

DOI:10.2478/tperj-2021-0004

## The Use of Digital Technologies in the Physical Education Lesson: A Systematic Analysis of Scientific Literature

Cristian MODRA<sup>1</sup>, Martin DOMOKOS<sup>2</sup>, Simona PETRACOVSKI<sup>3</sup>

### Abstract

**Introduction:** The development and diversification of digital technologies in modern era has got a tremendous influence in the field of Physical Education too.

This research's purpose is to examine the previous studies conducted upon the usage of these diverse digital technologies in the instructive and educational process for the subject of Physical Education.

**Methods :** Six electronic databases have been used to select the articles that include the usage of digital technologies for the Physical Education school subject. After applying the exclusion criteria, there have been selected and evaluated 26 scientific articles indexed during the years 2015 – 2016.

**Results:** We can notice that the worldwide technology evolution has contributed to the progressive growth of research regarding the usage of digital technologies even for the field of Physical Education. It was established that the technologies used for the lessons can improve the motor or moving skills and can improve the students motivational level for the Physical Education lessons. The current research also shows that digital technologies can be regarded as a way to involve students in cooperating with their peers. Important studies also refer to investigating the effects that short videos have upon the instructive and educational process itself as well as upon the students evaluation during the Physical Education classes. Using digital technologies (iPads, smartphones, tablets, audio players, computers and apps) doesn't necessarily involves giving up to the traditional methods, but furthermore, using them simultaneously, can improve the entire learning process, increasing the quality of the lessons and attracting the students towards the Physical Education classes. The article also presents some barriers that can appear in the process of integrating these digital technologies into the lessons. We notice that combining more learning methods of teaching (the reverse learning method with different games, learning by following instructions given with the help of augmented reality, integrating different ways of playing) in the course of Physical Education can bring benefits upon the motor abilities or movements performed by students.

**Conclusions:** In most of the studies that were analysed it can be noticed that positive results in the instructive and educational process were obtained in regard of improving the motor skills, the students learning abilities and motivation as a result of merging and integrating different digital technologies in the Physical Education classes.

**Keywords:** *physical education, digital technology, technology implementation, reverse learning*

### Rezumat

**Introducere:** Dezvoltarea și diversificarea tehnologiilor digitale în era modernă influențează foarte mult și domeniul educației fizice. Acest studiu are ca scop examinarea cercetărilor efectuate cu privire la folosirea diverselor tehnologii digitale în procesul instructiv-educativ la disciplina educație fizică.

**Metode :** Au fost utilizate șase baze de date electronice pentru a selecta articolele care includ utilizarea tehnologiei digitale la disciplina educație fizică. După criteriile de excludere au fost selectate și evaluate 26 de articole științifice indexate în perioada 2015-2020.

**Rezultate:** Se remarcă faptul că evoluția tehnologiei la nivel mondial a contribuit la creșterea progresivă a cercetărilor privind utilizarea tehnologiilor digitale la disciplina educație fizică. S-a constatat că tehnologiile folosite îmbunătățesc abilitățile motorii și cresc gradul de motivare a elevilor pentru lecția de educație fizică. Acest studiu arată de asemenea că tehnologiile digitale pot activa ca o sursă de implicare a elevilor în cooperarea cu colegii. Studii importante se referă la investigarea efectelor pe care le au utilizarea videoclipurilor atât în procesul de predare-învățare, cât și în evaluarea elevilor la disciplina educație fizică. Utilizarea tehnologiilor digitale (a iPad-urilor, smartphone-urilor, tabletelor, playerelor audio, computerelor și a aplicațiilor) nu impune renunțarea la metoda tradițională, ci prin utilizare simultană poate îmbunătăți întregul proces de predare-învățare, determinând o calitate superioară a lecțiilor și o atracție mai mare a elevilor pentru orele de educație fizică. Articolul prezintă și unele bariere care pot apărea în procesul de integrare a tehnologiilor digitale. Se observă că integrarea combinată a mai multor metode de predare (învățarea inversă combinată cu diverse jocuri, învățarea cu instrucțiuni asistate de realitate augmentată, implicarea diferitelor metode de joc) în cadrul disciplinei educație fizică, are efecte benefice asupra învățării motrice la elevi.

---

<sup>1</sup> PhD Student, West University of Timișoara, Faculty of Physical Education and Sport, Romania, email: [cristian.modra@e-uvvt.ro](mailto:cristian.modra@e-uvvt.ro)

<sup>2</sup> Associate Professor, West University of Timișoara, Faculty of Physical Education and Sport

<sup>3</sup> Professor, West University of Timișoara, Faculty of Physical Education and Sport

*Concluzii:* În majoritatea cercetărilor analizate se observă obținerea unor efecte pozitive asupra procesului instructiv-educativ, prin îmbunătățirea abilităților motorii, a învățării și a motivației elevilor, în urma integrării diferitelor mijloace tehnologice digitale în lecția de educație fizică.

**Cuvinte cheie:** *educație fizică, tehnologia digitală, implementarea tehnologiei, învățarea inversă*

## Introduction

Implementing digital technology can improve the physical education lesson through a multitude of graphics, sequences or still images, kinograms, audio-video recordings, animations, which keep the student focused on the given issue in the learning process, enabling them to improve their creative thinking skills. By using digital technology in the physical education lesson, the student has the opportunity to get a much clearer picture of what they are going to do, while it also facilitates their interest in working with these devices individually, understanding how to make the movement right and improving intuition. Following the development and diversification of digital technologies in today's society there is an increase in research into the integration of these technologies to discipline physical education. With an increasing and diverse number of technological means available, teachers have started to use these technologies and applications more and more frequently during their physical education classes, in order to make them more attractive and to facilitate learning.

A number of contributions arise as to how digital technology can be applied in order to improve teaching and learning in physical education lessons [1, 2]. In the learning process, the successful integration of a digital technology in the lesson of physical education by a teacher can improve the pace of motor learning [3]. The study carried out by researchers [4] provides an overview of the most important mobile digital technologies used in the physical education lesson and the considerations underlying their use. The rapid development of mobile digital technologies (tablets, iPad, computers, applications) and their accessibility have made them widely used in physical education lessons [5, 6, 7]. Bodsworth & Goodyear [7] present the facilities and barriers that can arise to the integration of digital technology (especially iPad's) into the physical education lessons. The implementation of digital technologies into the discipline of physical education can lead to an improvement in the testing of students' physical abilities [8, 9].

Following the research conducted on the integration of digital technologies in the physical education lesson, positive results were observed in terms of pupils' understanding and the cognitive motivation of students [10, 11]. There is some research that shows the positive impact on motor performance [12, 13, 14] and on physical activity [15]. Lee & Gao [16] study the short-term effects of the use of digital technology in physical education lessons on the level of physical activity of primary school students and on their psychosocial beliefs. The used technologies can measure physical activity

or record and track movement, so it helps students to self-evaluate. These devices can range from cameras, pedals, heart rate monitors to active video games and applications [17]. The video images can be used to improve and assess students' movement skills during physical education hours.

An important procedure is the use of digital video in the teaching-learning and assessment process in the discipline of physical education, which in most cases leads to positive learning outcomes results in terms of learning and enhances the cognitive understanding of pupils [18]. Koekoek et al. [19] conducts a study on the labeling of video images used by teachers in the process of teaching the physical education lesson. This study involves the innovation and development of a digital video tagging application. Tagged videos are immediately accessible and help students learn. Using digital video clips on smartphones or tablets can be a way for physical education teachers to motivate students to improve their self-assessment skills. The videos are used in both teaching and evaluation [11]. Learning videos that present the stages of a movement can be used in conjunction with a special application that describes the learning model based on a custom system. Thus, students have independence and responsibility in the learning process [20]. An innovative version is the video played on 3600.

There are few research studies on the use of this choice of technologies in physical education. The study by Paraskevaïdis & Fokides [21] uses the video played on 3600 in the process of teaching basic techniques in the volleyball game. The obtained results indicate a more effective quality of the game techniques in the students of the group being studied. Researchers have concluded that it is quite difficult to use such videos at present in the teaching process.

Virtual and augmented realities are also technologies that can be used in physical education lessons through accessible digital devices (smartphone or tablet) and they can also improve learning. As a completion to the video support often used in the physical education lesson, there is an augmented reality application introduced [22]. Augmented reality-assisted learning offers a possibility for interactive operation, therefore improving motor skills learning. The experimental results presented show that this type of learning has a better performance than video learning.

Quintas-Hijós et al. [23] analyzes the effects of applying a process that combines both physical exercise (gamification) as a teaching method and gaming (exergame) as an educational resource within physical education classes. The effects of this

use consist of positive attitudes such as self-learning, motivation and fun.

Digital technology also offers the opportunity to observe motor performance, both before and after classes. Students have the opportunity to record, track and evaluate themselves or in groups the images with the motor actions made by them. Immediate feedback is a useful teaching tool in physical education classes. Providing feedback on the pupils' physical activity contributes to making learning more effective. Hartwig's et al. study[24] develops a system capable of providing feedback quickly. The video feedback is an example of interference between digital technology and training. The student evaluation process is an area where digital technology is imprint [25]. The excessive use of digital valuation risks obtaining data that is not relevant.

Friskawati et al. [26] have identified four major challenges that can arise from the deployment of digital technology in physical education lessons: from teachers, students, the environment and from schools. Digital technology can be a transformation of the learning process. When the lesson focuses on psychomotor, physical and emotional achievements, the use of technology can benefit pupils and teachers [27].

The **aim** of this systematic analysis of specialized literature is to analyze research into digital technologies used in physical education lessons.

The **objectives** of this study are :

-to present an up-to-date analysis of scientific literature on the use of digital technologies in the physical education class ;

-to aim to identify and highlight new research trends in different teaching-learning methods regarding physical education discipline by using digital technologies ;

The following **assumption** has been issued: there is a link between the use of digital technologies and the improvement of pupil's motor skills in physical education classes.

## Materials and Methods

### Data collection

To conduct this study, a systematic search of electronic databases was performed: Scopus Database, Web of Science, ProQuest, Journals Springer, Research Gate, Google Scholar, NUS. A first search was carried out using the keywords: "physical education", "digital technology", "technology deployment", "reverse learning", followed by a combined search using both keywords, along with the search option to identify these words in the summary. The search period includes indexed publications (published) from January 2015 to December 2020.

Criteria for eligibility:

In order to be included in the review, scientific work had to fulfill the following criteria:

- be original articles, published in academic journals or in conference works;
- be published between 2015 and 2020 ;
- present research on at least one type of digital technology used in the physical education class ;
- be articles that have been written for a research purpose;
- be articles including experimental studies;
- the participants should be mostly students;
- be articles written only in English.

There have been excluded:

- articles of revision, editorial, summaries and letters;
- articles on the integration of technologies in teachers' or students' training ;
- duplicate items appearing in various databases;
- articles referring to pupils with disabilities or diagnose with a variety of disorders;
- articles not referring to the physical education discipline.

Figure 1 shows the plan of the Prism diagram used for the selection of scientific studies.

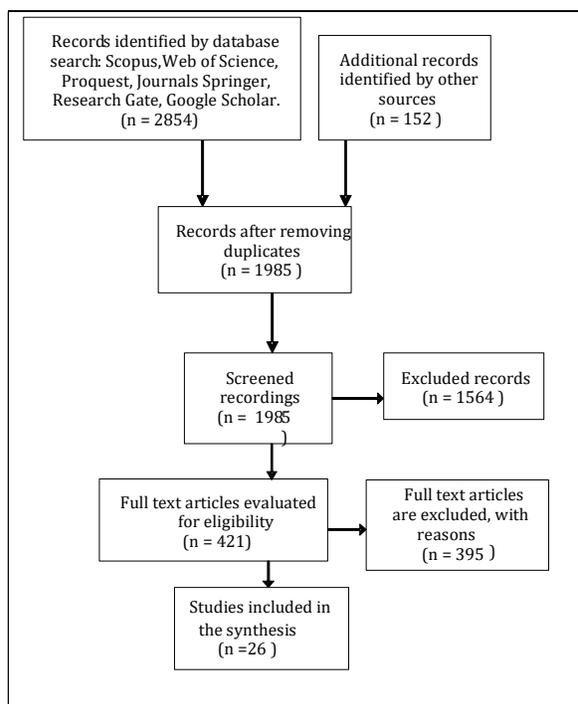


Figure 1. Prisma flow diagram

## Results

From the diagram shown in Figure 1 it is noted that 2854 items have been identified from the databases. 26 articles have been included in our study. These articles were published in 2015 (n=1; 3,85%), 2016 (n=2; 7,69%), 2017 (n=4; 15,38%), 2018 (n=4; 15,38%), 2019 (n=3; 11,55%), and in 2020 (n=12; 46,15%). There is a trend toward an increase in the number of articles published on this subject in 2020, some of which are research studies designed by comparison between the control group and the experimental group (n= 10; 38,46%). The control group shall be the one using the traditional method of teaching the physical education class, and one or more digital means or combinations thereof shall be used in the experimental group. Some studies do not include this comparison (n =15; 57,70%).

Four (15,38%) studies included in this review are based on a quasi-experimental design. Qualitative research is predominantly used as research method, using open question questionnaires (n=15; 57,70%), semi-structured interviews (n= 2; 7,69%) and group focus interviews (n= 7; 26,92 %). The sample of studies varied from 0-50 students (n= 7; 26,92%); 50-100 students (n= 8; 30,76%), 100-500 students (n= 9; 34,62%) and an undeclared number of students (n= 2; 7,69%).

Among the most commonly used digital technologies in selected studies are: Tablets (n=5), iPad (n=10), smartphone (n=3), computer (n=4), applications (n=4). These are studies that analyze the integration of more digital technologies (n= 4; 15,38%) into the physical education class. The video technique and the use of videos are found in half of the research contained in the selected articles (n= 13; 50%).

The use of some types of games in the physical education class is analyzed in three articles (11,54%), and the effects of different combined teaching methods using digital technology are presented in four articles (15,39%). Of these, three relate to reverse learning (11,54%) and one article studies teaching with instructions assisted by the augmented reality. In three articles researchers investigate the impact of video feedback in physical education lclasses on students (11,54%), one of which also analyzes self-controlled video feedback. (3,85%).

The items selected in this review, which point to a beneficial effect of integrating different types of digital technologies into the physical education class, represent 88,46%. (n=22). The most commonly observed effects concern learning effectiveness (n= 14), the development of motor skills (n= 7), motivation (n= 5). One article (3,84%) presents the challenges that may arise from the deployment of digital technologies, and two studies

also point to the potential negative effects of using them (7,69%).

Table I presents the bibliographic sources included in the review.

**Table I. Bibliographic sources included in the review**

AUTHORS	METHODS	RESULTS
Legrain P., Gillet N., Gernigon C. & Lafreniere M.- A. [10]	Objective: testing an integrative model in order to evaluate its effects in physical education classes Participants: - 96 students, age: 12-13 years old (44 boys and 52 girls) - quasi experimental design - mobile phones, camcorder	Improvements: - cognitive abilities - the students' motor performance
Lindberg R., Seo J. & Laine T.H. [28]	Objective: learning the effects of a game performed for this study (running Othello2 game with portable technology) Participants: - 61 students in the third grade - control group (29 students) - experimental group (32 students) - pre-test and post-test - the game running Othello 2 - accelerometer	- higher effectiveness in learning to exercise and increase motivation in physical education classes
Zhu X. & Dragon A.L. [29]	Objective: investigating the effects of the integration of mobile technology on students' interest and the fluctuation of physical activity in the physical education class Participants: - 53 sixth grade students, age: 10-12 years old (38 girls and 15 boys) - quasi-experimental preliminary design - comparison group - experimental group - iPad and applications - accelerometer	- students in the comparison group are more interested in physical education lessons - integrated mobile technology (iPad and applications) in the physical education class may not be effective in order to increase the level of physical activity of students in a short time
Bodsworth H. & Goodyear V.A. [7]	Objective: exploring barriers and facilities for technology integration Participants: - 36 students, age: 11-12 years old - interviews with groups of students - interviews with the didactic researcher - reflections and observation of a colleague - iPad - Dartfish application	- facilities: digital technologies uphold students' group learning - barriers: students' digital competence (they need time to use technology)
Luptáková G. & Monte B.A. [30]	Objective: creating a video exercise called "Brain Break" Participants: - 94 high school students (46 girls and 48 boys) - questionnaire (designed to investigate students' learning outcomes, participation, evaluation and attitudes towards the application) - statistical analysis	- improving selected social skills - better relationships with teammates - acquired knowledge about music and video editing 40%
Robinson D.B. & Randall L. [5]	Objective: investigating the implementation of various digital technologies Participants: - 206 in the polls, 12 in the focus group - survey with online questionnaires and interviews (focus group)	- technologies used more often (iPad, audio players, computers) - frequently used video analysis software and applications (Dartfish, iTouch)

	<ul style="list-style-type: none"> <li>- mixed methods, iPad, audio players, computers</li> <li>- applications</li> </ul>	
Kretschmann R. [31]	<p>Objective: determining the impact of video feedback over swimming performance</p> <p>Participants :</p> <ul style="list-style-type: none"> <li>- 31 students (fifth grade)</li> <li>- experimental group (16 students)</li> <li>- control group (15 students)</li> <li>- tab</li> <li>- semi-structured interviews</li> </ul>	video feedback - effective for improving swimming performance
Koekoek J., van der Mars H., Walinga W. & Hilvoorde I. [19]	<p>Objective: pilot study of the use of digital technology in developing students' knowledge of game tactics</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- 5 groups of students, age: 13-14 years old</li> <li>- Dartfish label board</li> <li>- tables equipped with cameras that produce digital video images</li> <li>- interviews</li> </ul>	<ul style="list-style-type: none"> <li>- innovation, introduction and development of a digital video tagging application</li> <li>- learning and correcting movements</li> </ul>
Ashanin V., Filenko L., Pasko I.V., Tserkovna A.O., Filenko I., Poltoratskaya I. A. et al. [32]	<p>Objective :</p> <ul style="list-style-type: none"> <li>-study the influence of rugby-5 sessions on functional and physical abilities</li> </ul> <p>Participants :</p> <p>62 students, age: 12-13 years old (18 girls and 44 boys)</p> <ul style="list-style-type: none"> <li>-computer, video</li> <li>-analysis of the scientific literature</li> <li>-testing (running 30 m, long jump, etc.)</li> <li>-Ruffier's functional test</li> <li>-methods of mathematical statistics</li> </ul>	<ul style="list-style-type: none"> <li>-rugby-5 was introduced in physical education classes;</li> <li>-computer training program for theoretical training</li> <li>-functional state of health -45.8%,</li> <li>-physical development -17.2%</li> <li>-improving students' cardiovascular system</li> </ul>
Glapa A., Grzesiak J., Laudanska-Krzeminska I., Chin M.K., Edginton C.R., Mok M.M.C. et al. [33]	<p>Objective: study the Brain Breaks® physical activity program in students</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- 326 students from the third grade up to the fifth grade, age: 9 -11 years old (170 boys and 156 girls)</li> <li>- experimental group -264 students</li> <li>- control group -62 students</li> <li>- technological system, videos</li> <li>- post-test</li> <li>- survey with questionnaires</li> <li>- questionnaire of anthropometric measurements (body length and weight)</li> </ul>	- the Brain Breaks® physical activity program improves learning self-efficacy
Potdevin F., Vors O., Huchez A., Lamour M., Davids K. & Schnitzler C. [34]	<p>Objective: investigate the effects of using video feedback on the acquisition of motor skills, self-assessment skills and motivation</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- 43 students, age: 12-13 years old</li> <li>- experimental group (10 girls - 8 boys)</li> <li>- control group (12 girls - 13 boys)</li> <li>- Camcorder</li> <li>- Questionnaires</li> </ul>	<p>Using video feedback improves:</p> <ul style="list-style-type: none"> <li>- the performances of motor skills</li> <li>- the students' ability to self-evaluate during a physical education program</li> </ul>
Hartwig T.B., del Pozo-Cruz B., White R.L., Sanders T.,	<p>Objective: development and validation of a system capable of providing feedback</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- 492 students, age: 13-14 years old (eighth</li> </ul>	<ul style="list-style-type: none"> <li>- the ability to monitor the system can provide good results;</li> <li>- it can generate feedback in regular</li> </ul>

Kirwan M., Parker P.D. et al. [24]	<p>grade)</p> <ul style="list-style-type: none"> <li>- 100 students, age: 10-11 years old(third and fourth grade)</li> <li>- an application for a smart device and wireless pedometers</li> <li>- accelerometer</li> </ul>	physical education classes
Chang K.E., Zhang J., Huang Y.S., Liu T.C. & Sung Y.T. [22]	<p>Objective: verifying the effects of learning motor skills and learning motivation with augmented reality-assisted instruction</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- 52 seventh grade students</li> <li>- control group - 25 students</li> <li>- experimental group - 27 students</li> <li>- quasi-experimental design, pre-post-test</li> <li>- identification test on motor skills</li> <li>- motor skills assessment scale (Arnheim and Sinclair's)</li> <li>- the learning motivation measurement (Keller's measure)</li> <li>- computer</li> </ul>	augmented reality-assisted instruction is more effective than video-assisted instruction in terms of learning motor skills
Friskawati G. F., Karisman V.A. & Stephani M. R. [26]	<p>Objective: determining the challenges of using technology in the physical education class.</p> <p>Participants :</p> <ul style="list-style-type: none"> <li>- 49 physical education teachers</li> <li>- survey - open questionnaire</li> </ul>	<p>Four challenging indicators:</p> <ul style="list-style-type: none"> <li>- environmental factors 32%</li> <li>- teacher 28%</li> <li>- students 24%</li> <li>- school 16%</li> </ul>
Quintas-Hijós A., Peñarrubia-Lozano C. & Bustamante J.C. [23]	<p>Objective : studying the applicability of the gamified exergaming intervention using a qualitative method</p> <p>Participants :</p> <ul style="list-style-type: none"> <li>- eight teachers</li> <li>- 417 students, average age: 11-12 years old (53.2% girls and 46.8% boys)</li> <li>- 50.4% fifth grade students</li> <li>- 49.6% sixth grade students</li> <li>- field notes</li> <li>- questionnaire with open questions</li> <li>- individual semi-structured interviews</li> <li>- focus group interviews</li> </ul>	<p>The evaluations of the gamified system were positive :</p> <ul style="list-style-type: none"> <li>- evaluation (28.6%)</li> <li>- its motivating character (28.1%)</li> <li>- the informative character (13%)</li> <li>- the ability to individualize feedback (12.5%)</li> </ul> <p>Negative comments:</p> <ul style="list-style-type: none"> <li>- the feeling of indifference (6.3%)</li> <li>- stress (4.7%)</li> <li>- frustration (2.6%)</li> </ul> <p>The main source of motivation came from the game's atmosphere The points system as a game strategy determined a greater motivation.</p>
Williams L., Martinasek M.,Carone K. & Sanders S. [35]	<p>Objective: evaluating the students' perception regarding the traditional and online teaching of the physical education class</p> <ul style="list-style-type: none"> <li>- 506 high school students</li> <li>- 355 students</li> <li>- survey method</li> <li>- 13 questions</li> <li>- a quantitative evaluation on 13 variables which included didactic perception, the teacher and personal components</li> <li>- computer</li> </ul>	<p>Quantitative evaluation:</p> <ul style="list-style-type: none"> <li>- 47% girls; 53% boys (high school)</li> <li>- 29% girls; 71% boys (students).</li> </ul> <p>Qualitative evaluation: positive perceptions of high school students and students are approximately equal (in terms of feedback, teacher's ability to respond, understanding and interest in content)</p>
Lee J.F. & Gao Z. [16]	<p>Objective: examination about the short-term effects (two weeks) belonging to the integration of mobile devices in the physical education class</p> <p>Participants :</p>	<ul style="list-style-type: none"> <li>- use of short-term digital devices have little influence on the increase of children' physical and psychosocial activity as</li> </ul>

	<ul style="list-style-type: none"> <li>- 157 students, age: 9-11 years old (fourth and fifth grades)</li> <li>- comparison group -77 students</li> <li>- traditional group - 80 students</li> <li>- quasi-experimental design</li> <li>- questionnaires</li> <li>- iPad and mobile applications</li> <li>- accelerometer</li> </ul>	<p>compared to the traditional physical education classes.</p>
Vega-Ramírez L., Notario R.O. & Ávalos-Ramos M.A. [36]	<p>Objective: analyzing the use of the smartphone and evaluating the degree of satisfaction attributed to the Polar Beat application within the physical education class</p> <p>Participants :</p> <ul style="list-style-type: none"> <li>- 40 students, age: 16-18 years old (24 girls, 16 boys)</li> <li>- Polar Beat application</li> <li>- Smartphones</li> <li>- two quantitative questionnaires</li> <li>- statistical data analysis</li> </ul>	<p>The Polar Beat application allows:</p> <ul style="list-style-type: none"> <li>- to better understand the projected activities</li> <li>- a more cursive activity rhythm</li> </ul>
Greve S., Thumel M., Jastrow F., Krieger C., Schwedler A. & Süßenbach J. [37]	<p>Objective: the way in which students interpret and experience the use of digital media in the physical education class</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- four classes of elementary school students</li> <li>- interviews (39 interviews)</li> <li>- tabs and iMovie application.</li> </ul>	<p>Digital media in physical education classes can be beneficial for:</p> <ul style="list-style-type: none"> <li>- students' motor performance</li> <li>- educational skills</li> </ul>
Kok M., Komen A., van Capelleveen L. & van der Kamp J. [38]	<p>Objective: examining the effects of self-controlled video feedback</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- 56 first grade students</li> <li>- a group with self-controlled video feedback: 22 students</li> <li>- a group with externally controlled video feedback: 17 students</li> <li>- a traditional group - 17 students</li> <li>- iPads</li> <li>- cameras</li> <li>- a scale for evaluating the throwing technique</li> <li>- pre-, post- and retention tests</li> </ul>	<p>Self-controlled video feedback has positive effects on:</p> <ul style="list-style-type: none"> <li>- self-learning effectiveness</li> <li>- the group (with self-controlled video feedback) has a greater learning effect</li> <li>- both distance and throwing technique have increased as well</li> <li>- improved self-efficacy for the self-controlled video feedback group and the traditional group.</li> </ul>
Steinberg C., Zühlke M., Bindel, T. & Jenett F. [6]	<p>Objective: surprises the socio-cultural practices of young people who have used digital technologies (mobile phone) in physical education classes</p> <p>Participants:</p> <ul style="list-style-type: none"> <li>- students (13th grade)</li> <li>- interviews with students (6)</li> <li>- mobile phone</li> </ul>	<ul style="list-style-type: none"> <li>- digital mobile technologies can be integrated into physical education classes</li> <li>- digital technology can be used for analysis and correction of the movement techniques</li> <li>- more challenges appertaining to sports teaching in terms of individualization and extension of teaching - learning outside the gym</li> </ul>
Zhou S. [39]	<p>Objective: the way of using and the role of modern technologies in teaching physical education</p> <ul style="list-style-type: none"> <li>- theoretical study</li> </ul>	<ul style="list-style-type: none"> <li>- teaching with the help of modern digital technology plays an auxiliary role in teaching physical education</li> </ul>
Sheng L. [40]	<p>Objective: analysis of the need and effects of using</p>	<ul style="list-style-type: none"> <li>- students' satisfaction with the use of</li> </ul>

	computer-assisted training in teaching physical education Participants: - 300 students - Questionnaires	- computer-assisted instruction was 55.8% - 49.3% were not satisfied with the content of computer-assisted training
Hinojo Lucena F.J., Belmonte J.L., Cabrera A.F., Torres J.M.T. & Sánchez S.P. [41]	Objective: analysis of the effectiveness of reverse learning in comparison to traditional learning in the physical education class Participants: - 119 students - 60 sixth grade students (26 boys, 34 girls; 12 years old) - 59 students - secondary education (23 boys, 36 girls; 16 years old) - control group - experimental group - questionnaire, semi-structured individual interviews and focus group interviews - descriptive and correlational experiment	Experimental group: - obtained better evaluations on academic indicators (motivation, autonomy and interaction) - high learning effectiveness
Segura-Robles A., Fuentes-Cabrera A., Parra-González M.E. & López-Belmonte J. [42]	Objective: analysis of the effects of a reverse learning program based on games on autonomy, competence and relationship with other students in the physical education class Participants: - 64 students, age: 15 years old (secondary education) - control group - experimental group - pre-test and post-test data	Improvements in: - autonomy - student satisfaction - student motivation
Østerlie O. & Mehus I. [11]	Objective: examining the effects of using the reverse learning method in the physical education class (a situational motivation) Participants: - 206 students, age: 15 years old (48% girls) - experimental group (85 students; 42.4% girls) - control group (121 students; 50.5% girls) - online videos - questionnaires	- more efficient acquisition of knowledge with the use of online videos - negative motivational switch for male students

## Discussion

The main purpose of this study was to identify the most relevant articles which present the trends in the use of digital technologies in physical education classes. This study shows that most researchers are interested in both the integration of new technologies and the effects they can produce in the instructional-educational process. Importantly, most of the selected articles are based on the use of Ipad, smartphones, tabs, audio players, computers and applications as digital media for learning in physical education classes. [5-7, 11, 16, 19, 22, 29, 32, 36-39, 42]. In addition to the other works, the article by Robinson & Randall [5] presents a classification of the most important technologies.

Generally, most of the articles selected in the review have positive effects on integrating digital technologies into the physical education class. Most researchers have concluded that the most important benefits of using digital technology are: the increased learning effectiveness in students [7, 32, 36-37], the improved motor skills [10, 37, 39] and the increased motivation [32, 36]. In the article by Ashanin et al. [32] it is shown that modern procedures of teaching physical education by presenting game tactics and using digital technology increase the students' interest to practice physical activities. Unlike others, there is an article in the review that makes an analysis of students' socio-cultural practices by developing a model which allows a description of the practices of digital technology used in physical education. The results

of this study indicate that digital technologies can be integrated into the physical education class in order to analyze and correct movement [6].

From the reviewed studies we noticed that there is a higher motivation in students to use iPads, smartphones and tablets into the learning process [36,39]. When using computer-assisted instruction [40], students better understand the movements they need to learn during classes and they are very satisfied with the teaching process. In addition to experimental research, Strikes et al. [37] review the state of research on the use of digital media in the physical education class. The experiment consisted of some students creating media products using tabs and applications. The obtained results demonstrate that the use of technology in the classes is beneficial both for the acquisition of motor skills and for the acquisition of the skills using gadgets.

In this review there are two selected studies which analyze the barriers and challenges that may arise in integrating digital technologies into physical education classes [7, 26]. As to the research conducted by Friskawati et al. [26], it reveals four challenges that arise when using digital technologies. The main challenge is represented by the environmental factors (32%), due to the problems of accessibility and availability of the infrastructure and multimedia equipment. The second challenge is indicated by teachers, due to the lack of experience in the use of digital technologies and applications. 24% of students constitute a challenge factor, due to the fact that they do not know how to use technologies for learning purposes. The other article is more complex, based on the use of the iPad, tabs and applications for conducting physical education classes mixed with the cooperative learning pedagogical model [7]. When it comes to technology, the barrier identified in this case is the lack of both knowledge and of the teaching method used and last, but not least, a deficient cooperation between students of the same group.

In addition to the positive effects of the use of digital technologies in the teaching-learning process of physical education, this review contains two articles which indicate that the use of technologies does not have positive effects [16, 29]. Although the articles were published 5 years apart, they reached the same result, namely that the digital technology (iPad and applications) used in physical education classes for a short period of time (the experiments lasted two weeks) do not lead to an increase in students' physical activity. Both studies have a quasi-experimental design and use the accelerometer in order to determine physical activity. In the case of the research conducted by

Zhu & Dragon [29], the sample of students was smaller (53 students; 12-13 years old) and there was a lower interest in students who took the classes with the help of technologies rather than those who did the traditional ones. Lee & Gao [16] conducted the research with a larger number of students (157; 9-11 years) and observed a small influence on the increase of students' psychosocial activity.

In the articles included in the review, several works in which it is argued that audio-video applications can improve the teaching level of the physical education are selected. The articles include research related to the use of videos in the teaching, learning and assessment process [7, 11, 19, 22, 30-33, 41-42]. Thus, videos are a source to support student learning and to correct movement in physical education classes. In the article by Koekoek et al. [19] it is mentioned that besides the positive effects of using videos, they are also combined with educational game strategies. Thus, a digital video labeling application system which can be developed by students is proposed. By watching the videos, students can analyze game tactics, with a better control of the movements. At the same time, by reviewing them, students can easily identify the mistakes they made, while correcting and learning from them. Glapa et al. [33] follows the analysis of the results obtained after studying the use of a video-based activity program in primary school students, where they found an improvement in self-efficacy.

One of these articles includes a pedagogical experiment, through which students must create a video exercise. Following this experiment, the statistical results indicate an improvement of the group activity, the acquisition of some knowledge (56% capacity to elaborate some exercises, 40% video editing capacity). Following the results obtained, the researchers identified a significant increase in students' creative abilities [30].

By using video technology, teachers have the opportunity to provide instant feedback on students' motor performance. Some articles present video feedback as a positive effect obtained from the application of digital technology in the evaluation process - specific to physical education [31, 34, 38]. Video feedback can be a useful tool used to improve student instruction. Two of the presented articles include research showing that the use of video feedback improves the performance of motor skills, self-assessment and students' motivation during a physical education class [31,34]. Kok et al. [38] conducted a complex research on the effects of self-controlled video feedback, comparing it to the video and traditional feedback. They found that using self-controlled

video feedback in students improves learning and self-efficacy. In this context, researchers Hartwig et al. [24] developed a monitoring system that can provide feedback during physical education classes for students' motor activity.

This review also includes selected articles that present the promotion in physical education lessons of various digital technologies focused on games, which are used for learning purposes and for students' development [23, 28, 33]. Games play an important role in physical education classes, especially for inactive children, because they can stimulate their motor skills. The authors of the first two articles use "exergames" in their research, which combine physical exercises with digital games. In the first study, a game with portable technology, called *Running Othello2*, is used during physical education classes, and the observed effects consists in a greater physical activity effectiveness, with an increased motivation and a better learning effect after using it [28]. In comparison, the second study uses two combined digital games, one as a teaching method and the "exergame" game as an educational resource, analyzing their applicability to physical education [23]. The results obtained for this game system are positive, noticing an improvement in students' learning performance. There were also negative comments about frustration and indifference. The introduction of the game (exergame) in physical education classes is associated with fun and merriment. Both studies are performed in comparison to the traditional learning method of the discipline.

Some articles refer to the use of combined teaching methods in which digital technology is integrated, so as to analyze the effects on the teaching-learning process in the physical education class [11, 22, 41-42]. Three articles analyze the reverse learning process and one deals with augmented reality-assisted training. While Hinojo Lucena et al. [41] and Østerlie & Mehus [11] analyze the effectiveness of reverse learning over the traditional learning in physical education classes, Segura-Robles et al. [42] analyzes the effects of reverse learning mixed with games.

For the study, Hinojo Lucena et al. [41] use an approach to the reverse learning method, in which the development of lessons is based on watching videos and teaching software. The results obtained from the use of the reverse learning method, as compared to the traditional teaching method, show a better evolution of academic indicators (motivation, autonomy and interaction) and a high efficiency in learning, in the case of the students who were trained by the experimental method. This method is effective in both primary and secondary

education, facilitating the teaching process of physical education.

When it comes to the study conducted by Østerlie & Mehus [11], the students from the experimental group who participate in the teaching through the reverse learning method, have access to videos that present the topics of the lesson topics. This research shows a better cognitive knowledge learning by students as compared to the traditional teaching method.

Positive results were also observed in the study conducted by Segura-Robles et al. [42]. To carry out this research, the results obtained from reverse learning mixed with the use of a game (escape room) and with traditional learning were compared. The reverse learning method is used to teach the content of the lessons (audio-visual presentation) and the game is used to achieve the objectives. The experimental method is a combination of reverse learning and the "escape room" game method, in which teaching is done digitally. The tests, the challenges which the students in the experimental group had to solve were based on various physical activities (strength, running). It has been found that the new teaching methods based on the interaction between play and reverse learning lead to an improvement in students' autonomy, satisfaction and play pleasure. The new method used improves students' learning.

In a complex study, the article by Chang et al. [22] presents the effects the teaching method has over the augmented reality-assisted instruction on learning in the physical education class. The teaching content of the augmented reality system is combined with 3D representations about learning motor skills. The results were obtained by comparison with the video-assisted instructional learning method. The results show that there is an improvement in the effects of learning motor skills and learning motivation when using the combined method of augmented reality-assisted instruction with 3D representations.

Furthermore, in the context of comparing different teaching methods used in physical education lessons is included the selected article, which presents students' perceptions of the online teaching process [35]. An analysis by comparison between the online physical education lesson and the traditional one is presented, in order to see the differences between the perceptions of high school students. The results obtained from this analysis indicate positive perceptions for both online and traditional courses. Feedback, understanding and interest in content are the most important positive perceptions of students for both teaching methods. From the data obtained in accordance with the

applied questionnaire, none of the students stated that they improved their motor skills [35].

### Conclusions

The first and most important conclusion that can be observed from the analysis of the studies is that the application of digital technologies in physical education classes play an important role in strengthening students' teaching and training. Most of the research in the selected and studied articles indicate that, by using digital technologies in the teaching-learning process, the level of theoretical knowledge and students' motor skills are improved. The videos used in the physical education class are an important tool for improving the teaching and learning system and for assessing students' motor skills. The use of videos in the physical education activity contributed to the increase of the students' interest for the taught content, motivating them to actively participate in the lesson. During this research, it was observed that the use of digital games combined with various teaching methods (reverse learning, augmented reality learning) can be innovative models for learning content components specific to the physical education class, improving the lessons' quality and often motivating students to learn. This review could encourage physical education teachers to use various digital technologies in lessons, generating one or more benefits highlighted during this analysis (improving motor skills, learning, or motivation).

It is important to know the state of research on the use of digital technologies in the physical education class, in order to use those technologies and teaching methods which are best suited to our education system, with an eye to obtain the best benefits for students.

In the future studies we aim to review the articles that appear in scientific publications during 2021, those which present research on the integration of digital technologies in the physical education lessons and those which addresses the effects of online teaching in the current context of the pandemic. It would be very interesting to conduct a bibliometric study of the articles published in recent years, one that studies the impact of using digital technologies in physical education classes.

### References

1. Wintle J. (2019). *Digital technology in physical education: global perspectives*. Sport, Education and Society, 24 (6), 665-667.
2. Wyant J. & Baek J.H. (2018). *Re-thinking technology adoption in physical education*. Curric. Stud. Health Phys. Educ., 10, 3-17.
3. Sargent J. (2017). *Digital technologies and learning in physical education: Pedagogical cases*. Digital Technologies and Learning in Physical Education: Pedagogical Cases, 3322, 1-264.
4. Palička P., Jakubec L., Zvoniček J. (2016). *Mobile apps that support physical activities and the potential of these applications in physical education at school*. Journal of human sport & exercise, 11 (1), 176 - 194.
5. Robinson D.B. & Randall L. (2017). *Gadgets in the gymnasium: physical educators' Use of digital technologies*. CJLT/RCAT, 43 (1), 1-21.
6. Steinberg C., Zühlke M., Bindel T. & Jenett F. (2020). *Aesthetic education revised: a contribution to mobile learning in physical education*. Ger. J. Exerc. Sport Res., 50, 92-101.
7. Bodsworth H. & Goodyear V.A. (2017). *Barriers and facilitators to using digital technologies in the cooperative learning model in physical education*. Physical Education and Sport Pedagogy, 22, 563-579
8. Cohen D.D., Voss C. & Sandercock G.R. (2015). *Fitness testing for children: Let's mount the zebra!* J. Phys. Act. Health, 12, 597-603.
9. Vazou S., Mischo A., Ladwig M.A., Ekkekakis P. & Welk G. (2019). *Psychologically informed physical fitness practice in schools: A field experiment*. Psychol. Sport Exerc., 40, 143-151.
10. Legrain P., Gillet N., Gernigon C. & Lafreniere M.A. (2015). *Integration of information and communication technology and pupils' motivation in a physical education setting*. Journal of Teaching in Physical Education, 34 (3), 384-401.
11. Østerlie O. & Mehus I. (2020). *The impact of flipped learning on cognitive knowledge learning and intrinsic motivation in norwegian secondary physical education*. Educ. Sci., 10(110), 1-16.
12. Hsiao H.-S. & Chen J.-C. (2016). *Using a gesture interactive game-based learning approach to improve preschool children's learning performance and motor skills*. Comput. Educ., 95, 151-162.
13. Alhamdi M.M.H., Salih S.B. & Abd Aljalee A.M. (2019). *The impact of learning technology on some motor skills of deaf and mute students in comparison with healthy students*, Indian. J. Public Health Res. Dev., 10, 828-831.
14. Lauer E.E., Martin S.B. & Zakrajsek R.A. (2019). *iSCORE: Using technology and imagery to enhance performance of closed motor skills*. Strategies, 32, 19-24.
15. Melton B., Bland H., Harris B., Kelly D. & Chandler K. (2015). *Evaluating a physical activity app in the classroom: A mixed methodological approach among university students*. Phys. Educ., 72, 601-620.
16. Lee J. F. & Gao Z. (2020). *Effects of the iPad and mobile application integrated physical education on children's physical activity and psychosocial beliefs*. Physical Education and Sport Pedagogy, 25 (6), 567-584.
17. Casey A., Goodyear V.A. & Armour K.M. (2017). *Rethinking the relationship between pedagogy, technology and learning in health and physical education*. Sport Educ. Soc., 22, 288-304.
18. Palao J.M., Hastie P.A., Cruz P.G. & Ortega E. (2015). *The impact of video technology on student performance in physical education*. Technology, Pedagogy and Education, 24 (1), 51-63.
19. Koekoek J., van der Mars H., Walinga W. & Hilvoorde I. (2018). *Aligning digital video technology with game*

- pedagogy in physical education*. Journal of Physical Education Recreation & Dance, 89 (1), 13-22.
20. Juditya S., Suherman A., Rusdiana A., Nur L., Agustan B. & Zakaria D.A. (2020). *Digital teaching material "POJOK": One of the technology based media in physical education*. Learning International Journal of Psychosocial Rehabilitation, 24 (10), 1774-1784.
  21. Paraskevaidis P. & Fokides E. (2020). *Using 360° videos for teaching volleyball skills to primary school students*. Open Journal for Information Technology, 3 (1), 21-38.
  22. Chang K.E., Zhang J., Huang Y. S., Liu T.C. & Sung Y. T. (2019). *Applying augmented reality in physical education on motor skills learning*. Interactive Learning Environments, 28 (2), 1-13.
  23. Quintas-Hijós A., Peñarrubia-Lozano C. & Bustamante J.C. (2020). *Analysis of the applicability and utility of a gamified didactics with exergames at primary schools: Qualitative findings from a natural experiment*. PLoS ONE, 15(4), 1-27.
  24. Hartwig T.B., del Pozo-Cruz B., White R.L., Sanders T., Kirwan M., Parker P.D. et al. (2019). *A monitoring system to provide feedback on student physical activity during physical education lessons*. Scand. J. Med. Sci. Sports, 29, 1305-1312.
  25. Enright G., Gyani A., Raadsma S., Allman-Farinelli M., Rissel C., Innes-Hughes C., et al. (2016). *Evaluating factors influencing the delivery and outcomes of an incentive-based behaviour change strategy targeting child obesity: protocol for a qualitative process and impact evaluation*. BMJ Open, 6 (12),1-10.
  26. Friskawati G.F., Karisman V.A. & Stephani M.R. (2019). *Analyzing the challenges to using technology in physical education*. Advances in social science, Education and Humanities Research, 407,15-17.
  27. Lambert C. (2016). *Technology has a place in physical education*. Journal of Physical Education, Recreation & Dance, 87 (9), 58-60.
  28. Lindberg R., Seo J. & Laine T.H. (2016). *Enhancing physical education with exergames and wearable technology*. IEEE Transactions on Learning Technologies, 9 (4), 328-341.
  29. Zhu X. & Dragon A.L. (2016). *Physical activity and situational interest in mobile technology integrated physical education: A preliminary study*. Acta Gymnica, 46 (2), 59-67.
  30. Luptáková G. & Monten B.A. (2017). *Collaborative learning with application of screen-based technology in physical education*. J. Sports Sci. Med., 6 (2), 49-56.
  31. Kretschmann R. (2017). *Employing tablet technology for video feedback in physical education swimming class*. Journal of E-Learning and Knowledge Society, 3(2), 103-115.
  32. Ashanin V., Filenko L., Pasko I.V., Tserkovna A.O., Filenko I., Poltoratskaya I.A. et al. (2018). *Implementation practices of the Rugby-5 into the physical education of schoolchildren 12-13 years old using information technology*. Journal of Physical Education and Sport, 18(2), 762-768.
  33. Glapa A., Grzesiak J., Laudanska-Krzeminska I., Chin M.K., Edginton C. R., Mok M.M.C. et al. (2018). *The impact of Brain Breaks classroom-based physical activities on attitudes toward physical activity in polish school children in third to fifth grade*. Int. J. Environ. Res. Public Health, 15, 368-379.
  34. Potdevin F., Vors O., Huchez A., Lamour M., Davids K. & Schnitzler C. (2018). *How can video feedback be used in physical education to support novice learning in gymnastics? Effects on motor learning, self-assessment and motivation*. Physical Education and Sport Pedagogy, 23 (6), 559-574.
  35. Williams L., Martinasek M., Carone K. & Sanders S. (2020). *High school students' perceptions of traditional and online health and physical education courses*. J. Sch Health, 90, 234-244.
  36. Vega-Ramírez L., Notario R.O. & Ávalos-Ramos M.A. (2020). *The relevance of mobile applications in the learning of physical education*. Educ. Sci., 10, 329-340.
  37. Greve S., Thumel M., Jastrow F., Krieger C., Schwedler A. & Süßenbach J. (2020). *The use of digital media in primary school PE – student perspectives on product-oriented ways of lesson staging*. Physical Education and Sport Pedagogy, 25(1),1-16.
  38. Kok M., Komen A., van Capelleveen L. & van der Kamp J. (2020). *The effects of self-controlled video feedback on motor learning and self-efficacy in a Physical Education setting: an exploratory study on the shot-put*. Physical Education and Sport Pedagogy, 25 (1), 49-66.
  39. Zhou S. (2020). *On the application and development of modern information technology in physical education*. J. Phys.: Conf. Ser., 1648(3),1-5.
  40. Sheng L. (2020). *Research on application effect in physical education teaching based on computer-aided technology*. J. Phys.: Conf. Ser., 1648(2), 1-5.
  41. Hinojo Lucena F.J., Belmonte J.L., Cabrera A.F., Torres J.M.T. & Sánchez S.P. (2020). *Academic effects of the use of flipped learning in physical education*. Int. J. Environ. Res. Public Health, 17, 1-14.
  42. Segura-Robles A., Fuentes-Cabrera A., Parra-González M.E. & López-Belmonte J. (2020). *Effects on personal factors through flipped learning and gamification as combined methodologies in secondary education*. Front. Psychol., 11: 1-8.