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Web-Based Technologies in Middle School Physical Education
Tecnologías basadas en la web en la educación física de la escuela secundaria

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Abstract. The key aspect discussed in this article is the effectiveness of introducing digital and web-based technologies into present-day middle school physical education. An experimental digital technology-based training course was launched in four comprehensive educational schools in the Republic of Kazakhstan. It involved the use of accelerometers during lessons as well as the Facebook social media platform for exchanging subject-related information. The student's physical activity was measured during each physical education lesson throughout the semester (comprising a total of 50 sessions). The total student sample consisted of 338 students (191 girls and 147 boys), with the mean age of participants being 13.2 ± 1.05 years. At the baseline stage of the study and after the course, the students underwent a series of physical fitness tests, such as running a 60-meter sprint, long jumps, ball throwing, and pull-ups. Following that, they took a Motivated Strategies for Learning Questionnaire. The results have shown that the incorporation of digital technologies increased students' physical activity. If before the intervention, the physical activity of the students during the lesson, on average across the sample (n=338), corresponded to light physical activity, then after the intervention, it shifted to moderate-to-vigorous physical activity. Furthermore, a significant enhancement in academic performance and motivation has been documented. The findings of this study are of great importance to all physical education teachers who are involved in the introduction of new technologies in the educational process, as well as to other representatives of the educational field.
Keywords: academic performance; physical activity; motivation; accelerometer; social media; sedentary behaviour.

Resumen. El aspecto clave discutido en este artículo es la efectividad de introducir tecnologías digitales y basadas en la web en la educación física de la escuela secundaria en la actualidad. Se lanzó un curso experimental de formación basado en tecnología digital en cuatro escuelas de educación integral en la República de Kazajistán. Esto implicó el uso de acelerómetros durante las lecciones, así como la plataforma de redes sociales Facebook para intercambiar información relacionada con la materia. Se midió la actividad física de los estudiantes durante cada lección de educación física a lo largo del semestre (que comprendía un total de 50 sesiones). La muestra total de estudiantes consistió en 338 estudiantes (191 chicas y 147 chicos), con una edad promedio de los participantes de 13.2 ± 1.05 años. En la etapa inicial del estudio y después del curso, los estudiantes se sometieron a una serie de pruebas de aptitud física, como correr 60 metros, saltos largos, lanzamiento de pelota y dominadas. Después de eso, completaron un Cuestionario de Estrategias Motivadas para el Aprendizaje. Los resultados han demostrado que la incorporación de tecnologías digitales aumentó la actividad física de los estudiantes. Si antes de la intervención, la actividad física de los estudiantes durante la lección, en promedio en toda la muestra (n=338), correspondía a una actividad física ligera, entonces después de la intervención, cambió a una actividad física moderada a vigorosa. Además, se ha documentado una mejora significativa en el rendimiento académico y la motivación. Los hallazgos de este estudio son de gran importancia para todos los profesores de educación física que están involucrados en la introducción de nuevas tecnologías en el proceso educativo, así como para otros representantes del campo educativo.
Palabras clave: rendimiento académico; actividad física; motivación; acelerómetro; redes sociales; comportamiento sedentario.

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Introduction

Emphasizing the importance of physical activity (PA) for the world's population is one of the main global targets for improving the prevention and treatment of non-communicable diseases (World Health Organization, 2019). Over the past decades, there has been an overall decrease in PA in children and teenagers (Farooq et al., 2020; Sallis, 1993). The transition from traditional in-class education to online learning has further reduced physical activity levels and increased the sedentary behaviour of students (Paterson et al., 2021). During the first year of the COVID-19 pandemic, many sports competitions and physical activities in general were either very limited or completely cancelled. In the same way online classes of physical education (PE) did not allow students to engage their motor skills (Catucci et al., 2021; Chen et al., 2021; Rúa-Alonso et al., 2022). In such conditions, a decline in physical training effectiveness among students is to be expected (Goad et al., 2019). Research in this area is needed to objectively assess the current state of physical education in schools and develop innovative training courses to increase the average PA levels of children.

Previous studies have reported that digital technology integrated into PE classes improved students' cognitive ability and motivation (Calderón et al., 2020; Nur et al., 2022; Sofias & Pierrakeas, 2023), academic performance (Calderón et al., 2020; Palao et al., 2015) and increased their physical activity levels (Lin et al., 2022). Nevertheless, the matter of improving the general fitness dynamics remains insufficiently studied.

Mobile technology advances enabled humanity to effectively improve health behaviour without any additional expenses or complications (Petersen et al., 2019). Particularly, we are talking about using various mobile applications and PA trackers (Yang et al., 2020). Nowadays, PA tracking apps are the most popular mobile health apps (Carroll et al., 2017; Vlahu-Gjorgievska et al., 2023; Yu et al., 2018).

Walsh et al. (2016) conducted a 5-week group training using the Accupedo Pedometer app. The purpose of the app is to count the number of steps a person makes daily and monitor the distance travelled. According to the results, the experimental group made a significantly higher number of steps compared to the control group (Walsh et al., 2016). Fanning et al. (2017) measured not only the students' PA but also their exercise self-efficacy and perceived barriers to physical activity. Here, the use of web-based technologies significantly increased participants' PA, while also lowering their barriers when it comes to exercising. However, no statistically significant differences in exercise self-efficacy were found.

In 2014, Al Ayubi et al. (2014) developed the PersonA mobile app for tracking PA and examined its effects over 4 weeks with the assistance of 13 study participants. This application, which uses Facebook as a platform for social support and networking, provided goal setting and PA control for each participant. By clicking on a Facebook link, participants were able to compare their results with those of other people, send messages, and leave comments and likes on posts (Al Ayubi et al., 2014). Consequently, the study found a significant increase in PA and duration of system usage.

A study by Torquati et al. (2018) reports a 3-month training based on the use of a mobile application and Facebook group posts. In this case, the participants did not demonstrate significant changes in PA upon the completion of the training.

There are not many studies in Kazakhstan related to the integration of technological innovations in physical education. Exploring this issue can justify the adoption and use of technology in physical education, improve the implementation process, and help move education forward (Wyant & Baek, 2019). The overall objective of the study is to evaluate the effectiveness of introducing digital and web-based technologies into middle school physical education.

The literature review allowed us to formulate three main research questions (RQ).

RQ1: Does the introduction of digital technologies into PE classes increase students' physical activity?

RQ2: Do technology-based PE classes improve students' academic performance?

RQ3: How does e-learning affect students' motivation?

Methods and materials

Study design

This study had an experimental research design and was conducted in several stages. During the baseline stage, we have identified the main starting points for designing an experimental technology-based training course that corresponds to Kazakhstan's educational standards. All teachers were instructed in the use of the software and physical fitness protocols.

Next, the developed course was implemented in four middle schools in Kazakhstan and lasted the whole academic semester (September-December 2022). All students had 3 lessons of 45 minutes each per week, and the semester lasted for 17 weeks. The total number of lessons was 50. Experimental data were collected both at the baseline stage of the study and after the course.

Participants

The study involved cohorts of students in 7th and 8th grades as well as two PE teachers from 4 middle schools in Aktobe City, Kazakhstan. Each school was represented by four cohorts: two included 7th graders and two included 8th graders. These were comprehensive schools with which the researchers were able to establish contact and that expressed a willingness to participate. Each of the schools had 4-5 classes corresponding to grades 7-8, with an enrollment of 27-36 students. The total student sample consisted of 338 students (191 girls and 147 boys). The mean age of participants was 13.2 ± 1.05 years.

To participate in the study, students had to: (1) regularly attend at least 75% of PE classes throughout the semester; (2) be a 7th or 8th-grade student; (3) obtain consent from parents/guardians to participate; (4) have no medical contraindications for attending PE classes; (5) own a smartphone. Teachers could join the study, provided they participated in the class in which they taught.

Procedure

The training took place from September to December 2022. All PE classes were held in person within the school gyms. The course involved traditional PE classes, during which students affixed accelerometers to their thighs, and a closed Facebook group as a form of communication between students and instructors. The teachers posted photo reports of each completed class along with the average PA levels of students to the Facebook group. All members of the group could comment on this information and share their thoughts and opinions. In addition, the individual results of the participants were not revealed. The primary function of the Facebook group was to enhance students' motivation to engage in physical education. They understood that they were training for improved results, which would be observed by their peers from other classes and schools, thereby encouraging them to strive for higher achievements. This group became a kind of honour board for some students, where they received likes and approvals, and their successes were commented on by their fellow students and teachers. Hate speech, mockery, and bullying were not tolerated, as the group administrator (one of the teachers) closely monitored such behaviour. The option to express disapproval was provided through dislikes or constructive criticism.

The teachers whose classes participated in the study col laborated closely with each other and with the researchers. A Telegram group was established for the exchange of information among teachers and researchers. Researchers had the opportunity to provide their recommendations, while teachers shared their experiences.

Upon completion of the course, an analysis was conducted to examine the changes in students' academic performance, physical activity, and motivation.

Measures

The students' PA during classes was measured using the triaxial accelerometers ActiGraph wGT3X-BT (ActiGraph Inc; Pensacola, FL, USA). Device specifications: size = 4.6cm x 3.3cm x 1.5cm, weight = 19g. These devices were attached to the right thigh of each participant. The PA data classification was performed according to the algorithm, proposed by Evenson et al. (2008):

• sedentary behaviour (SB): 0–100 counts per minute (CPM);

• light intensity physical activity (LPA): 101–2295 CPM;

• moderate-to-vigorous physical activity (MVPA): 2296–4011 CPM;

• Energetic behaviour (EB): over 4011 counts per minute

At the baseline stage and after the course, the students had to take some standard physical fitness tests, in accordance with the educational curricula established in the Republic of Kazakhstan for grades 5 to 9. These tests included a 60-meter sprint, long jump, ball throwing, and pull-ups, in addition to a motivation assessment. The tool for measuring motivation was the Motivated Strategies for Learning Questionnaire (MSLQ) developed by an educational psychologist Pintrich (1991). It consists of 31 items and assesses the goals and value beliefs of students regarding the course (Table 1).

Table 1.
Motivation scale (Pintrich, 1991)

Component		Number of items	Cronbach's alpha
Value components	Intrinsic Goal Orientation	4	.74
	Extrinsic goal orientation	4	.62
	Task Value	6	.90
Expectancy components	Control of Learning	4	.68
	Self-Efficacy for Learning	8	.93
Affective component	Anxiety	5	.80

According to Pintrich (1991), Intrinsic Goal Orientation indicates the student's perception of the reasons they are engaged in learning. It is the student's intrinsic goal in itself (challenge, curiosity, mastery). Whereas extrinsic goal orientation represents extrinsic incentives for student's participation in a certain task, such as grades, awards, and competition. Task Value refers to the student's perception of how interesting, how important and how useful course content is.

Control of learning is essentially the student's belief that their efforts will result in improved academic performance. Self-efficacy for Learning implicates one's self-assessment of the ability to deal with a task, as well as self-confidence and the expectation of success. Anxiety is the negative thoughts of students that interfere with performing tasks. Each questionnaire item had to be assessed on a scale from 1 to 5 (1 - strongly disagree, 2 - rather disagree, 3 – not sure, 4 – rather agree, 5 - strongly agree).

Statistical analysis

The pre-and post-course results were compared via Student's t-test for dependent samples ($p<0.01$), which was performed using the SPSS 27.0 statistical software. The indicators of students' physical activity and academic performance (PE test results) exhibited a normal distribution (according to Cain et al. (2017)), with skewness and kurtosis ranging from -1 to +1. The effect size was assessed using the standardized mean difference (Cohen's d). Interpretation was based on the following criteria: Small effect = 0.2, Medium Effect = 0.5, and Large Effect = 0.8 (Sullivan & Feinn, 2012).

Ethical issues

The study was approved by the ethics committee of each participating school. All students obtained written consent from their parents or guardians to participate in the study. The study procedures were conducted by the Declaration of Helsinki.

Results

Students' physical activity during PE classes

Table 2 presents descriptive and t-statistics of students' PA at the baseline stage and after the course. Prior to the introduction of the technology-based course, representatives of the first two schools demonstrated LPA in PE classes, while students of the other two mostly demonstrated MVPA. After three months of using accelerometers in class and sharing information on Facebook, students of each school significantly increased their PA levels ($p<0.01$). Upon the completion of the course, the average increase in PA was 1053 counts per minute. Moreover, each school demonstrated MVPA, which is a rather positive learning outcome.

Table 2.
Descriptive and t-statistics of students' PA (counts per minute) at the baseline stage of the study and after the course

	Baseline value	Post-course value	t	p	d
	Mean±SD	Mean±SD			
School 1	1289±18.6	3017±14.4	4.88	<0.01	103.889
School 2	2314±21.3	3244±12.6	5.16	<0.01	53.145
School 3	2181±14.5	2981±13.8	5.21	<0.01	56.52
School 4	2406±16.9	3159±15.1	7.34	<0.01	46.988
Average value	2047.5±17.8	3100.25±14.0	5.60	<0.01	65.746

For each of the schools, a notably strong intervention effect is observed ($d > 0.8$) in the context of increasing PA, with an average value across schools of $d = 65.746$ (Table 2).

Thus, the intervention proved to be a significant stimulus for enhancing physical activity during physical education lessons (RQ1).

Student fitness dynamics

As we can see from the table, the student's performance improved upon the completion of the course. Specifically, they were able to run the 60-meter sprint 1 second faster than before (10.1%) ($p<0.01$), which, in turn, changed the students' scores for this test from 3 to 4. When it comes to long jumps, the distance students could reach after taking the course increased by 43.7 cm (16.9%) ($p<0.01$). In ball throwing, the difference amounted to 6.6 m (23.4%) ($p<0.01$). Lastly, the number of pull-ups students could perform doubled (51.5%) ($p<0.01$).

A strong effect ($d > 0.8$) was observed for each of the tests (Table 3). From this, it can be inferred that the intervention significantly improved the physical fitness of the students (RQ2).

Student motivation

The data presented in Table 4 suggest that the use of

Table 3 shows the students' performances during physical fitness tests at the baseline stage and after the course. These tests are essential, as they determine the student's academic success.

web-based technologies positively affected students' intrinsic and extrinsic motivation, as well as goal orientation. These parameters before and after the course differ significantly.

On the other hand, there were no statistically significant differences in Control of Learning, Self-Efficacy for Learning and Anxiety. Although it is evident that students' Anxiety and Control of Learning exhibited slight improvements. Upon completion of the course, the overall motivation value increased from 2.87 to 3.46, which is a rather serious progress ($p <0.01$).

The intervention effect on Overall motivation ($d = 0.808$) can be classified as strong ($d > 0.8$). The highest values are observed for Intrinsic Goal Orientation ($d = 1.165$), Extrinsic Goal Orientation ($d = 1.785$), and Task Value ($d = 1.779$). Consequently, the intervention proved to be effective in enhancing participants' motivation (RQ3).

Table 3.
Students' baseline and after-the-course PE test results

	Baseline value	5-point scale assessment	Post-course value	t	p	
	Mean±SD		Mean±SD			d
Tests						
60-meter sprint, (sec.)	10.9±0.25	3	9.9±0.36	16.60	<0.01	-3.227
Long jumps, (cm.)	257.7±0.32	3	301.4±0.28	17.61	<0.01	145.34
Ball throwing, (m.)	28.2±1.12	4	34.8±1.67	18.63	<0.01	4.642
Pull-ups, (amt.)	3.9±0.88	3	5.9±0.70	50.20	<0.01	2.515

Table 4.
Descriptive and t-statistics of students' motivation during PE classes at the baseline stage of the study and after the course

		Baseline value	Post-course value	t	p	d
Component		Mean±SD	Mean±SD			
Value components	Intrinsic Goal Orientation	2.97±0.68	3.81±0.76	8.81	<0.01	1.165
	Extrinsic goal orientation	2.70±0.77	4.12±0.82	7.45	<0.01	1.785
	Task Value	2.54±0.75	3.78±0.64	6.12	<0.01	1.779
Expectancy components	Control of Learning	3.01±0.81	3.09±0.69	1.16	>0.01	0.106
	Self-Efficacy for Learning	3.16±0.66	3.05±0.75	1.34	>0.01	-0.156
Affective component	Anxiety	2.83±0.74	2.91±0.70	1.25	>0.01	0.111
Overall motivation		2.87±0.73	3.46±0.73	4.35	<0.01	0.808

* Statistically significant (p<.01)

Discussion

The results of our study have shown that the use of web-based technologies contributed to an increase in average PA levels among students (RQ1). Consequently, the higher PA improved students' performance on the 4 chosen physical fitness tests (RQ2).

Seah and Koh (2021) studied the effectiveness of using mobile apps to increase the PA of teenage girls during weekends. Noticeable differences between the experimental and control groups were recorded within the second week, which the authors attribute to the novelty effect (Seah & Koh 2021). Moreover, the authors report identified benefits of using the MapMyFitness app, according to the study participants: (1) increased motivation to perform PA; (2) facilitated self-monitoring of PA; (3) having a sense of autonomy in selecting the type of PA; (4) the ability to view friends' PA postings, which creates a sense of competition. However, Seah and Koh (2021) also found some difficulties in account setup as well as a lack of motivation to use this app regularly due to the inconvenience of certain features.

In comparison, Lee and Gao (2020) reported no effect after 2 weeks of using the iPad app during PE classes. Decreases in MVPA were observed in both the experimental and control groups (Lee & Gao, 2020). The authors note that such results were due to the short duration of the course and the incongruity between the app and the structure of PE classes. For this reason, in our study, efforts were made to ensure alignment across all four schools regarding course content, teaching methodology, and group communication on Facebook. Teachers and researchers maintained communication, exchanged information, and shared experiences. More importantly, our study lasted the whole academic semester. All these factors allowed for a significant increase in the PA and fitness dynamics of the participants and made the results of our study different from those of Lee and Gao (2020).

In addition, we have detected a statistically significant increase in students' internal, external and target motivation upon completion of the course (RQ3). Such motivation boost was found in all other physical activity studies where social media communication was part of the learning process (Al Ayubi et al., 2014; Degoy & Olmos, 2020; Divine et al., 2019; Krivsun, 2011; Wu et al., 2021). For instance, Wu et al. (2021) aimed to determine how watching Facebook live streams affected the respondents' dancing skills, learning motivation, and perception of PE classes. As a result, the experimental group reported being highly motivated and satisfied with the learning process and also noted improved dancing skills. A similar study by Awidi et al. (2019) revealed that Facebook interaction made the students feel supported by their peers, and inspired them to learn and engage with course content. Likewise, Divine et al. (2019) assessed the relationship between Facebook use, relatedness and exercise motivation. The obtained results were somewhat ambiguous. The authors report that the use of Facebook is associated with introjection and autonomous forms of motivation and that Facebook can either encourage or discourage students to exercise through connection/disconnection, positive/negative social comparison, or health-negating features. Hence, we can conclude that the use of devices and regular communication on social media platforms encouraged students to learn and achieve better results.

Limitations and prospects for future research

This study was constrained by its sample of Kazakhstani participants and had limited geographical coverage. Each school had its teachers, and their individual qualities could have influenced the course of the research. While this study achieved its objectives and addressed its primary research questions, several important aspects were not analyzed, such as differences between boys and girls, higher-achieving and lower-achieving students, students from different schools, students with varying levels of physical activity, and the correlation between Facebook activity and classroom activity. These areas remain open for exploration by future researchers.

Conclusion

To sum up, this study does not declare that technology alone can solve all existing education problems. Nevertheless, reasonable use of technology can contribute to high-quality learning. The authors confirmed that the well-planned and coordinated use of web-based technologies in middle school physical education improves students' physical activity, academic performance and motivation.

The modern educational environment is not conducive to physical activity. Therefore, PE classes should be aimed at minimizing the negative impact of a sedentary lifestyle that students are forced to lead when learning other subjects. This study demonstrated how physical activity, academic performance, intrinsic, extrinsic, and target motivation of students can be improved with the assistance of technology. The obtained results can be used by PE teachers to overcome the difficulties associated with the development of short-term, medium-term and long-term academic courses that involve the use of technology. Moreover, the findings of this study will help motivate students to learn.

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