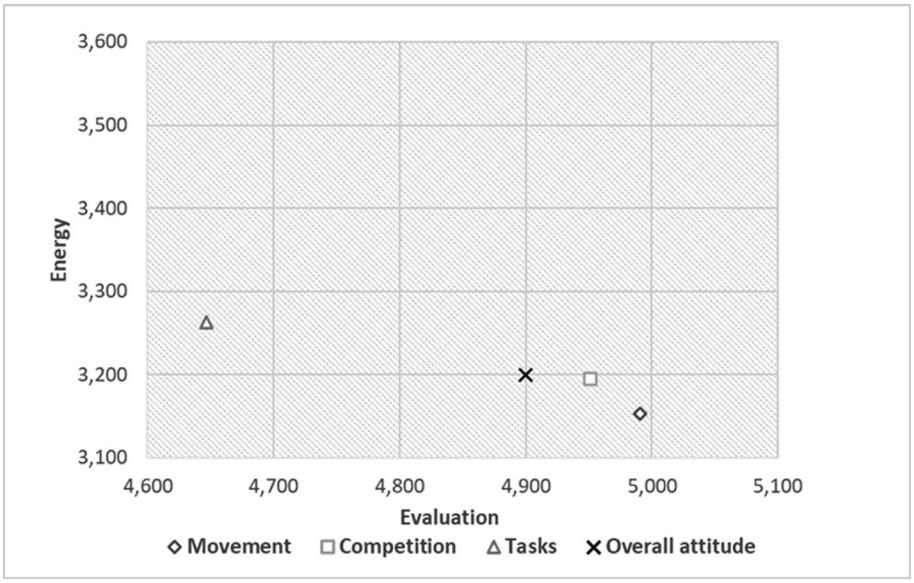

Fig. 5 The semantic space of each Gamifiter indicator

more demanding compared to other concepts, they also did not rate it positively. From the averages of all indicators, we calculated the overall attitude towards the application. Overall, pupils' attitudes towards the Gamifiter application demonstrate a positive attitude towards the application. Pupils did not perceive it as demanding. Important for our interpretation of the results are the content of the production analysis, the frequency of the pupils' responses (positive/negative charge) and some features—for example, criticism, recommendation, dissatisfaction, suggestions x satisfaction, praise, positive emotions. For an objective evaluation, we present a table of the frequency of responses with a negative or positive charge. All results of the incomplete sentences test are available in Appendix 1.

A total of 6 categories emerged through second-order sorting: Competition in the application, Movement, Tasks in the application, Watches, Applications, Steps. The results show that in the incomplete sentences test, pupils have a positive perception of the watch and the in-app competition. However, at the same time, the highest number of recommendations is related to the watch itself. The movement and the tasks in the app did not evoke any negative feelings in the pupils. The app itself evoked positive emotions in them and they do not perceive it too negatively. The use of the Gamifiter app elicited both positive emotions and, to a lesser extent, expressive emotions.

Teachers' subjective evaluation of the intervention

Teachers find Gamifiter to be an interesting tool for promoting PA and literacy, based on the results of a survey conducted among the four participating teachers. Although some express a desire to have the ability to create their own tasks and challenges, the overall feedback was positive. The only drawback mentioned was the lengthy process of synchronizing the bracelets and occasional incomplete sports activities data. All four collaborating teachers consider Gamifiter to be a suitable and usable tool for motivating pupils to PA, and for reviewing educational content. The surveyed teachers believe that use of the Gamifiter had a positive impact on the classroom atmosphere and they would like to incorporate this program into their future teaching practices. All four teachers prefer the option to customize the content of the motivational educational modules over selecting from pre-prepared ones.

Discussion

The utility and effectiveness of Gamifiter for enhancing PA, AT and physical literacy among adolescents have been tested in the study. The Gamiffiter intervention helped adolescents to increase their PA literacy, being a tool well considered by the teacher involved. Gamified intervention using PA tracker could be an effective tool for promoting a healthy lifestyle among adolescents.

The use of the gamification elements for the intervention could be one of the reasons of the success of the Gamifiter. Despite some studies support that gamification improve the knowledge or skills (Gentry et al. 2019; Suleiman-Martos et al. 2021) to engage and to encourage adherence with healthy habits such as PA or AT, the motivation is a key element (Mora-Gonzalez et al. 2020). Using game elements, the extrinsic motivation (Morris et al. 2022; Ryan & Deci, 2000) could result, showing positive changes in the behaviour during the intervention, as the step number increase observed in the current study. However, to obtain an increase and maintenance of the expected behavior after the intervention program, intrinsic motivation (Morris et al. 2022; Ryan & Deci, 2000) should be enhanced. Therefore, gamified interventions such as Gamifiter could be an effective tool for promoting a healthy lifestyle among adolescents (Mora-Gonzalez et al. 2020).

The Gamifiter system is an educational-motivational tool designed to support PA and a healthy lifestyle among adolescents by leveraging gamified elements to enhance engagement and motivation. Key elements used in the intervention, such as points, badges, leaderboards, and thematic challenges, contributed to increasing extrinsic motivation during the intervention. For example, students earned points for completing activities, which were reflected on class-wide leaderboards, fostering a sense of competition and engagement. Thematic challenges, such as the "Journey through Europe," allowed students to accumulate steps to virtually explore different cities, linking PA with educational experiences (Ohn et al. 2022). This innovative approach enriched the activity by adding a sense of purpose and exploration, which could be one of the main reasons for the observed success in increasing PA levels.

The theoretical foundation of the Gamifiter system is rooted in the Self-Determination Theory (SDT) by Deci and Ryan (2000), focusing on the fulfilment of three basic psychological needs: autonomy, competence, and relatedness. Autonomy was supported by giving students the freedom to choose among various challenges, competence was promoted by tracking progress and earning badges, and relatedness was fostered through leaderboards and team-based challenges, which encouraged social connections and a sense of belonging. These elements not only enhanced extrinsic motivation but also laid the groundwork for fostering intrinsic motivation, which is crucial for maintaining positive behavioral changes after the intervention. By integrating gamified elements with educational content, Gamifiter aims to provide a comprehensive approach that not only promotes PA but also enhances physical literacy and knowledge expansion, creating an environment conducive to long-term behavior change and health promotion among adolescents.

The main finding of this study is the increase of the step count during the intervention. Following a recent model of motivation (Strombach et al. 2016), when the negative influences of the cost to achieve the behavior (e.g., effort) and extrinsic drivers disappear (e.g., rewards for step count achievement or graphical information as feedback of the performance), despite the maintenance of the intrinsic motivation (e.g., satisfaction or feeling healthier), the behavior declined (Hanus & Fox, 2015; Mazéas et al. 2024). Intrinsic motivation remains sustained during gamified activities, even with increased step count, due to several key factors that enhance engagement and enjoyment. Gamification effectively addresses psychological needs such as competence, autonomy, and relatedness, which are crucial for maintaining intrinsic motivation (Luarn et al. 2023). Additionally, the incorporation of game elements supports enjoyment, which has been shown to be a lasting form of motivation, particularly in rehabilitation contexts (van der Kooij et al. 2019). Thus, Gamifiter could be a good tool to increase PA, and additional effort on intrinsic motivation and maintenance of extrinsic drivers should be designed to engage adolescents after its use.

The ATER questionnaire and the incomplete sentence test measure the hidden connotative (subjective) meanings of terms related to the used Gamifiter. The future focus on the movement and competition of pupils, to achieve the desired results by using the Gamifiter is needed. The results of the data analysis of the incomplete sentences test confirmed the correctness of the selected indicators for displaying the semantic space. For further evaluation, the ATER questionnaire could be supplemented with a watch indicator. The results of the tests have revealed that pupil's attitudes towards the Gamifiter are positive, which may be associated with subsequent motivation and engagement. The established positive attitudes may be related to expected values and future behaviors of pupils. Gamification thus serves as a mean of change pupils PA habits, and it has been shown that the school environment is conducive to implementing such interventions (David & Weinstein, 2023; Saucedo-Araujo et al. 2020). Implemented gamification concept is effective in satisfaction from PA and a sense of rewards, connection of users with the class community, the school itself and other schools, which was proven in other

studies as well (Cotton & Patel, 2019; Mora-Gonzalez et al. 2020; Sailer et al. 2017). For example, ranking of the best participants, classes, or schools; or in the form of cooperation: participants form a team for a common purpose, feel a commitment to the performance of others (Sailer et al. 2017). The benefit of the Gamifiter could be the power of motivation for regular PA. It is thus a specific element of game design that has a psychological effect on pupils themselves. Our research investigation has confirmed that the competition itself has generated positive attitudes towards the application among pupils.

The use of tools like Gamifiter might help the improvement of the PA levels based on the extrinsic motivation (Morris et al. 2022; Ryan & Deci, 2000). In educational or public health contexts, the use of these strategies is recommended when the PA levels should be improved. However, due to its success is based in the extrinsic motivation, the effect on PA levels will appear while the strategy is performed. To maintain the improvements after the intervention, other methodologies based on the intrinsic motivation are needed. Moreover, for the educational context, teachers suggests that Gamifiter is a tool suitable and usable in compulsory education. A previous research suggested that a similar tool might be also used in Physical Education lessons (Saucedo-Araujo et al. 2022). This highlights the growing interest for the educational community and researchers to include within the curriculum this kind of tools to increase the motivation and adherence of the students. Therefore, next steps should study the sustainability of these tools in the compulsory education and the inclusion of additional strategies that allow a transformation of the extrinsic motivation into intrinsic motivation.

Limitations of this study include small sample size, absence of a control group, short-term follow-up period, and no analysis of the tracker wear time. However, the Gamifiter application can be a useful tool for promoting PA and AT among children and adolescents. Future studies should include larger sample sizes and longer follow-up periods to better understand the effectiveness of gamified interventions in promoting healthy lifestyle.

Conclusions

The study demonstrated that intervention using Gamifiter was useful and effective in motivating adolescents to engage in higher levels of PA and AT, with a positive attitude towards Gamifiter. Adolescents were more motivated to exercise and move when using the application challenges, being a key to enhance PA, AT, and physical literacy. Competition among pupils and the presence of wristbands emerged as influential variables in shaping the expected attitudes towards gamification. Policy makers, researchers, and educators should consider the acute effects of this kind of tool to propose additional methodologies or tools to extend the effects after the intervention.

Appendix 1

See Tables 1 and 2; Figs.
6 and
7

Appendix 1 shows the results of the incomplete sentences test: the matrix of each real content. The contents of the answers in the incomplete sentences test are grouped into

Table 1 The results of the incomplete sentences test: the matrix of each real content

I liked it…	I appreciate the most	It would be better if…	I would recommend…
Competition. (4×) Competition with other schools. (3×) Competition on the map. (2×) Competition with friends and classmates. (2×) Catching up someone else's footsteps. (2×) Many students competed	Competition in the application Supporting children movement via competition	More time for competing	More competitions
Going out with friends. (2×) Move/movement. (2×) Movement activities on the map	It made me move Ability to see mine movement in steps		
Appearance of the watch. (2×) Display. (2×) Testing/trying a new watch. (2×) Technology/Functionalities. (2×) Precision of steps count Watches Automatic activity tracking App connectivity Battery time (no need to charge) Customization	Technology/Functionalities. (3×) Don't need to pay if I break the watch. (2×) Great wearability / pleasant to the hand. (2×) Precision of steps count Watches Testing/trying a new watch. (2×) Customization Water resistance Alarm clock	More premium watch. (6×) Better app connectivity. (5×) Touch sensitive display. (3×) Tighter strap Bigger watch Functionality to monitor drinking regime More precise steps counter	This app and watch to other people. (2×) More premium watch. (2×) Small and handy watch Watch with touch display and call functionality Touch display More precise steps counter Better app connectivity Mini game in the watch controlled by walking
Well-designed app. (2×) Clear and understandable. (3×) Application. (2×)	App development and ideation	Automatic data watch/app synchronization	Connectivity with other third-party apps
Precision of steps count Tracking number of steps. (2×)	Tracking number of steps. (3×)	More precise steps counter. (4×) GPS tracking	More precise steps counter GPS tracking More tracking functionalities These tracking devices to people who do a lot of sports

No responses for category "Tasks in the application"

Table 2 Total score, positive charge (+ 1), negative charge (-1), Incomplete Sentences test

	Positive charge (+ 1)	**Negative charge (−1)**
Competition in the application	18	2
Movement	7	0
Tasks in the application	0	0
Watches	31	25
Applications	8	2
Steps	7	9

three categories based on semantic space indicators: Movement, Competition and Tasks. Additional categories emerged during the sorting of the answer contents. The contents of the pupils' answers were related to other concepts such as watch, application and

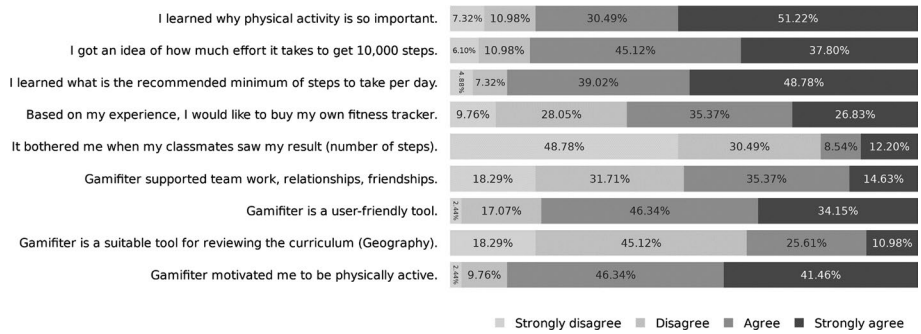

Fig. 6 Pupils' opinions on the usability of the Gamifiter application and its contribution in terms of physical activity and physical literacy

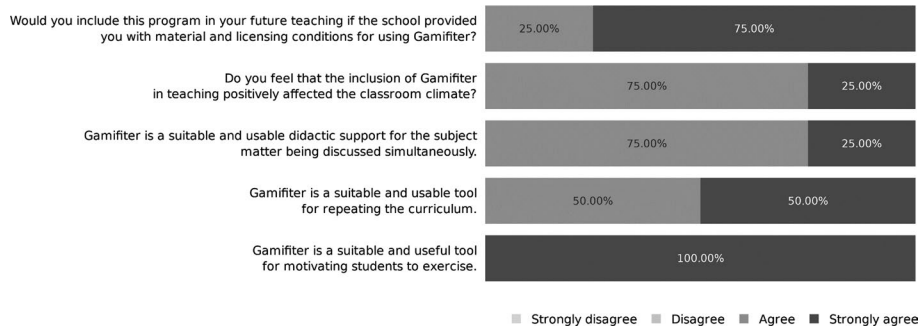

Fig. 7 Teachers' opinions on the usability of the Gamifiter application and its contribution in terms of physical activity and education

steps. The following Table 2 shows the summary results of all categories of the incomplete sentences test.

Abbreviations

AT	Active transportation
ATER	Attitudes towards educational reality
BMI	Body mass index
CLES	Common language effect size
PA	Physical activity
WHO	World health organization

Acknowledgements
The authors would like to participants for their generous collaboration in this study.

Author contributions
MV, DP, JN and JH contributed to the development of the data collection methods and analysis plans. MV applied the program. MV, DP, JN and JH undertook the data collection process. SM and MHC contributed to the analysis process, interpreted the data, and contributed to the development of the text. JM, KF and EH critically evaluated the manuscript and contributed to the overall tone of the article. All the authors reviewed and edited the text and eventually approved of the final version.

Funding
This study was supported by the research grant of Palacký University, Czech Republic (No. JG_2023_007) and by the GAMA 2 project, funded by the Technology Agency of the Czech Republic (No. TP01010015).

Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Competing interests

Sandra Mandic is the founder and the director of the research consultancy AGILE Research Ltd. (www.agileresearch.nz) and the Team Leader Transport Strategy at Wellington City Council (Wellington, New Zealand).

Received: 13 February 2024 Accepted: 26 November 2024
Published online: 24 December 2024

References

Beemer, L. R., Ajibewa, T. A., DellaVecchia, G., & Hasson, R. E. (2019). A pilot intervention using gamification to enhance student participation in classroom activity breaks. *International Journal of Environmental Research and Public Health, 16*(21), 4082. https://doi.org/10.3390/ijerph16214082

Bort-Roig, J., Gilson, N. D., Puig-Ribera, A., Contreras, R. S., & Trost, S. G. (2014). Measuring and influencing physical activity with smartphone technology: A systematic review. *Sports Medicine, 44*(5), 671–686. https://doi.org/10.1007/s40279-014-0142-5

Chillón, P., Hales, D., Vaughn, A., Gizlice, Z., Ni, A., & Ward, D. S. (2014). A cross-sectional study of demographic, environmental and parental barriers to active school travel among children in the United States. *International Journal of Behavioral Nutrition and Physical Activity*. https://doi.org/10.1186/1479-5868-11-61

Chráska, M. (1998). Využití dotazníku ATER pro výzkum a rozvoj tvůrčího potenciálu žáků. In *Tvoření v dětství a mládí* (pp. 175–182). Karolinum.

Chráska, M. (2003). *Metody sběru dat v evaluačních pedagogických výzkumech*. Votobia.

Coombes, E., & Jones, A. (2016). Gamification of active travel to school: A pilot evaluation of the Beat the Street physical activity intervention. *Health and Place*. https://doi.org/10.1016/j.healthplace.2016.03.001

Cooper, A. R., Jago, R., Southward, E. F., & Page, A. S. (2012). Active travel and physical activity across the school transition: The PEACH project. *Medicine and Science in Sports and Exercise, 44*(10), 1890. https://doi.org/10.1249/MSS.0b013e31825a3a1e

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. https://doi.org/10.1177/0890117118790394

Cugelman, B. (2013). Gamification: What it is and why it matters to digital health behavior change developers. *In JMIR Serious Games, 1*, e3. https://doi.org/10.2196/games.3139

David, L., & Weinstein, N. (2023). A gamified experiential learning intervention for engaging students through satisfying needs. *Journal of Educational Technology Systems, 52*(1), 52. https://doi.org/10.1177/00472395231174614

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227. https://doi.org/10.1207/S15327965PLI1104_01

Gába, A., Baďura, P., Vorlíček, M., Dygrýn, J., Hamřík, Z., Kudláček, M., Rubín, L., Sigmund, E., Sigmundová, D., & Vašíčková, J. (2022). The czech republic's 2022 report card on physical activity for children and youth: a rationale and comprehensive analysis. *Journal of Exercise Science and Fitness, 20*(4), 340. https://doi.org/10.1016/j.jesf.2022.08.002

Gentry, S. V., Gauthier, A., Ehrstrom, B. L. E., Wortley, D., Lilienthal, A., Car, L. T., Dauwels-Okutsu, S., Nikolaou, C. K., Zary, N., Campbell, J., & Car, J. (2019). Serious gaming and gamification education in health professions: systematic review. *In Journal of Medical Internet Research, 21*, e12994. https://doi.org/10.2196/12994

Grimes, A., Lightner, J. S., Eighmy, K., Steel, C., Shook, R. P., & Carlson, J. (2022). Decreased Physical activity among youth resulting from COVID-19 pandemic-related school closures: Natural experimental study. *JMIR Formative Research, 6*(4), e35854. https://doi.org/10.2196/35854

Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers and Education, 80*, 152. https://doi.org/10.1016/j.compedu.2014.08.019

Harris, M. A., & Crone, D. (2021). Using gamification to encourage active travel. *Journal of Transport and Health, 23*, 10175. https://doi.org/10.1016/j.jth.2021.101275

Holaday, M., Smith, D. A., & Sherry, A. (2000). Sentence completion tests: A review of the literature and results of a survey of members of the society for personality assessment. *Journal of Personality Assessment, 74*(3), 371. https://doi.org/10.1207/S15327752JPA7403_3

Hsu, C. L., & Chen, M. C. (2018). How does gamification improve user experience? An empirical investigation on the antecedences and consequences of user experience and its mediating role. *Technological Forecasting and Social Change, 132*, 118. https://doi.org/10.1016/j.techfore.2018.01.023

Johnson, D., Deterding, S., Kuhn, K. A., Staneva, A., Stoyanov, S., & Hides, L. (2016). Gamification for health and wellbeing: A systematic review of the literature. *In Internet Interventions, 6*, 89. https://doi.org/10.1016/j.invent.2016.10.002

Kek, C. C., GarcíaBengoechea, E., Spence, J. C., & Mandic, S. (2019). The relationship between transport-to-school habits and physical activity in a sample of New Zealand adolescents. *Journal of Sport and Health Science, 8*(5), 463. https://doi.org/10.1016/j.jshs.2019.02.006

Khan, A., Mandic, S., & Uddin, R. (2021). Association of active school commuting with physical activity and sedentary behaviour among adolescents: A global perspective from 80 countries. *Journal of Science and Medicine in Sport, 24*(6), 567. https://doi.org/10.1016/j.jsams.2020.12.002

Lavelle, G., Norris, M., Flemming, J., Harper, J., Bradley, J., Johnston, H., Fortune, J., Stennett, A., Kilbride, C., & Ryan, J. M. (2022). Validity and acceptability of wearable devices for monitoring step-count and activity minutes among people with multiple sclerosis. *Frontiers in Rehabilitation Sciences*. https://doi.org/10.3389/fresc.2021.737384

Lu, A. S., Kharrazi, H., Gharghabi, F., & Thompson, D. (2013). A systematic review of health videogames on childhood obesity prevention and intervention. *In Games for Health Journal, 2*, 131. https://doi.org/10.1089/g4h.2013.0025
Luarn, P., Chen, C. C., & Chiu, Y. P. (2023). Enhancing intrinsic learning motivation through gamification: a self-determination theory perspective. *International Journal of Information and Learning Technology*. https://doi.org/10.1108/IJILT-07-2022-0145
Mazeas, A., Duclos, M., Pereira, B., & Chalabaev, A. (2022). Evaluating the effectiveness of gamification on physical activity: systematic review and meta-analysis of randomized controlled trials. *In Journal of Medical Internet Research, 24*, e26779. https://doi.org/10.2196/26779
Mazéas, A., Forestier, C., Harel, G., Duclos, M., & Chalabaev, A. (2024). The impact of a gamified intervention on daily steps in real-life conditions: Retrospective analysis of 4800 individuals. *Journal of Medical Internet Research, 26*, 1–15. https://doi.org/10.2196/47116
Mora-Gonzalez, J., Pérez-López, I. J., & Delgado-Fernández, M. (2020). The "$in TIME" gamification project: using a mobile app to improve cardiorespiratory fitness levels of college students. *Games for Health Journal, 9*(1), 37. https://doi.org/10.1089/g4h.2019.0001
Morris, L. S., Grehl, M. M., Rutter, S. B., Mehta, M., & Westwater, M. L. (2022). On what motivates us: a detailed review of intrinsic v. Extrinsic motivation. *Psychological Medicine, 52*(10), 1801–1816. https://doi.org/10.1017/S0033291722001611
Ohn, M. H., Ohn, K. M., & Luen, N. P. (2022). Gamified learning effectiveness model. *In Handbook of Research on the Influence and Effectiveness of Gamification in Education*. https://doi.org/10.4018/978-1-6684-4287-6.ch005
Pérez-López, I. J. (2020). *De las 7 Bolas de Dragón a los 7 Reinos de Poniente: viajando por la ficción para transformar la realidad*. CopiDeporte S.L.
Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J.-P., Janssen, I., Katzmarzyk, P. T., Pate, R. R., Gorber, S. C., Kho, M. E., Sampson, M., & Tremblay, M. S. (2016). Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism, 41*(6 (Suppl. 3)), S197–S239. https://doi.org/10.1139/apnm-2015-0663
Roman, D. H., Conlee, K. D., Abbott, I., Jones, R. P., Noble, A., Rich, N., Ro, I., Kaufman, J., Weikert, R., & Costa, D. (2015). The digital revolution comes to US healthcare. *Goldman Sachs Global Inverstment Research Internet of Things, 5*, 54.
Romeo, A., Edney, S., Plotnikoff, R., Curtis, R., Ryan, J., Sanders, I., Crozier, A., & Maher, C. (2019). Can smartphone apps increase physical activity? systematic review and meta-analysis. *Journal of Medical Internet Research, 21*(3), e12053. https://doi.org/10.2196/12053
Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: classic definitions and new directions. *Contemporary Educational Psychology, 25*(1), 54. https://doi.org/10.1006/ceps.1999.1020
Ryan, R. M., & Tanaka, A. (2014). Autonomy and control in human behavior: Research on motivation and wellness from self-determination theory. *The Proceedings of the Annual Convention of the Japanese Psychological Association, 78*, SL-002. https://doi.org/10.4992/pacjpa.78.0_sl-002
Sailer, M., Hense, J. U., Mayr, S. K., & Mandl, H. (2017). How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. *Computers in Human Behavior, 69*, 371. https://doi.org/10.1016/j.chb.2016.12.033
Sardi, L., Idri, A., & Fernández-Alemán, J. L. (2017). A systematic review of gamification in e-Health. *In Journal of Biomedical Informatics, 71*, 31. https://doi.org/10.1016/j.jbi.2017.05.011
Saucedo-Araujo, R. G., Chillón, P., Pérez-López, I. J., & Barranco-Ruiz, Y. (2020). School-based interventions for promoting physical activity using games and gamification: A systematic review protocol. *International Journal of Environmental Research and Public Health, 17*(14), 5186. https://doi.org/10.3390/ijerph17145186
Saucedo-Araujo, R. G., Huertas-Delgado, F. J., Barranco-Ruiz, Y. M., Pérez-López, I. J., Aznar-Laín, S., Chillón, P., & Herrador-Colmenero, M. (2022). Testing the mystic school mobile application to promote active commuting to school in spanish adolescents: the PACO study. *Children, 9*(12), 1997. https://doi.org/10.3390/children9121997
Strombach, T., Strang, S., Park, S. Q., & Kenning, P. (2016). Common and distinctive approaches to motivation in different disciplines. *In Progress in Brain Research, 229*, 3. https://doi.org/10.1016/bs.pbr.2016.06.007
Suleiman-Martos, N., García-Lara, R. A., Martos-Cabrera, M. B., Albendín-García, L., Romero-Béjar, J. L., Guillermo, A., la Fuente, C.-D., & Gómez-Urquiza, J. L. (2021). Gamification for the improvement of diet, nutritional habits, and body composition in children and adolescents: A systematic review and meta-analysis. *Nutrients, 13*(7), 2478. https://doi.org/10.3390/nu13072478
van der Kooij, K., van Dijsseldonk, R., van Veen, M., Steenbrink, F., de Weerd, C., & Overvliet, K. E. (2019). Gamification as a sustainable source of enjoyment during balance and gait exercises. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2019.00294
Vargha, A., & Delaney, H. D. (2000). A Critique and Improvement of the CL common language effect size statistics of McGraw and Wong. *Journal of Educational and Behavioral Statistics, 25*(2), 101–132. https://doi.org/10.3102/10769986025002101
Vašťatková, J., & Chvál, M. (2018). K využití sémantického diferenciálu při autoevaluaci školy. *Orbis Scholae, 4*(1), 111–128. https://doi.org/10.14712/23363177.2018.185
Wang, W., Gan, H., Wang, X., Huan, Lu., & Huang, Y. (2022). Initiatives and challenges in using gamification in transportation: a systematic mapping. *European Transport Research Review*. https://doi.org/10.1186/s12544-022-00567-w
Warburton, D. E. R., & Bredin, S. S. D. (2017). Health benefits of physical activity: A systematic review of current systematic reviews. *Current Opinion in Cardiology, 32*(5), 541–556. https://doi.org/10.1097/HCO.0000000000000437
WHO. (2023). *World Health Organization*. https://www.who.int/health-topics/physical-activity

Publisher's Note