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DISTANCE EDUCATION IN UNDERGRADUATE PHYSIOTHERAPY PROGRAMS: A SYSTEMATIC REVIEW

SYSTEMATIC REVIEW

ABSTRACT

Purpose: The use of distance education (DE) models and tools has become increasingly popular in health profession education, including physiotherapy (PT). However, there are few reviews focusing on DE in PT education, which could enable researchers to access comprehensive information, and reviews on various health profession groups often do not include physiotherapy studies. The aim of this study was to synthesize existing evidence and determine the effectiveness of DE systems in PT education.

Methods: This study was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. PubMed, Scopus, EBSCO, Web of Science, and ERIC were searched from inception to July 2020. The initial search resulted in 689 studies. The risk of bias was assessed using the Cochrane risk of bias tool.

Results: In this systematic review, 25 studies which included 2129 physiotherapy undergraduate students (11 DE models / 14 e-systems) were found suitable for review. Generally, outcome measures were students' knowledge, satisfaction, and skill. In 16 of the studies, the level of knowledge was investigated, and it was found that the knowledge increased. In 38% of these studies, the increase in the knowledge level of traditional education and DE was similar. It was found that 79% of the studies demonstrated an increase in satisfaction, 14% demonstrated a decrease in satisfaction, and satisfaction with traditional education and DE was similar in 7%. Skill was investigated in 12% of the studies, and all the studies showed the positive effects of DE.

Conclusion: DE can promote learning in undergraduate PT education, even though its effectiveness in some areas, such as practical skill acquisition or cost, is controversial. Further high-quality studies with long follow-up periods are needed to investigate the various aspects of the PT curriculum, including both theoretical and practical courses.

Keywords: Blended Model, Distance Education, E-System, Flipped Model, Hybrid Model

FİZYOTERAPİ LİSANS PROGRAMLARINDA UZAKTAN EĞİTİM: SİSTEMATİK DERLEME

SİSTEMATİK DERLEME

ÖZ

Amaç: Uzaktan eğitim (UE) modellerinin ve araçlarının kullanımı, fizyoterapi dahil olmak üzere sağlık mesleği eğitiminde giderek daha popüler hale geldi. Bununla birlikte, araştırmacıların kapsamlı bilgilere erişmesini sağlayabilecek olan fizyoterapi eğitiminde uzaktan eğitime odaklanan derlemeler az sayıdadır ve farklı sağlık meslek gruplarına ilişkin derlemeler sıklıkla fizyoterapi çalışmalarını içermemektedir. Bu çalışmanın amacı fizyoterapi eğitiminde mevcut kanıtları sentezlemek ve UE sistemlerinin etkinliğini belirlemektir.

Yöntem: Bu çalışma, Sistematik Derlemeler ve Meta Analizler için tercih edilen Raporlama Öğeleri Yönergelerine uygun olarak yürütülmüştür. PubMed, Scopus, EBSCO, Web of Science ve ERIC, başlangıçtan Temmuz 2020 tarihine kadar tarandı. İlk arama 689 çalışmayla sonuçlandı. Yanlılık riski, Cochrane yanlılık risk aracı kullanılarak değerlendirildi.

Sonuçlar: Bu sistematik derlemede 2129 fizyoterapi lisans öğrencisini içeren 25 çalışma (11 uzaktan eğitim modeli / 14 e-sistem) inceleme için uygun bulundu. Genel olarak, sonuç ölçütleri öğrencilerin bilgi, memnuniyet ve beceri düzeyleriydi. Çalışmaların 16'sında bilgi düzeyi araştırıldı ve bilginin arttığı tespit edildi. Bu çalışmaların %38'inde geleneksel ve uzaktan eğitimin bilgi düzeyindeki artışı benzerdi. Çalışmaların %79'unda memnuniyetin arttığı, %14'ünde memnuniyetin azaldığı, %7'sinde ise geleneksel ile uzaktan eğitim memnuniyetinin benzer olduğu belirlendi. Çalışmaların %12'sinde beceri düzeyi araştırılmış olup bu çalışmaların tamamında uzaktan eğitimin olumlu etkileri gösterilmiştir.

Tartışma: UE pratik beceri kazanımı veya maliyet gibi bazı alanlarda etkinliği tartışmalı olsa da fizyoterapi lisans eğitiminde öğrenme sürecini teşvik edebilir. Teorik ve pratik dersler de dahil olmak üzere fizyoterapi müfredatının çeşitli yönlerini araştırmak için uzun takip süreleri olan daha fazla sayıda yüksek kaliteli çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Harmanlanmış Model, Uzaktan Eğitim, E-Sistem, Ters Yüz Model, Hibrit Model

INTRODUCTION

Distance education (DE) started with an advertisement published in a Swedish newspaper in 1833 offering composition lessons. Since then, technological developments have been the most important factor determining the content of DE. DE was at first provided through correspondence and television and later through computers (1). Today, digital technologies have become an indispensable resource for students and academicians (2). The ubiquitous use of the Internet and the introduction of social networks, interactive boards, and online learning environments and tools, along with Web 2.0 technologies, have provided opportunities for changes in higher education and the introduction of DE applications (3, 4).

DE provides students with a high degree of active participation, flexibility, and comfort. Moreover, it is effective in arousing students' interest in learning and promoting autonomy (5). The main aim of DE is to overcome the limitations of classical passive teacher-oriented learning and promote more active student participation (6). Students are continuously trained without traditional face-to-face or campus training; they receive education using different digital technologies, either web-based, online, computer-based/assisted, multimedia-supported, or virtual (5, 7). Various DE models have been developed, such as hybrid models, flipped classroom model, and online-only models (8, 9). However, the use of technology as a learning tool leads to complex results in terms of acquisition of knowledge and skills and moral and ethical behavior (9, 10). Therefore, the effectiveness of DE should be considered independently for each branch of health education.

With an increasing demand for qualified health-care providers worldwide in recent years, PT education has entered a period of rapid growth and development. Lectures include not only theoretical training but also practical skills, various technique applications, device training, and—most importantly—patient-oriented clinical problem-solving methods. To manage this versatility in PT education and to quickly adapt to changing student needs, academicians have sought new teaching and learning methods in light of the new opportunities of the digital age (11). Various derivatives of online education technologies have become important to meet the increasing vocational training needs of PT programs. A systematic review showed that online technologies bring considerable benefits to PT education (9). As of 2019, up to 75% of entry-level PT education curricula across the US used hybrid education systems to gain advantages of both learning environments (12).

The coronavirus disease 2019 pandemic has led to restrictions in almost all areas of social life and has had dramatic effects in the field of education. The temporary measures taken to contain the pandemic at the beginning of 2020 have tended to become permanent as vaccine and drug studies continue, and various organizations have been forced to operate under different systems. Governments have restricted or halted activities in some areas of daily life; however, education differs from other areas in that it cannot be stopped or delayed. Instructors have been struggling to educate students and meet their needs in a way that does not overlap with the scope of PT education. Obviously, we have never before experienced a situation in which students' competencies were at such risk and their vocational abilities so dependent on the skills and effort of the instructor. Consequently, online education systems in universities around the world have become a necessity rather than a choice amid the pandemic. It has necessitated a deeper understanding of the new learning strategies in PT education afforded by the new technologies. In these adverse conditions, academicians' most important responsibility is to maintain the highest possible quality of education. Therefore, it is imperative to improve our DE skills, which are admittedly at the beginner level.

The effectiveness of the online technology use in the undergraduate and postgraduate PT education was demonstrated by the Mącznik, A. K. et al in 2015 (9). Although this is an important study indicating the importance of online technology

use in PT education, it did not reflect the new educational conditions created by the COVID-19 pandemic. In addition, comparative studies on the use of DE systems in PT education are scarce, and research in various fields often ignores physiotherapy studies (10, 13). For these reason, this review aimed to synthesize the existing evidence and determine the effectiveness of DE systems in PT education. We hypothesized that implementation of DE systems and tools will improve knowledge, student satisfaction and skills in undergraduate physiotherapy programs.

METHODS

This review is registered with PROSPERO (registration no: CRD42020209645).

Search Strategy

We used PubMed, Web of Science, Scopus, EBSCO, and ERIC from inception until July 14th, 2020 to search for studies published.

Selection of Studies

This systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (14). The search was conducted by two reviewers (O.C. and T.M.) independently. The keywords used in the search are listed in the online supplementary material. One author (O.C.) exported all the studies found to reference manager (EndNote X7.5, Clarivate Analytics, Philadelphia, PA, USA) and deleted duplicates. The article titles and abstracts were then screened. Articles that met the inclusion criteria were obtained, and the full texts were screened for inclusion. The search and selection process is shown in the PRISMA flowchart (Figure 1).

Inclusion criteria

The following studies were included:

- Studies conducted in PT education programs at the undergraduate level.
- Studies using a DE model (flipped, blended or hybrid) or system (online and electronic systems).
- Cross-sectional, case-control, cohort studies, randomized controlled trials and qualitative studies.

Exclusion criteria

The following were excluded:

- Studies not involving undergraduate students exclusively.
- Studies on health care areas other than PT.
- Non-English or non-Turkish full-text articles.
- Reviews, commentaries, editorials, gray literature, case series, protocols, and letters.

Data extraction

Two reviewers (O.C. and ME.Y.) independently extracted data of studies meeting the inclusion criteria. The following information was retrieved from each article: authors' names, year of publication, country, course/participants, study description, outcome measures (tools/method), and conclusions. Any discrepancies were resolved in a meeting with the participation of a third reviewer (T.M.). The studies in this review were categorized and presented based on whether the intervention was a learning system or an online learning tool.

Risk of bias

Two reviewers (O.C. and T.M.) independently assessed the risk of bias in included randomized controlled trials using the Cochrane risk of bias assessment tool (15). In case of any disagreement, a third reviewer (ME.Y.) made the final decision. The domains were the following: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, and selective reporting. The domains were classified as low, high, or unclear risk of bias.

RESULTS

The initial search yielded 689 potential articles. References in some articles were also evaluated, and three additional articles were identified. After excluding duplicates, 330 articles remained for testing against the inclusion criteria. After scanning the titles and abstracts, 96 full articles were retrieved and reviewed. Of those studies, 25 did not involve undergraduate PT students exclusively, 12 were not based on a non-campus education model, 10 were not reported in English

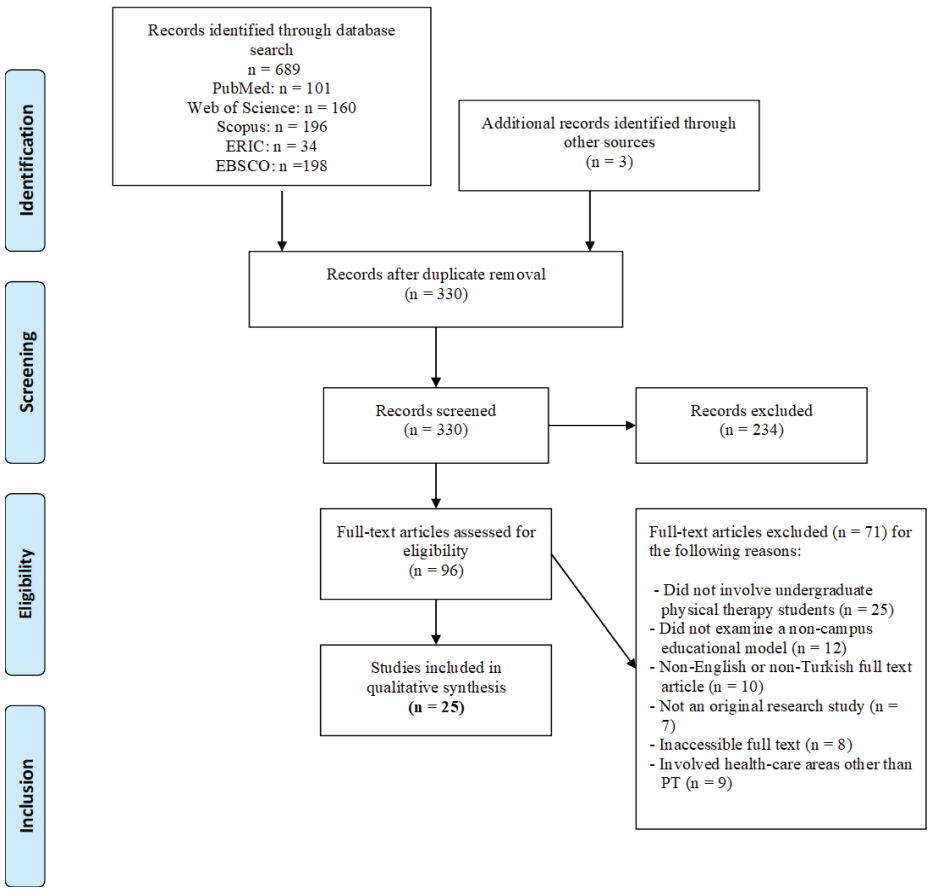

Figure 1. Flowchart

or Turkish, 7 were not original research studies, and 9 were related to health care areas other than PT. Additionally, the full text of eight articles could not be accessed. After excluding these studies, 25 remained for the analysis (Figure 1).

All included articles were published in English. The studies were conducted in various countries, including Australia, Brazil, Bangladesh, Canada, Norway, Denmark, India, Sweden, Hong Kong, South Africa, Spain, the UK, and the USA. Among the included studies were controlled trials, randomized controlled trials, descriptive studies, and cohort studies. The reviewed studies involved 2.129 first-, second-, third-, and fourth-year PT students. The studies were published from 2005 to 2020 in journals whose scopes include distance education and other education and technology topics.

The reviewed studies assessed DE models or e-system tools in basic sciences (e.g., anatomy) and various physiotherapy areas of practice (e.g., neurological analysis in neurological physiotherapy, oncological physiotherapy, and cardiovascular and cardiopulmonary curricula). Sixteen studies investigated the effectiveness of DE in knowledge acquisition, while seven explored PT students' perceptions. Other investigated aspects were skills, attitude, participation, perceived confidence, student feedback/opinions, student satisfaction, and quality and cost of education. The quality evaluation of trials using the risk of bias tool is shown in Table 1.

Table 2 presents the main aspects of 11 studies that applied DE models in PT education. Seven of them examined blended models, three investigated the flipped classroom approach, and one evaluated a hybrid model. In four of the seven studies examining the level of knowledge, it was determined that the knowledge increased; and in other three, the effect of traditional education and DE on knowledge were similar. Students' satisfaction was evaluated in three studies, and

Table 1. Cochrane Collaboration Tool for Assessing Risk of Bias

Author, Year	Random Sequence Generation	Allocation Concealment	Blinding of Personnel and Participants	Blinding Outcome Assessment	Incomplete Outcome Data	Selective Reporting
Arroyo-Morales, 2012	Low	Unclear	Unclear	Unclear	Low	Unclear
Cantarero-Villanueva, 2012	Low	Unclear	High	Low	Low	Unclear
Da Costa Vieira, 2016	Low	Unclear	High	High	Low	Unclear
Nicklen, 2016	Low	Low	Unclear	Unclear	Low	Unclear
Ulrich, 2019	Low	Unclear	Unclear	Low	Low	Unclear
Jones, 2010	Unclear	Unclear	Unclear	Low	Low	Unclear
Hossain, 2015	Low	Unclear	Low	Low	Low	Unclear
Lozano, 2020	Low	Unclear	Low	Low	Low	Unclear
Da Silva, 2012	Low	Unclear	Unclear	Unclear	Low	Unclear

skills were evaluated in two studies, all of which found that DE increased satisfaction and skills (Table 2).

Table 3 shows the main aspects of 14 studies involving DE systems in PT education. The effectiveness of online learning tools was assessed in 14 studies, with nine focusing on knowledge, eleven on satisfaction, and one on skill. In 33% of the studies investigating the level of knowledge, the effects of traditional education and DE were similar. The students' satisfaction was evaluated with their feedback and opinions. This study found that 73% of students had positive opinions about DE and 9% believed that traditional education and DE were similar. Only one study focused on skill outcomes and yielded positive results (Table 3).

DISCUSSION

This systematic review included 25 studies evaluating the effectiveness of DE and involved a total of 2129 undergraduate PT students. Our review suggests that DE seems to be at least as effective as traditional methods in increasing knowledge and developing skills. Furthermore, students expressed positive opinions about and high levels of satisfaction with DE programs in most studies.

Eleven studies examining the effectiveness of various models in PT education fell within the scope of this review (16-26). Two of them investigated the effectiveness of the flipped classroom model. Day (2018) reported an increase in students' knowledge level, whereas Roe et al. (2018) observed no change. Similarly, studies investigating the effectiveness of blended models found that the knowledge levels either increased (16, 23) or did not change (17). All studies investigating student satisfaction reported an increase in satisfaction levels (16-18, 24). Few studies examined the cost of DE, and whether DE is economical remains open to debate (22, 24). Only two studies reported skill improvement with a blended model (17, 18). Student feedback offered some important clues about the effectiveness of DE models. For example, students reported higher perceived workloads with a blended model (23). This suggests that students struggle with heavy loads during online education. This is unsurprising, given that students must learn to simultaneously manage the delivery environment, course content, and educational technologies. Instructors organizing such courses must adopt an organized and clear course design and select engaging materials and activities suitable for different learner levels to reduce the mental load (27). Students also reported that they perceived self-initiation in learning as an important factor for success (21).

We reviewed 14 studies investigating the effectiveness of e-system tools in PT education (28-41). These tools included educational software, online courses, video activities, discussion forums, e-modules, and virtual exams, which were

Table 2. Key Aspects of Distance Learning Models (Blended, Flipped, or Hybrid) in Physiotherapy Education Literature

Study	Country	Course/ Participants	Study Description	Outcome Measures (Tool/Method)	Conclusion
Aguilar-Rodriguez et al. 2019	Spain	Ethics and Physiotherapy course for third-year PT students	Prospective single-blinded clinical trial 1) Blended model (n =65) 2) Control (n = 64)	• *Attitude* toward learning professional ethics with AQPEPT • *Knowledge* with the Perceptions about Knowledge Regarding Professional Ethics in Physiotherapy questionnaire • *Perceptions* of online learning with a questionnaire comprising eight dichotomous questions and one open question	• Knowledge and attitudes toward learning professional ethics significantly improved in the blended model group. • Students were satisfied with the online program and the learning opportunities offered.
Arroyo-Morales et al. 2012	Spain	Palpation and Ultrasound Examination of Knee course for second-year PT students	Randomized controlled study 1) Blended model (ECOFISIO website) (n = 23) 2) Control (n = 23)	• *Skills* with an objective structured clinical examination • *Knowledge* with a multiple-choice questionnaire • *Quality* of the educational intervention with a questionnaire (5-point Likert scale)	• Skills were improved in the blended model group compared to the control group. • The groups were similar in terms of acquisition of theoretical knowledge. • Participants in the blended model group reported that they had more fun, learned more, were able to apply what they learned, and would like to participate in a study of another anatomical region. Participants in neither group would have preferred to be in the other learning program.
Cantarero-Villanueva et al. 2012	Spain	Palpation and Ultrasound Examination of Lumbopelvic Area course for undergraduate PT students	Single-blinded randomized controlled study 1) Blended model (ECOFISIO website) (n = 23) 2) Control (n = 21)	• *Skills* with an objective structured clinical examination • *Quality* of the educational intervention with a questionnaire (5-point Likert scale)	• Skills were improved in the blended model group compared to the control group. • The groups had similar opinions about the assessments of the educational intervention. • The blended model group reported a high level of satisfaction with the website's characteristics.
Cherry and Blackinton 2017	USA	First- (n =34) and second-year (n = 20) PT students	Mixed methodology 1) Hybrid program (n = 54) 2) Traditional program (n = 71)	• Factors influencing student success with Q-sort analysis	• Time management, academic work ethic, and ability to prioritize study focus were perceived as strongly influencing factors for success by both groups. • Only students in the hybrid group perceived student success, self-initiation in learning, problem-solving, and organization of courses as influencing factors. • Only students in the traditional program perceived the instructor's ability to organize course material as an influencing factor.
Davies et al. 2005	England	Neurologic Analysis within Neurological Physiotherapy course for undergraduate PT students	Qualitative research Lecture-based group activity: observing and discussing patient movement disorders on video Video clips on CD-ROM for personal use In the learning center: using video clips and online questions in WebCT Using learning technologies for a mock exam and assessment	*Student opinions* with a short questionnaire (n = 82) *Qualitative data* from four focus group discussions with 17 randomly selected students	• Students suggested that watching and discussing the video in a lecture-based group activity and their experience in the learning center added value to their learning experience. • Students were much less satisfied about their experiences in the context of the mock exam and assessment. • Students spoke of the importance of "flexible learning" in developing their physiotherapy skills.

Day 2018	USA	Gross Anatomy course for undergraduate PT students	Controlled study 1) Flipped classroom model (n = 112) 2) Control (n = 105) Kinesiology class grades as a second control for analysis	• *Knowledge* with three-unit examinations and one cumulative final examination • Analysis of long-term retention and knowledge transfer	• Students in the flipped anatomy class had higher grades on higher-level analytical questions. • Previously low-performing students showed better performance in subsequent courses (kinesiology) after participating in the flipped gross anatomy course.
Gaida et al. 2016	Australia	Skill classes for third-year PT students	Mixed methodology Blended model (n = 72) Two skills classes taught using a blended model	• *Students' perceptions* with an anonymous online survey. • *Costs* with year-on-year delivery were modeled by manipulating key variables, such as class size and the video update schedule.	• Students reported that they felt greater control over their learning (power shift), acquired a deeper understanding (skill development), and perceived greater efficiency in the teaching method (efficiency). • Video production costs were recouped after three years.
Green et al. 2016	Australia	Anatomy course for second-year PT students	Retrospective cohort study 1) Face-to-face education (n = 150) 2) Transitional group (some online content) (n = 160) 3) Fully blended (n = 151)	• *Knowledge* with a combination of practical tests and a final exam • *Student participation* with the number of posts on discussion forum. • *Student perceptions* with a questionnaire (5-point Likert scale)	• Grades were higher in the transitional and blended groups than in the face-to-face group. • The groups were similar in terms of student participation. • Students in the blended group reported heavier perceived workloads.
Nicklen et al. 2016a	Australia	Third-year PT students	Controlled study 1) Blended model (n = 78) 2) Control (previous third year students)	• *Cost* of education • *Satisfaction* with the quality of teaching and learning with a questionnaire (5-point Likert scale)	• The blended model was more economical. • Satisfaction was higher in the blended model group.
Roe et al. 2018	Norway	Musculoskeletal Disorders course for second-year PT students	Crossover design study 1) Flipped classroom model (n = 45) 2) Control	• *Knowledge* with an oral exam (6-point grading scale) • *Perceptions* of the flipped classroom model with open-ended questions and on a 10-point scale	• The groups were similar in terms of academic outcomes. • Flexibility and responsibility increased in the flipped classroom group. The disadvantages reported by the students were associated with little feedback and variation during learning activities
Roe et al. 2019	Norway	Musculoskeletal Disorders course for second-year PT students	Prospective, controlled cohort study 1) Flipped classroom model (n = 54) 2) Control (previous second year students)	• *Knowledge* with a course exam • *Perceptions* of the flipped classroom model with six open-ended questions	• Students in the flipped classroom group had higher grades and better performance than those in the control group. • The flipped classroom model increased the responsibility of learning.

AQPEPT: Attitudes Questionnaire towards Professional Ethics in Physiotherapy

Table 3. Key Aspects of Online Learning Systems/Tools in Physiotherapy Education Literature

Study	Country	Course/Participants	Study Description	Outcome Measures (Tool/Method)	Conclusions
Corrigan and Hardham 2011	Australia	Physiotherapy Rehabilitation Techniques course for third-year PT students	Mixed methodology Simulated practical exam task (n = 61)	• Pre-experience survey • Post-experience survey and preference feedback • Feedback evaluation	• A simulated practical exam task is a useful tool for evaluating and reflecting on students' performance according to set assessment criteria. • Feedback provided to the peer group is the preferred method for task evaluation and discussion. • Defining the learning outcomes of the simulated task and establishing clear links with a summative assessment can maximize student confidence and accuracy in self-assessment. • The contextual nature of the simulated task provides students with insights into possible treatments and interactions between patients and themselves as therapists.
Da Costa Vieira et al. 2017	Brazil	Oncological Physiotherapy course for second- to fourth-year undergraduate PT students	Prospective, controlled, randomized, crossover study 1) A traditional classroom model group (n = 35) 2) An e-learning group using the Articulate® application (n = 32)	• *Knowledge* with a diagnosis evaluation before the course and after each module	• The course resulted in significant acquisition of knowledge. • The level of information retention was similar between groups.
Green et al. 2014	Australia	Anatomy course for second-year PT students	Mixed methodology Participation in asynchronous online discussion forums (n = 138)	• *Knowledge* with a combination of practical tests and final exam	• Posting more regularly improved students' learning outcomes and final grades.
Hammarlund et al. 2015	Sweden	Basic Research Methodology course for PT students	Qualitative study Online course (n = 34)	• *Student feedback* with qualitative manifest content analysis	• The effects of external and internal factors on learning strategies and self-efficacy are important aspects to consider when designing online courses. • Factors such as pedagogical design, clarity of purpose and goals, and guidelines, as well as continuous opportunities for communication and collaboration, are important.
Hossain et al. 2015	Bangladesh	Physiotherapy Management of Spinal Cord Injuries course by MOOC for second- and third-year undergraduate PT students	Randomized controlled trial 1) MOOC (n = 24) 2) Physiotherapy-specific online learning module (n = 24)	• *Knowledge* with a multiple-choice test • *Perceived confidence* in treating patients with spinal cord injuries and *satisfaction* with the learning experience (10-point Likert scale)	• The MOOC was no better for students than working at their own pace through an online learning module for increasing knowledge, confidence, or satisfaction.
Jones et al. 2010	Hong Kong Canada USA	Cardiovascular and Cardiopulmonary curriculum for middle- and final-year PT students	Randomized controlled study 1) VL + web-based (n = 19) 2) Web-based (n = 19) 3) Traditional teaching (n = 26)	• *Knowledge* with standardized short-answer question quizzes. • *Satisfaction* with learning experience of participating with a questionnaire with closed-ended questions.	• VL learning outcomes were similar in conventional formats. • VL learning outcomes may augment students' learning satisfaction. • VL technology may play a role in reducing the demands on academic programs.
Keiller and Inglis-Jassiem 2015	South Africa	Problem-Based Learning Physiotherapy module for third-year PT students	Empirical study Videos and blogging (n = 18)	• *Student opinions* with a self-administered engagement questionnaire	• Student-generated videos of clinical skills could be successfully implemented with adequate support from staff.

Kumar and Kumar 2013	India	Physiotherapy Ethics course for final-year PT students	Descriptive study e-module (n = 25)	• *Knowledge* with a written examination • *Student opinions* with a questionnaire	• The e-module enhanced self-directed learning and can be implemented.
Lozano-Lozano et al. 2020	Spain	Ecofisio mobile app for sport pathologies for undergraduate PT students	Multicenter, double-blinded randomized controlled trial 1) Ecofisio mobile app (n = 55) 2) Control group (n = 55)	• *Knowledge* with MCQ • *Skills* with an objective structured clinical examination • *Satisfaction* with a questionnaire (5-point Likert scale)	• Knowledge and skills were improved. • The Ecofisio group showed a higher satisfaction level.
Maloney et al. 2013a	Australia	Fourth- year PT students	Mixed methodology Physeek for Web-based learning (n = 18)	• *Perceptions* of Physeek utilization and its impact on learning with a questionnaire (5-point Likert scale)	• Students perceived online repositories as a potential tool to support lifelong learning and health care delivery.
Maloney et al. 2013b	Australia	PT students in their final preclinical semester	Descriptive study Self-videos (n = 60)	• *Technical details* and *student opinions* with a questionnaire (5-point Likert scale)	• Despite some technical difficulties, web-based student self-video of performance with remote tutor feedback and guided reflection is a feasible method for increasing students' capacity for reflection and self-evaluation.
Marques da Silva et al. 2012	Brazil	Bronchial Hygiene Techniques course for fourth-year PT students	Randomized controlled trial 1) Online group (including multimedia resources) (n = 8) 2) Control group (n = 8).	• *Knowledge* with pre- and posttests	• The online group performed significantly better than the control group.
Nicklen et al. 2016b	Australia	Third-year PT students	Randomized controlled study 1) RO-CBL (n = 19) 2) Traditional face-to face CBL (n = 19)	• *Knowledge* with MCQ • *Satisfaction* with the RO-CBL with a questionnaire (5-point Likert scale) • *Perceptions* of remote learning with a questionnaire (3-point Likert scale)	• The groups were similar in terms of MCQ. • Satisfaction decreased in the RO-CBL group and they reported a perception that RO-CBL negatively impacted their learning.
Ulrich et al. 2019	Denmark	PT students	Randomized controlled study 1) E-learning with virtual reality (n = 28) 2) Regular video (n = 26) 3) Traditional teaching (n = 27)	• *Knowledge* with a final test. • *Satisfaction* with learning and climate with a questionnaire (13 items rated on a Likert scale)	• E-learning virtual reality was as effective in enhancing academic performance as regular videos and traditional teaching. • E-learning virtual reality and regular videos were less effective than traditional teaching in terms of student learning satisfaction.

MOOC: Massive Open Online Courses, VL: Virtual Learning, MCQ: Multiple Choice Question, RO-CBL: Remote-online case-based learning

mostly found to be effective in increasing knowledge. More frequent use of such systems was found to be associated with greater academic success (31). We believe that ease of access to information and effective use of time play an important role in increasing students' academic success. In addition, the inclusion of different components that stimulate learning, such as the variety of visuals and sound effects in the tools, may have helped increase success by helping students focus their attention. In most studies, the use of e-system tools increased student satisfaction, although a decrease (34) and indifference (35) were also reported. The reason for this may be that students prefer the classical classroom environment because of its social characteristics. Students generally stated that online teaching aids and repositories significantly supported lifelong learning (38). Nicklen et al. (2016b), who examined the effects of case-focused remote education, found no change in students' knowledge levels than tradition education and a decrease in perception and satisfaction levels, concluding that face-to-face instruction in patient-focused clinical training was superior (34). This study is particularly important since a certain number of hours of patient-focused clinical work was required for graduation.

The novel study by Mącznik et al. revealed the effectiveness of online technology in PT education in both undergraduate and post-graduate education up to 2015 (9). In our study, we chose to focus exclusively on undergraduate education, since online technology has been widely used and understood in 'Master of Science' and 'Philosophy of Doctoral' programs in the world's leading universities for a long time. Considering the pandemic has had a rather negative impact on undergraduate education by interrupting the face-to-face training required by practical training, it has become a necessity to examine in detail the undergraduate PT education. As we exclusively focus on the use of DE technologies alone in undergraduate education, we aimed to increase a better understanding and usage of DE technologies in undergraduate PT education.

DE has been introduced into many disciplines, including physiotherapy (PT) programs, and has become the new normal in education due to its positive outcomes in higher education. Similar to our study, a meta-analysis study of the flipped classroom model, including many different health disciplines such as physicians, nurses, dentists, showed that flipped classroom improved student learning significantly compared with traditional teaching methods (42). Another review conducted to analyze the effectiveness of DE during the Coronavirus Disease 2019 (COVID-19) epidemic in undergraduate students from various health disciplines. This study highlights the benefits of online learning in enhancing students' academic, clinical, and communication skills, despite potential connection issues and lack of interaction between teachers and students (43). A recent systemic review by Naciri and colleagues analyzing the effectiveness of e-learning systems has been reported similar results (44).

Studies investigating the effectiveness of DE in PT education have only included certain courses, which are only part of the curriculum. This limits our ability to arrive at safe conclusions on the effectiveness of DE models and/or e-system tools in PT education. Although the reviewed studies examined various aspects of PT education, hands-on training, which is a necessary part of PT competence, was generally not examined. Further studies are needed to investigate the various aspects of the PT curriculum, including both theoretical and practical courses.

Certain limitations of this review should be acknowledged. Only English and Turkish full-text articles were searched. A multicenter team proficient in more languages might have enabled us to include more articles. We are unable to reach a definitive conclusion regarding the quality of the studies included in this review because numerous categories were not assessed due to lack of information provided in the studies. Moreover, only nine studies had a high-quality (RCT) design, while the rest had descriptive, cohort, and other designs. Furthermore, these studies did not investigate the long-term effectiveness of DE. Therefore, future high-quality studies with long follow-up periods are needed to thoroughly investigate knowledge levels, skills, self-efficacy, and occupational satisfaction in

professional life. Numerous studies on DE in the PT field at the postgraduate and continuing education levels are also available in the literature. Further reviews might focus on the effectiveness of DE in postgraduate and continuing education. Finally, a meta-analysis was not possible due to the included studies' dissimilarity and heterogeneity. On the other hand, this review is valuable in that it systematizes implemented online education models and systems. It should be noted, however, that all included studies were conducted before the pandemic, when DE was an option rather than a necessity. Therefore, we cannot draw conclusions on how the global public health crisis has changed students' perceptions or satisfaction levels.

We synthesized studies on DE models and e-system tools used in PT education to evaluate their effectiveness in terms of students' knowledge, skills, and satisfaction. This review concludes that while DE can assist and complement traditional methods to provide an engaging and inspiring environment that improves teaching and learning, it cannot replace traditional face-to-face modes of education. Accordingly, DE can promote learning in PT education, even though its effectiveness in some areas, such as practical skill acquisition and cost, remains controversial.

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