The Impact of Mobile Application-Assisted Instruction on Intrinsic Motivation and Sports Nutrition Knowledge: The Case of Blended Learning

https://doi.org/10.3991/ijet.v18i11.38637

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Abstract—In the physical education literature, E-learning in terms of online or blended learning has been lacking and facing several challenges which highlighted a need to conduct more research to investigate modern instruction in the context of physical education. This study is one of the few to determine the impact of Mobile Application-Assisted Instruction (MAAI) on intrinsic motivation and sports nutrition knowledge in a blended learning setting. The "KI-coach" app has been used as a state of an art mobile application based on artificial intelligence. This study adopted quasi experimental approach. Students were randomly assigned into a control group (n=25) that received the convolutional instruction method and an experimental group (n=25) that received MAAI. Study groups adopted a blended learning approach. Measures of intrinsic motivation and sports nutrition knowledge were administered to both groups before and after teaching the nutrition and physical performance course. The ANCOVA analysis revealed a statistically significant difference between the mean scores of the two groups on intrinsic motivation and sports nutrition knowledge. These findings indicated that using MAAI in blended learning promoted the development of intrinsic motivation and enhanced sports nutrition knowledge among physical education students. These findings encourage the decision-makers at the ministry of higher education and physical education instructors to improve blended learning instruction and practice.

Keywords—mobile application, intrinsic motivation, sports nutrition knowledge, physical education, blended learning, instruction

1 Introduction

To achieve sustainable development, it is vital to equip individuals with digital-age skills. To do this, educational institutions should use the most recent practices and methods, such as blended learning (BL), which combines face-to-face and distance learning modes. The primary aim is to capitalize on the positive aspects of both learning delivery systems [1]. Regarding their educational benefits, such as stimulating students' curiosity, engagement, confidence, critical thinking, satisfaction, and learning outcomes,

BL has expanded rapidly in higher education [2–10]. To realize these advantages, educators and designers must overcome obstacles inherent to BL settings, such as a lack of motivation and contact [11–12]. Intrinsic motivation is a major determinant of student advancement and academic achievement [13–15].

The efficacy of BL courses is heavily dependent on pedagogies, teachers' practice, and set design. Despite this, the literature requires further research on the systematic implementation and design of successful BL [16]. On the other hand, researchers incorporating numerous current technologies in BL settings, such as mobile technologies, have garnered interest due to its portability, portability, accessibility, and flexibility in learning [17–18]. Consequently, they conducted several kinds of research employing them in BL mode, such as in the context of learning language. They discovered that it had several favorable effects, such as improving motivation and language acquisition. Numerous studies have demonstrated the favorable impact of employing mobile devices in education across a variety of learning modalities, including online, blended, and face-to-face learning, in several subjects that are prevalent in the target language.

However, in the context of physical education, courses are predominantly implemented and presented face-to-face [19]. However, there is still a need for educational literature about the implementation of blended learning in the context of physical education across all disciplines. Sports nutrition knowledge (SNK) is an important subject of physical and health education. Nutrition plays a significant role in the health and physical performance of the individual, and it is the primary factor that determines the optimal level of sports performance for athletes, it influences their dietary intakes [21–22].

A solid SNK level qualifies physical education students to adequately train athletes. Despite the importance of this topic, numerous studies have demonstrated that physical education students and athletes in various countries, including Jordan, lack general nutrition knowledge [20, 22–25]. Also in 2021, the Jordanian ministry of higher education established instructions for the incorporation of e-learning in institutions of higher education. In addition, requiring universities to redesign their academic programs and subject plans to satisfy the standards for incorporating e-learning (i.e. online and blended learning) in all programs and majors [26]. This necessitated a recent study to determine the efficacy of employing the mobile application in the BL environment to increase intrinsic motivation and SNK among Jordanian physical education (PE) undergraduates.

1.1 Aim of the study and research questions

This study examines on developing students' intrinsic motivation and Sport Nutrition Knowledge among PE undergraduates in BL mode. Exactly, This research tries to answer the following research questions:

RQ1: Are there statistically significant differences at the significance level ($\alpha <= 0.05$) in the development of intrinsic motivation among PE undergraduates attributable to the instructional BL method (MAAI and conventional)?

RQ2: Are there statistically significant differences at the significance level ($\alpha <= 0.05$) in the acquisition of Sport Nutrition Knowledge among PE undergraduates attributable to the instructional BL method (MAAI and conventional)?

2 Literature review and theoretical framework

2.1 Intrinsic motivation

Motivation is an inner construct that inspires an individual's desire and energy to be consistently interested in and devoted to pursuing a goal. It is the capacity to influence the conduct of individuals. The internal state initiates, directs, and maintains goal-directed action [27–28]. It is a learning condition that leads to, alters, or maintains the academic goals of a learner. It provides motivation for academic work, enables students to attain their learning objectives, engages them in learning activities, and empowers them to overcome learning problems and tough conditions. It affects their academic performance [29–33].

Several theories explain motivation in settings of learning. The self-determination theory (STD) is the human motivation theory with the most scientific support. It explains motivation in several contexts, including e-learning, as it has been effectively used in physical education [34–37]. STD considers motivation to be a multidimensional entity and differentiates between many sorts of motivation. It views motivation as a continuum between fully self-determined and non-self-determined. The research distinguished between intrinsic and extrinsic motivation. According to an individual's underlying regularity process, intrinsic and extrinsic motivation might vary.

Intrinsic motivation (IM) refers to behaviors that do not require external stimulation; they are self-determined and viewed as deliberate, stemming from a person's sense of self, and intrinsically interesting and gratifying [38]. Individuals that are innately driven participate in an activity without external incentives or stimulation with enthusiasm. In activities that are organically driven, the process of regularity and the apparent location of causality is internal to the self. In contrast, extrinsic motivation (EM) refers to actions taken in pursuit of an external condition, such as receiving benefits or avoiding negative consequences. The extrinsically motivated individual engaged in instrumental actions, which are motivated by a result apart from the activity itself. The regulatory mechanism in extrinsically motivated behavior is compliance, and the apparent locus of cause is external to the self [38–41]. Through the internalization process, which is a developmental process involving a person's translation of external regulatory mechanisms into internal regulatory processes, extrinsic motivation may become more autonomic and intrinsic [40–44].

According to STD satisfaction, basic psychological requirements (relatedness, autonomy, and competence) assist the internalization process that enables a person to become more self-determined and fulfilled [40, 45]. Therefore, pupils with more satisfaction with their fundamental psychological needs are more autonomous and intrinsically driven. Lei [46] outlined several advantages for intrinsically motivated students which are: positively relate to learning, achievement, self-efficacy, actively participate in class, cognitively engaged in learning tasks, attempt to achieve true understanding,

show creativity in performance, Keep trying to face learning difficulties or challenging issues, experience pleasure in learning process, as negatively relate to anxiety, depression, stress and frustration. In addition, academics and psychologists recommend implementing effective classroom practices and learning settings that meet students' fundamental psychological needs to promote intrinsic motivation among students in a variety of educational disciplines, including physical education [40, 47–48].

2.2 Sports nutrition knowledge

Knowledge of sports nutrition is crucial for athletic performance; it influences athletes' nutritional intake [21, 49]. Good knowledge of SNK among coaches and PE undergraduates assists them in preparing athletes effectively. In general, nutrition is the most influential aspect in achieving peak athletic performance [20]. Therefore, numerous researchers conducted studies to examine the nutrition knowldge of PE students and athletes. In Spain, Escribano-Ott et al., [22] performed descriptive research among basketball players and discovered that they lacked sufficient SNK; similarly, in Jordan, Elsahoryi and his colleagues [23] found that Jordanian athletes lacked nutrition knowledge. As well, In Palestine, Badrasawi, et al. [20] did a study among 249 students in physical education and discovered that they lacked an adequate nutrition understanding. The researchers Azizi and his colleagues [24] discovered that the nutritional understanding of elite college athletes requires improvement. In addition, Zuniga, et al. [25] conducted a descriptive study among Division I collegiate athletes and discovered that they lacked adequate nutrition knowledge (NK), emphasized the need for research to improve nutrition knowledge, and suggested conducting a study utilizing mobile technology to enhance it.

To improve the SNK of PE undergraduates, coaches, and athetes, researchers performed studies. As a result, mobile technologies such as nutrition-focused mobile applications were utilized and implemented to assist, monitor, and improve nutrition knowledge and SNK among individuals [50]. Despite the educational benefits of incorporating mobile technology into school, research has yet to examine its effect on SNK in the context of PE. Consequently, we may link to a few of the minor research that utilized it outside of the PE setting. Such as the study by Samoggia & Riedel [51], which examined the impact of nutrition-focused mobile applications (NFMA) on nutrition knowledge among 143 respondents (aged between 18 and 71) and found that NFMA positively increased nutrition knowledge and respondent motivation. Heikkila and his team mates [52] conducted a study involving seventy-nine endurance athletes and concluded that the mobile app did not increase nutrition information acquisition. These contradictory results, the absence of study on the impact of utilizing mobile applications on SNK, and the dearth of SNK among PE undergraduates and athletes demonstrate the need for contemporary research to improve SNK.

2.3 Blended learning and physical education context

BL is increasingly expanding in higher education. It is sometimes referred to as hybrid learning, mixed-mode learning, and flexible learning [3, 53]. There are several

definitions of blended learning in the literature; for instance, some define it as a combination of learning delivery modalities, frequently integrating face-to-face methods with asynchronous and/or synchronous online methods. In addition, some have characterized blended learning as the utilization of both face-to-face and computer-mediated training [54, 55] Moreover, some view blended learning as a combination of online, offline, and face-to-face instruction [56]. Despite these various definitions, the core concept is to capitalize on the positive aspects of both learning delivery systems [1].

Several studies on the educational benefits of BL have been conducted [57–59]; however, literature on implementing and designing effective BL is lacking, despite the crucial role of implementation in the success of BL courses [16]. Bidarra and Rusman [60], for instance, proposed a paradigm with three dimensions: context, technology, and pedagogy. It proposes constructing learning activities that apply to students' lives and are transferrable to real-world circumstances, as well as using current interactive technology like mobile or virtual reality.

Researchers highlighted some considerations and suggestions for designing BL courses, such as: determining the course objectives, the educator's experience, and the learner's characteristics; as well as the availability of learning and technological resources, providing online collaborative learning activities, considering students' learning experience regarding the technology, providing technical support, and employing strategies to increase the interaction among learners [16, 61]. Therefore, researchers and educators integrated BL in higher education across several domains and disciplines slowly [5–9]. Though, physical education courses are predominantly taught via the conventional face-to-face method [19]. This could be due to several factors: first, the lack of practical BL experiences in PE; second, the challenging issues that accompanied the implementation of online learning in PE courses, such as a lack of resources, a lack of information literacy among PE instructors, the limited availability of specific venues and environments at home, and the difficulty of implementing regular teaching plans online [62, 63].

2.4 Mobile applications-assisted instruction and physical education context

Mobile technology and its applications have been quickly adopted in the sphere of education; it enables the facilitation of the learning process anywhere, at any time, regardless of physical location. Consequently, it might be utilized in various learning delivery modes, including face to face, distance, and BL, which give new opportunities to merge face-to-face and online learning strategies. Additionally supports flipped learning and mixed learning [64]. There are two types of mobile-based instruction: a) mobile-mediated instruction (MMI), where instruction and learning are conducted over the mobile device, similar to distance learning; and b) mobile-assisted instruction (MAI) or mobile-aided instruction (MAI), where mobile users help and assist the learning and teaching processes, whether in BL, distance, or conventional face-to-face learning mode. These ideas stem from computer-mediated instruction (CMI) and computer-assisted instruction (CAI). MAI is more valuable than CAI because it promotes learning at any place and at any time [65–71].

The expansion of mobile use in education is a result of its widespread application in language learning to engage pupils. Mobile-assisted language learning (MALL) refers to the use of a mobile device anywhere and at any time for language learning activities. As a result, some mobile applications, such as Babbel and Busuu, were created and utilized to facilitate language learning [72–74]. MAI utilizes face-to-face, remote learning, and BL in a variety of settings [75–76]. Mobile blended learning refers to the use of a mobile device in the BL delivery mode, such as for specialized learning tasks or activities [64].

There are several pedagogical advantages of using mobile technology in BL delivery modality; for instance, Bardus and his colleagues [77] did research involving 100 students at the universities of Karazin and Berdyansk. Their findings indicated that the use of mobile applications to learn foreign languages in BL had a favorable effect on students' motivation and perspective of language learning. In addition, Ustun [78] proved in his literature review that the use of mobile technology in BL has a considerable favorable influence on students' learning acquisition and attitude toward mobile learning. In addition, Osifo [79] conducted a qualitative study in higher education with EAP students in UAE, demonstrating that MALL apps with Differentiated Activities in BL had a beneficial influence on students' teamwork, motivation, and research abilities. Alternatively, Suartama and his team mates [64] conducted a research and development study that proposed a mobile BL design with three phases: pre-analysis, activity, and resource design; they utilized the mobile application for Moodle LMS.

In the context of physical education literature that combines technology, the emphasis was on combining ICT tools with conventional learning. Little effort was devoted to determining the efficacy of mobile applications or technologies in the BL context; hence, we refer to all research that utilized mobile apps in all learning contexts (i.e., face-to-face, BL, and distance). For instance, Cheng and Chen [80] did a study using a mobile application in face-to-face mode. It followed the experimental approach undertaken in Taiwan with 90 primary school kids and discovered that mobile applications improved students' health-related physical fitness. Mabrouk [19], on the other hand, utilized mobile applications in distant learning contexts; he performed experimental research among PE undergraduates in Egypt. The study demonstrated statistically significant differences between students who used mobile applications with self-Regulated learning methodologies and those who did not.

Hung, et al. [81] conducted a study among 225 college students to examine the influence of incorporating mobile technology into badminton classes and discovered that it increases students' enthusiasm and badminton abilities. In addition, Alssaid and his team mates [82] performed descriptive research among 450 professors from Libyan faculties of physical education. They discovered a greater indirect effect of mobile applications through the instructor's function than its direct effect on enhancing students' enthusiasm to study. This study emphasizes the significance of the instructor's instructional tactics and deployment of the mobile application in the learning process. Similarly, Dana et al. [83] did an experimental study with 68 high school students in Iran that demonstrated intervention-based self-determination theory in online learning physical education had a good effect on students' motivation and physical activity. This experimental study highlighted the need of employing effective tactics in online physical education sessions to motivate students. In contrast, Vu and Lien's [84] research

of 125 physical education students in Vietnam revealed that the majority of them were prepared for mobile learning. However, students confront obstacles such as internet infrastructure and they required training for online learning skills.

In conclusion, the MAAL research revealed the absence of conceptual frameworks [75], highlighting the necessity for a theoretical basis for employee mobile technology and its instructional uses. In addition, literature on the use of mobile technology in education has primarily focused on its influence on language acquisition; additional research is required to examine its impact in the setting of physical education.

In light of the aforementioned literature review and prior research, the conceptual framework of this study has been established and given in Figure 1. Although this study is based on the theory of self-determination, it was hypothesized that undergraduates' intrinsic motivation could be increased in BL delivery modes through the use of effective instructional strategies and practice (i.e., employing mobile applications) that support undergraduates' basic psychological needs (i.e., Autonomy and competence), thereby improving their sports nutrition knowledge.

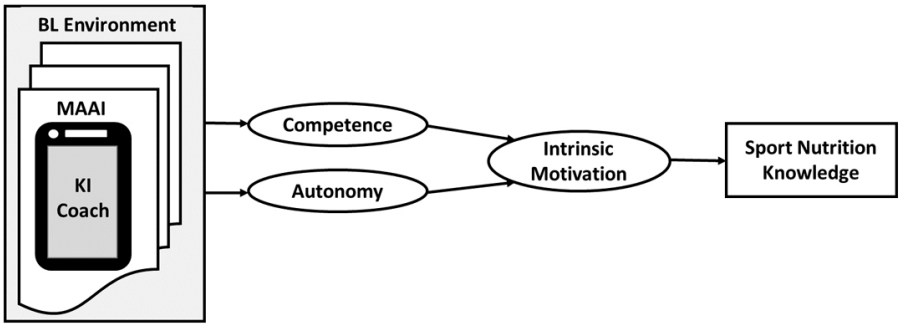

Fig. 1. Conceptual framework of the study

3 Methodology

3.1 Study design, participants, and procedures

This study utilized a quasi-experimental methodology using pre-test, post-test, and two-group design. As pre- and post-tests, a valid and reliable academic intrinsic motivation measure and a sports nutrition knowledge exam were provided to both groups. 50 PE undergraduates enrolling Al-Ahliyya Amman University (AAU) in Jordan during the second semester of the academic year 2021–2022 were included in the study. The administration of the university granted permission to conduct this study, and informed consent was obtained from all participants. They were told of the study's objective and the option to discontinue participation at any moment without dropping the course. All individuals were eager and willing to participate in the study. Table 1 shows the characteristics of the participants.

Table 1. Characteristics of the participants (N = 50)

Variable	Value	EG (n = 25)		CG (n = 25)	
		F	P	F	P
Gender	Male	12	48%	17	68%
	Female	13	52%	8	32%
GPA	Excellent	12	48%	8	32%
	Very good	11	44%	12	48%
	Good or less	2	8%	5	20%
Academic Level	Freshman	14	56%	19	76%
	Sophomore	9	36%	4	16%
	Junior	2	8%	2	8%
	Senior	0	0%	0	0%

Note: n: number of students in the group; P: Percentage; F: Frequencies.

The school of physical education provided one BL-mode nutrition and physical performance course. Participants were randomly assigned to the experimental group (EG) n=25 and the control group (CG) n=25. The same teacher delivered the nutrition and physical performance course to undergraduates in both groups using BL mode (20% online sessions and 80% face-to-face sessions in class), undergraduates in CG were taught the course using conventional BL teaching. In contrast, the EG pupils utilized MAAI. EG participants had a one-hour online instruction on "KI-coach" applications before the start of the trial. Before and after the nutrition and physical performance course teaching, both groups were evaluated on their intrinsic motivation and sports nutrition knowledge. The course was given by the same physical education instructor for fourteen weeks (42 hours) over the semester. The Independent variable of the study was the instructional BL approach (conventional, MAAI), whereas the dependent variables were intrinsic motivation and sports nutrition knowledge.

This BL course included both synchronous and asynchronous online lectures in addition to face-to-face lectures. The lecturer conducted asynchronous lessons on the Moodle learning management system (LMS) and synchronous lectures on the Teams platform. In contrast, face-to-face lectures were given in classroom settings at camps. During face-to-face lectures, the teacher taught students in CG and EG using the same manner. In the BL lectures, however, CG students were taught utilizing conventional BL instruction (students do traditional assignments, practice, and project using textbox and Microsoft word and then upload it to the university learning management system). While EG pupils were taught using MAAI (students do their assignments, project, and practice using the artificial intelligence mobile app "KI-Coach"). This was intended to support their learning process anytime, anyplace, and give them possibilities for self-paced, rapid feedback learning. A "KI-coach" app is an app powered by artificial intelligence that aids strength training and diet planning. It gives students an outstanding personal trainer who provides them with individualized workout regimens, daily goals, and dietary information. In addition, it addresses the learning goals of the selected topics with scientific nutrition knowledge and concepts, such as the identification of food kinds in great detail, i.e. (carbohydrates, portions, fats, mineral salts, vitamins,

and water). In addition, practice planning such as the creation and production of meal programs, and practice calculating the daily caloric needs of humans or athletes. These elements inspire and motivate students to use their knowledge outside of the classroom. In addition, it provides students with a personalized training experience, since they are supported in their knowledge and practice by an outstanding private coach.

3.2 Study instrument

Two instruments that had been translated from English to Arabic and reviewed and assessed by (10) expert specialists in Arabic and English languages, measurement and evaluation, psychology, and physical education from numerous universities in Jordan. First, both instruments were translated into Arabic since its the official language of Jordan. Then, their validity and reliability were confirmed by administering them to a pilot sample.

Intrinsic motivation scale. The data was collected using the Academic Motivation Scale (AMS) developed by Vallerand et al. [85], which is available at https://www.lrcs.uqam.ca. It compromised three subscales: Intrinsic motivation, extrinsic motivation, and motivation. Researchers evaluated the intrinsic motivation levels of individuals using the Intrinsic Motivation subscale (IMS). It consisted of 12 items and three subscales: intrinsic motivation to know, motivation to experience stimulation, and intrinsic motivation to accomplish. Each scale item required respondents to assess questions such as "Why do you attend college?" The responders were nominated using a seven-point Likert scale ranging from (1) doesn't correspond at all to (7) corresponds exactly. The range of intrinsic motivation scores was between (12 to 84). These scores represent the intrinsic academic motivation of respondents; the higher the score, the greater the intrinsic drive of respondents.

Several investigations validated the AMS measure's validity and reliability [86–88, 90, 99]. In addition, researchers in this study administered the IMS to a pilot sample of forty students to ensure its reliability and validity. The Cronbach alpha for IMS was 0.95, and the Pearson's correlation coefficients between each subscale item and the total IMS score were statistically significant ($P<0.05$) and varied from 0.37 to 0.72, ensuring the internal consistency of IMS. These results demonstrate that the IMS is a reliable and valid instrument.

Sports nutrition knowledge questionnaire. A concise Sports Nutrition Knowledge Questionnaire (A-SNKQ) created by Trakman et al., [91] was used to collect data. Researchers used the second section of the A-SNKQ, titled "sports nutrition knowledge" (SNK), to evaluate students' understanding and knowledge of sports nutrition (i.e., knowledge of athletes' macronutrient and fluid requirements, weight loss and gain strategies for athletes, and supplementation for athletes). It consisted of 20 questions, nine of which were multiple-choice and eleven of which were true or false, with test scores ranging from 0 to 20. Previous research has confirmed the reliability SNKQ's and validity [91–92]. In addition, to assure the SNK's psychometric properties, researchers retrieved Cronbach's alpha values of 0.91, indices of discriminating values over 0.22, and difficulty indexes ranging between (0.13–0.84). These results imply that the SNK measurement is reliable and an valid test for this investigation.

3.3 Data analysis

The descriptive statistics mean (M) and standard deviation (SD) were extracted for the study variables. In addition, a one-way analysis of covariance (ANCOVA) was conducted to answer the research questions and determine whether there was a statistically significant difference between the post-test means of the research groups. Kolmogorov Smirnov and Levene tests were performed to verify the data's normality and homogeneity as conditions to perform the ANCOVA analysis test. In addition, the eta square was calculated to determine the influence of the instructional approach on the dependent variables (intrinsic motivation and sports nutrition knowledge). All statistical analyses were carried out using SPSS package software.

4 Findings and discussion

The impact of MAAI on physical education undergraduates' intrinsic motivation.

RQ1: Are there statistically significant differences at the significance level ($\alpha <= 0.05$) in the development of intrinsic motivation among PE undergraduates attributable to the instructional BL method (MAAI and conventional)?

To answer this question, the researchers collected the descriptive statistics M and DS from the participant's IMS pre- and post-test scores, as shown in Table 2. The results indicated that the mean scores for both groups on the intrinsic motivation post-test were comparable (3.75, 3.68). In addition, it demonstrated an apparent difference between the research groups' intrinsic motivation post-test mean scores (EG and CG). The MAAI's mean was greater. The mean post-test score for the experimental group was 4.41, whereas the mean score for the control group was 3.60, indicating an evident difference between the teaching approach and the intrinsic motivation of students in favor of MAAI.

Table 2. Means and standard deviations physical education undergraduates pre-test and post-test IMS scores

Group	N	Pre-test		Post-test	
		SD	M	SD	M
EG	25	0.99	3.75	0.86	4.41
CG	25	0.96	3.68	0.98	3.60
Total	50	0.97	3.71	1.0	4.01

Note: N: number of participants in the group.

A one-way ANCOVA analysis was carried out to see if these apparent differences were statistically significant after the ANCOVA essential conditions were ensured by conducted normality and homogeneity tests, and the intrinsic motivation data were normally distributed and homogeneous. Additionally, the partial eta squared was extracted to determine the amount of variance that the instructional approaches can explain. The results of these experiments are shown in Table 3.

Table 3. ANCOVA results for physical education undergraduates' post-test IMS scores

Source of Variation	Sum Square	Df	Mean Square	F	Sig	(η2)
IMS Pre-test	35.565	1	35.565	304.626	.000*	0.866
Instructional Method	7.047	1	7.047	60.357	.000*	0.562
Error	5.487	47	0.117			
Adjusted Total	49.253	49				

Note: Sig: significant, Df: degrees of freedom, F: F-test, and η2: partial Eta square.

Table 3 Revealed significant differences (α=0.05) in IMS post-test scores between the study groups as the value of F (60.357). In addition, the partial eta squared reached 0.56, indicating that instructional BL methods had a medium influence on the development of intrinsic motivation. As indicated in Table 4, the Adjusted means and standard error of the IMS were computed to determine the cause of these disparities.

Table 4. Adjusted means and standard errors of of the post-test IMS scores

Group	AM	SE
Experimental Group	4.38	0.07
Control Group	3.36	0.07

Note: SE: Standard Error and AM: Adjusted Means.

Adjusted mean post-test IMS scores for undergraduates taught with the MAAI were (4.38), which is greater than those taught with the conventional method (3.36). This finding reveals that the adjusted means of the IMS-favored and experimental groups differ significantly. Undergraduates scored considerably higher on the IMS test when taught utilizing the MAAI method as opposed to the conventional BL approach. This demonstrated the effectiveness of the instructional method MAAI in fostering intrinsic motivation in undergraduate physical education students. This positive effect of employing MAAI in BL mode may be interpreted by many factors. First, the KI-coach's built-in functionalities give students with options and additional educational materials and resources to support their autonomy (i.e., state of the art nutrition and sports performance knowledge), tools for organizing strength nutrition knowledge and workouts, and flexible learning time. An undergraduate can choose when and where to study and learn; these chances to voluntarily dedicate time and effort to their education foster student autonomy [40, 93]. In addition, "KI-coach" increases the students' sense of control by allowing them to personalize their fitness and establish objectives for their body weight, diet, and activity. This allows individuals to utilize their abilities and provides purposeful justifications for their learning efforts. These characteristics of offering alternatives, choices, flexibility in learning, and compelling rationales for learning activities tend to be autonomy-supportive, resulting in less controlling learners. According to STD, Autonomy supporting practice and learning environments meet the demand for satisfying the psychological need of autonomy [40, 45, 93].

The second "KI-coach" application is an artificial intelligence tool that delivers appropriate feedback to undergraduates and continuously evaluates their performance.

This instantaneous feedback promotes student success and beliefs of effectiveness, which support the need of competence [40, 93]. In addition, "KI-coach" enables undergraduates to continue practicing until they gain the necessary skills and knowledge and overcome any learning difficulties or obstacles. This provides students with an excellent learning experience to accomplish their learning activities (i.e., assignments and projects) and enables them to attain their learning objectives. In addition, this enables pupils to be competent since they can confront the problems of their schooling and learning assignments [40]. The "KI-coach" app is regarded as an elite private coach for seven days/24 hours who assists students in studying nutrition and sport performance themes that allow individualization learning and account for variances in undergraduates' learning capacities.

In addition, the "KI-coach" app provides challenging learning activities that enable undergraduates to practice and improve their skills and academic talents. They can practice diet planning, for instance, by establishing or producing meal programs and plans based on certain sports activities or food choices. In addition, students got several opportunities to practice calculating the daily caloric needs of an individual or an athlete. These demanding learning exercises give students opportunities to test and enhance their academic skills, therefore meeting their psychological need of competence [40].

MAAI in BL provides an active learning environment (i.e., "KI-coach" mobile applications) that helps meet the competence and autonomy demands of students. According to SDT, the internalization process is facilitated by methods that promote autonomy and competence (i.e., feedback and choice). This causes the external focus of causality to become internal. This increases intrinsic motivation [38, 40, 94]. Undergraduates in experimental groups taught with MAAI using "KI-coach" apps exhibited a greater intrinsic motivation drive to study. This positive effect of MAAI in the BL setting on the intrinsic motivation of PE undergraduates is consistent with the findings of Mabrouk [19], who found that using the mobile application with self-Regulated learning strategies increased the motivation to learn among PE undergraduates in a distance learning setting. In addition, this is congruent with the findings of Hung, et al. [80], who discovered that integrating mobile technology into badminton lessons increased college students' motivation. Also consistent with the findings of [83], intervention-based SDT in online PE learning had a favorable effect on student motivation.

The impact of MAAI on physical education undergraduates' sports nutrition knowledge

RQ2: Are there statistically significant differences at the significance level ($\alpha <= 0.05$) in the acquisition of Sport Nutrition Knowledge among PE undergraduates attributable to the instructional BL method (MAAI and conventional)?

To answer this question, descriptive data M and DS of the participant's pre- and post-test scores on the SNK test were retrieved and shown in Table 5. The mean SNK pre-test results for both groups were nearly identical (6.68, 6.40). In addition, it demonstrated an apparent difference between the research groups' SNK post-test mean scores (EG and CG). The mean SNK post-test score for the experimental group, which was taught using MAAI, was 15.92, whereas the mean SNK post-test score for the control

group was 10.76. This substantiated an ostensible instructional method effect on the acquisition of Sports Nutrition Knowledge by students in favor of MAAI.

Table 5. Means and standard deviations physical education undergraduates' pre-test and post-test SNK scores

Group	N	Pre-test		Post-test	
		SD	M	SD	M
EG	25	2.10	6.68	2.27	15.92
CG	25	3.86	6.40	2.77	10.76
Total	50	3.08	6.54	3.62	13.34

Note: N: number of participants in the group.

A one-way ANCOVA analysis was conducted to determine the statistical significance of these apparent differences after the ANCOVA essential conditions were ensured by the conducted of the normality and homogeneity tests, and the sport nutrition knowledge data were normally distributed and homogeneous In addition, the partial eta square was calculated to investigate the instructional approaches' effect size. The results are presented in Table 6.

Table 6. ANCOVA results for physical education undergraduates' post-test SNK scores

Source of Variation	Sum Square	Df	Mean Square	F	Sig	(η2)
SNK Pre-test	11.423	1	11.423	1.808	0.185	0.037
Instructional Method	326.483	1	326.483	51.67	.000*	0.524
Error	296.977	47	6.319			
Adjusted Total	641.22	49				

Note: Sig: significant, Df: degrees of freedom, F: F-test, and η2: partial Eta square.

The result of F (51.76) indicated a statistically significant difference (α=0.05) between the SNK post-tests of the two groups. The partial eta square was 0.524, indicating that 52.4% of the variation in the dependent variable (knowledge of sports nutrition) was attributable to the instructional approach. To determine the origin of these disparities, the adjusted means and standard error of the SNK post-test scores were extracted and displayed in Table 7.

Table 7. Adjusted means and standard errors of of the the post-test SNK scores

Group	AM	SE
Experimental Group	15.90	0.5
Control Group	10.78	0.5

Note: SE: Standard Error and AM: Adjusted Means.

The post-test SNK adjusted mean for the experimental group taught using the MAAI (15.90) was greater than that of the control group taught using the

conventional method (10.78). This suggests that the mean score of undergraduates on the SNK test was much higher when MAAI was utilized as opposed to the usual BL approach. This demonstrates the effectiveness of the instructional approach MAAI in boosting the SNK of undergraduate physical education students. This positive impact on MAAI may be attributable to several factors; the "KI-coach" application provides a rich active learning environment that assists undergraduates in acquiring sports nutrition knowledge topics by, for example, providing immediate feedback, consultation, state of the art resources and information, and opportunities to practice and learn at their own pace. These alternatives supplied to students in the experimental group enhanced their awareness of sports nutrition and corrected their misconceptions. In addition, the "KI-coach" app provides opportunities for students to engage in authentic learning activities, which can be achieved using technology [95–97], such as planning their diet, monitoring their dietary intake, and tracking their physical performance. This dynamic learning environment facilitates the attainment of learning objectives and enhances student performance [98, 99].

In addition, the "KI-coach" app's capacity to foster intrinsic motivation might play a crucial part in this enhancement of SNK among EG undergraduates. As a result, intrinsic motivation empowers and motivates undergraduates to study and accomplish their learning objectives where some researchers have demonstrated the effect of intrinsic motivation on academic achievement and performance [13, 100]. The positive impact of MAAI on improving SNK among PE undergraduates is consistent with the findings of Mabrouk's [19] study, which employed a mobile app in a distance learning setting and found statistically significant differences for its use to improve PE cognitive achievement among undergraduates. Similarly, Samoggia and Riedel's [51] study indicated that nutrition-focused mobile applications on nutrition increased respondents' nutrition knowledge. Additionally, Cheng and Chen [80] discovered that the use of mobile applications improved students' health-related physical fitness accomplishments. In contrast to research by Heikkila, et al. [52], which indicated that mobile applications did not increase nutrition knowledge among young endurance athletes, the results of this study contradict those findings and highlighted a need for further research.

5 Conclusions

In the educational literature, integrating technology into the learning and teaching processes has been mostly dominant. Despite this, further research is required to determine the impact of mobile applications in physical education courses. This study is one of the few to assess the impact of mobile application-assisted instruction on physical education undergraduates' intrinsic motivation and knowledge of sports nutrition in a blended learning setting. The "KI-coach" app was employed as a state-of-the-art artificial intelligence mobile app in the field of strength sports science. It supports the topic of nutrition and physical performance course. The mobile app provides an active learning environment that gives an authentic learning experience and an environment that is conducive to the intended learning outcomes of the course. In addition, it provides students with access to a top private coach that is available anytime and everywhere.

The results of the study indicate that mobile apps assisted instruction in blended learning has a strong positive effect on the intrinsic motivation and sports nutrition knowledge of undergraduate physical education students. MAAI creates settings that promote the internalization process by supporting the autonomy and competency needs of students. This stimulates the intrinsic motivation of pupils and increases their sport nutrition knowledge. Despite the small sample size, the results demonstrate the efficacy of mobile app-assisted instruction in enhancing students' intrinsic motivation and sports nutrition knowledge acquisition. These findings should encourage decision-makers at higher education institutions to consider artificial intelligence-based mobile apps and to encourage physical education instructors to incorporate these apps into their BL courses and instructional practices to increase their students' intrinsic motivation and sports nutrition knowledge. There is a need for more research on the influence of mobile app-assisted physical education instruction, particularly artificial intelligence applications, on the development of intrinsic motivation and sports nutrition knowledge. Researchers advocate repeating the study with more samples and other variables.

Informed Consent Statement: Informed consent was obtained from all study's participants.

Data Availability Statement: The study data will be provided by the authors when requested.

Competing Interests: The authors declare that they have no competing interests.

6 References

[1] Güzer, B. & Caner, H. (2014). The past, present and future of blended learning: An in depth analysis of literature. Procedia – Social and Behavioral Sciences, 116, 4596–4603. https://doi.org/10.1016/j.sbspro.2014.01.992

[2] Sankar, J. P., Kalaichelvi, R., Elumalai, K. V., & Alqahtani, M. S. M. (2022). Effective blended learning in higher education during COVID-19. Information Technologies and Learning Tools, 88(2), 214–228. https://doi.org/10.33407/itlt.v88i2.4438

[3] Ma, L. & Lee, C. S. (2021). Evaluating the effectiveness of blended learning using the ARCS model. Journal of Computer Assisted Learning, 37(5), 1397–1408. https://doi.org/10.1111/jcal.12579

[4] Setiadi, G. (2021, March). Effectiveness of blended learning to improve critical thinking skills and student science learning outcomes. In Journal of Physics: Conference Series (Vol. 1823, No. 1, p. 012095). IOP Publishing. https://doi.org/10.1088/1742-6596/1823/1/012095

[5] Yennita, Y. & Zukmadini, A. Y. (2021). Problem-based learning (PBL) and blended learning in improving critical thinking skills and student learning activities in biochemistry courses. In Journal of Physics: Conference Series (Vol. 1731, No. 1, p. 012007). IOP Publishing. https://doi.org/10.1088/1742-6596/1731/1/012007

[6] Wang, C. (2021). Employing blended learning to enhance learners' English conversation: A preliminary study of teaching with Hitutor. Education and Information Technologies, 26(2), 2407–2425. https://doi.org/10.1007/s10639-020-10363-5

[7] Liya, A. D. W. (2021). The effect of Google classroom in Blended Learning on university students' English ability. J-SHMIC: Journal of English for Academic, 8(1), 12–23. https://doi.org/10.25299/jshmic.2021.vol8(1).6216

[8] Hassan, I., Madarina Abdul Rahaman, A., & Latiff Azmi, M. N. (2021). Development of English writing skills through blended learning among ESL learners in Malaysia. Arab World English Journal (AWEJ) Special Issue on CALL, 7, 377–389. https://doi.org/10.24093/awej/call7.26

[9] Kang, H. Y. & Kim, H. R. (2021). Impact of blended learning on learning outcomes in the public healthcare education course: A review of flipped classroom with team-based learning. BMC Medical Education, 21(1), 1–8. https://doi.org/10.1186/s12909-021-02508-y

[10] Seitan, W. I., Ajlouni, A. O., & Al-Shra'h, N. D. (2020). The impact of integrating flipped learning and information and communication technology on the secondary school students' academic achievement and their attitudes towards it. International Education Studies, 13(2), 1–10. https://doi.org/10.5539/ies.v13n2p1

[11] Aji, W. K., Ardin, H., & Arifin, M. A. (2020). Blended learning during pandemic corona virus: Teachers' and students' perceptions. IDEAS: Journal on English Language Teaching and Learning, Linguistics and Literature, 8(2), 632–646. https://doi.org/10.24256/ideas.v8i2.1696

[12] Boelens, R., De Wever, B., & Voet, M. (2017). Four key challenges to the design of blended learning: A systematic literature review. Educational Research Review, 22, 1–18. https://doi.org/10.1016/j.edurev.2017.06.001

[13] Trevino, N. N. & DeFreitas, S. C. (2014). The relationship between intrinsic motivation and academic achievement for first generation Latino college students. Social Psychology of Education, 17(2), 293–306. https://doi.org/10.1007/s11218-013-9245-3

[14] Taylor, G., Jungert, T., Mageau, G. A., Schattke, K., Dedic, H., Rosenfield, S., & Koestner, R. (2014). A self-determination theory approach to predicting school achievement over time: The unique role of intrinsic motivation. Contemporary Educational Psychology, 39(4), 342–358. https://doi.org/10.1016/j.cedpsych.2014.08.002

[15] Liu, W. C., Wang, C. K. J., Kee, Y. H., Koh, C., Lim, B. S. C., & Chua, L. (2014). College students' motivation and learning strategies profiles and academic achievement: A self-determination theory approach. Educational Psychology, 34(3), 338–353. https://doi.org/10.1080/01443410.2013.785067

[16] Ustun, A. B. & Tracey, M. W. (2021). An innovative way of designing blended learning through design-based research in higher education. Turkish Online Journal of Distance Education, 22(2), 126–146. https://doi.org/10.17718/tojde.906821

[17] Wang, W. (2022). Influences of education app-assisted teaching technology on learning efficacy of learners. International Journal of Emerging Technologies in Learning, 17(21), 4–16. https://doi.org/10.3991/ijet.v17i21.35369

[18] Liu, L., Zhang, L., Ye, P., & Liu, Q. (2018). Influence factors of satisfaction with mobile learning APP: An empirical analysis of China. International Journal of Emerging Technologies in Learning, 13(3), 87–99. https://doi.org/10.3991/ijet.v13i03.8381

[19] Mabrouk, W. M. E. (2020). The effectiveness of an educational program based on self-regulated learning strategies using some mobile learning applications on cognitive achievement and motivation for fourth year student with a boxing specialty in the faculty of physical education – Banha University. المجلة العلمية علوم وفنون الرياضة, 35(035), 186–224. https://doi.org/10.21608/ijssaa.2020.37573.1254

[20] Badrasawi, M. M., Shraim, N. Y., & Al-Atrash, M. H. (2018). Knowledge of physical education students about nutrition: A cross-sectional study from Palestine. International Journal of Nutrition, Pharmacology, Neurological Diseases, 8(4), 101–107. https://doi.org/10.4103/ijnpnd.ijnpnd_32_18

[21] O'Brien, L., Collins, K., & Amirabdollhian, F. (2021). Exploring sports nutrition knowledge in Elite Gaelic footballers. Nutrients, 13(4), 1081. https://doi.org/10.3390/nu13041081

[22] Escribano-Ott, I., Mielgo-Ayuso, J., & Calleja-González, J. (2021). A glimpse of the sports nutrition awareness in Spanish basketball players. Nutrients, 14(1), 27. https://doi.org/10.3390/nu14010027

[23] Elsahoryi, N. A., Trakman, G., & Al Kilani, A. (2021). General and sports nutrition knowledge among Jordanian adult coaches and athletes: A cross-sectional survey. PloS One, 16(11), e0258123. https://doi.org/10.1371/journal.pone.0258123

[24] Azizi, M., Rahmani-Nia, F., Malaee, M., Malaee, M., & Khosravi, N. (2010). A study of nutritional knowledge and attitudes of elite college athletes in Iran. Brazilian Journal of Biomotricity, 4(2), 105–112.

[25] Zuniga, K. E., Downey, D. L., McCluskey, R., & Rivers, C. (2017). Need for and interest in a sports nutrition mobile device application among division I collegiate athletes. International Journal of Sport Nutrition and Exercise Metabolism, 27(1), 43–49. https://doi.org/10.1123/ijsnem.2015-0305

[26] MOHE, Ministry of Higher Education, (2023). Instructions for the integration of e-learning in higher education institutions, Amman, Jordan. [Online] Available: https://www.mohe.gov.jo/ebv4.0/root_storage/ar/eb_list_page/تعليمات_اجراءات_التعلم_الإلكتروني_في_مؤسسات_التعليم_العالي_لسنة_٢٠٢١-.pdf

[27] Sharipovna, J. J. & Oybekovna, D. G. (2019). Role of teachers' motivation in teaching. Вопросы науки и образования, 3(47), 84–88.

[28] Chumbley, S. B., Haynes, J. C., & Stofer, K. A. (2015). A measure of students' motivation to learn science through agricultural STEM emphasis. Journal of Agricultural Education, 56(4), 107–122. https://doi.org/10.5032/jae.2015.04107

[29] Gopalan, V., Bakar, J. A., & Zulkifli, A. N. (2020). A review of motivation theories models and instruments in learning environment. Journal of Critical Reviews, 7(6), 554–559. https://doi.org/10.31838/jcr.07.06.100

[30] Rafii, F., Saeedi, M., & Parvizy, S. (2019). Academic motivation in nursing students: A hybrid concept analysis. Iranian Journal of Nursing and Midwifery Research, 24(5), 315. https://doi.org/10.4103/ijnmr.IJNMR_177_18

[31] Lee, J., Chang, E. C., Lucas, A. G., & Hirsch, J. K. (2019). Academic motivation and psychological needs as predictors of suicidal risk. Journal of College Counseling, 22(2), 98–109. https://doi.org/10.1002/jocc.12123

[32] Bacanlı, H. & Sahinkaya, O. (2011). The adaptation study of academic motivation scale into Turkish. Procedia – Social and Behavioral Sciences, 12, 562–567. https://doi.org/10.1016/j.sbspro.2011.02.068

[33] Ajlouni, A., Rawadieh, S., AlMahaireh, A., & Awwad, F. A. (2022). Gender differences in the motivational profile of undergraduate students in light of self-determination theory: The case of online learning setting. Journal of Social Studies Education Research, 13(1), 75–103.

[34] Salikhova, N. R., Lynch, M. F., & Salikhova, A. B. (2020). Psychological aspects of digital learning: A self-determination theory perspective. Contemporary Educational Technology, 12(2). https://doi.org/10.30935/cedtech/8584

[35] Noour, M. A. T. & Hubbard, N. (2015). Self-determination theory: Opportunities and challenges for blended e-learning in motivating Egyptian learners. Procedia – Social and Behavioral Sciences, 182, 513–521. https://doi.org/10.1016/j.sbspro.2015.04.836

[36] Perlman, D. & Goc Karp, G. (2010). A self-determined perspective of the sport education model. Physical Education and Sport Pedagogy, 15(4), 401–418. https://doi.org/10.1080/17408980903535800

[37] Deci, E. L. & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. Canadian Psychology/Psychologie canadienne, 49(3), 182–185. https://doi.org/10.1037/a0012801

[38] Deci, E. L. & Ryan, R. M. (1985). Intrinsic Motivation and Self-determination in Human Behavior. New York: Plenum. Theory and Research in Education, 7(2), 142. https://doi.org/10.1007/978-1-4899-2271-7

[39] Deci, E. L., Olafsen, A. H., & Ryan, R. M. (2017). Self-determination theory in work organizations: The state of a science. Annual Review of Organizational Psychology and Organizational Behavior, 4, 19–43. https://doi.org/10.1146/annurev-orgpsych-032516-113108

[40] Niemiec, C. P. & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom: Applying self-determination theory to educational practice. Theory and Research in Education, 7(2), 133–144. https://doi.org/10.1177/1477878509104318

[41] Deci, E. L. & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11, 227–268. https://doi.org/10.1207/S15327965PLI1104_01

[42] Black A. & Deci, E. (2020). The effects of instructors' autonomy support and students' autonomous motivation on learning organic chemistry: A self-determination theory perspective. Science Education, 84(6), 740–756. https://doi.org/10.1002/1098-237X(200011)84:6<740::AID-SCE4>3.0.CO;2-3

[43] Ryan & Deci. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, 1–11. https://doi.org/10.1016/j.cedpsych.2020.101860

[44] Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. American Educational Research Journal, 29(3), 663–676. https://doi.org/10.3102/00028312029003663

[45] Müller, F. H. & Louw, J. (2004). Learning environment, motivation and interest: Perspectives on self-determination theory. South African Journal of Psychology, 34(2), 169–190. https://doi.org/10.1177/008124630403400201

[46] Lei, S. A. (2010). Intrinsic and extrinsic motivation: Evaluating benefits and drawbacks from college instructors' perspectives. Journal of Instructional Psychology, 37(2), 153–160.

[47] Sun, H., Li, W., & Shen, B. (2017). Learning in physical education: A self-determination theory perspective. Journal of Teaching in Physical Education, 36(3), 277–291. https://doi.org/10.1123/jtpe.2017-0067

[48] Reeve, J., Deci, E. L., & Ryan, R. M. (2004). Self-determination theory: A dialectical framework for understanding socio-cultural influences on student motivation. Big Theories Revisited, 4, 31–60.

[49] Vázquez-Espino, K., Rodas-Font, G., & Farran-Codina, A. (2022). Sport nutrition knowledge, attitudes, sources of information, and dietary habits of sport-team athletes. Nutrients, 14(7), 1345. https://doi.org/10.3390/nu14071345

[50] Villasana, M. V., Pires, I. M., Sá, J., Garcia, N. M., Zdravevski, E., Chorbev, I., ... & Flórez-Revuelta, F. (2019). Mobile applications for the promotion and support of healthy nutrition and physical activity habits: A systematic review, extraction of features and taxonomy proposal. The Open Bioinformatics Journal, 12(1). https://doi.org/10.2174/1875036201912010050

[51] Samoggia, A. & Riedel, B. (2020). Assessment of nutrition-focused mobile apps' influence on consumers' healthy food behaviour and nutrition knowledge. Food Research International, 128, 108766. https://doi.org/10.1016/j.foodres.2019.108766

[52] Heikkilä, M., Lehtovirta, M., Autio, O., Fogelholm, M., & Valve, R. (2019). The impact of nutrition education intervention with and without a mobile phone application on nutrition knowledge among young endurance athletes. Nutrients, 11(9), 2249. https://doi.org/10.3390/nu11092249

[53] Müller, C. & Mildenberger, T. (2021). Facilitating flexible learning by replacing classroom time with an online learning environment: A systematic review of blended learning in higher education. Educational Research Review, 34, 100394. https://doi.org/10.1016/j.edurev.2021.100394
[54] Graham, C. R. (2006). Blended learning systems: Definition, current trends, and future directions. In C. J. Bonk & C. R. Graham (Eds.), The handbook of blended learning: Global perspectives, local designs (pp. 3–21). Pfeiffer Publishing.
[55] Vernadakis, N., Giannousi, M., Tsitskari, E., Antoniou, P., & Kioumourtzoglou, S. (2012). A comparison of student satisfaction between traditional and blended technology course offerings in physical education. Turkish Online Journal of Distance Education, 13(1), 137–147.
[56] Abdullah, W. (2018). Model blended learning dalam meningkatkan efektifitas pembelajaran. Fikrotuna, 7(1), 855–866. https://doi.org/10.32806/jf.v7i1.3169
[57] Huda, N., Mustaji, F. A., & Ayubi, N. (2022). The application of blended learning with a community science technology approach to improve student learning outcomes in higher education. International Journal of Emerging Technologies in Learning, 17(14), 246–252. https://doi.org/10.3991/ijet.v17i14.32927
[58] Prahani, B., Jatmiko, B., Hariadi, B., Sunarto, D., Sagirani, T., Amelia, T., & Lemantara, J. (2020). Blended Web Mobile Learning (BWML) model to improve students' higher order thinking skills. International Journal of Emerging Technologies in Learning (iJET), 15(11), 42–55. https://doi.org/10.3991/ijet.v15i11.12853
[59] Banyen, W., Viriyavejakul, C., & Ratanaolarn, T. (2016). A blended learning model for learning achievement enhancement of thai undergraduate students. International Journal of Emerging Technologies in Learning, 11(4), 48–55. https://doi.org/10.3991/ijet.v11i04.5325
[60] Bidarra, J. & Rusman, E. (2017). "Key pedagogical and technological factors for effective blended learning design." In The Envisioning Report for Empowering Universities, edited by G. Ubachs and L. Konings, 20–23. Maastricht: EADTU.
[61] Zhu, M., Berri, S., & Zhang, K. (2021). Effective instructional strategies and technology use in blended learning: A case study. Education and Information Technologies, 26(5), 6143–6161. https://doi.org/10.1007/s10639-021-10544-w
[62] Zheng, W., Ma, Y. Y., & Lin, H. L. (2021). Research on blended learning in physical education during the covid-19 pandemic: A case study of chinese students. SAGE Open, 11(4), 21582440211058196. https://doi.org/10.1177/21582440211058196
[63] Oliver, M. & Trigwell, K. (2005). Can 'blended learning' be redeemed? E-learning and Digital Media, 2(1): 17–26. https://doi.org/10.2304/elea.2005.2.1.17
[64] Suartama, I. K., Setyosari, P., & Ulfa, S. (2019). Development of an instructional design model for mobile blended learning in higher education. International Journal of Emerging Technologies in Learning, 14(16), 4–22. https://doi.org/10.3991/ijet.v14i16.10633
[65] Bull, K. S., Kimball, S. L., & Stansberry, S. (1998). Developing interaction in computer mediated learning.
[66] Hung, D. (2001). Theories of learning and computer-mediated instructional technologies. Educational Media International, 38(4), 281–287. https://doi.org/10.1080/09523980110105114
[67] Arnold, D. N. (2000). Computer-aided instruction. Microsoft Encarta Online Encyclopedia.
[68] Matta, K. F. & Kern, G. M. (1989). A framework for research in computer-aided instruction: Challenges and opportunities. Computers & Education, 13(1), 77–84. https://doi.org/10.1016/0360-1315(89)90041-9
[69] Zheng, Q., Chen, T., & Kong, D. (2017). An empirical study on context awareness integrated mobile assisted instruction and the factors. Eurasia Journal of Mathematics, Science and Technology Education, 13(6), 1737–1747. https://doi.org/10.12973/eurasia.2017.00695a

[70] Chinnery, G. M. (2006). Going to the MALL: Mobile assisted language learning. Language Learning & Technology, 10(1), 9–16.
[71] Aeen, J. B., Riasati, M. J., & Zamanian, M. (2021). Recast, uptake, and learners' perception during video-based mobile-mediated interaction. Computer Assisted Language Learning, 22(3), 107–125.
[72] Gonulal, T. (2019). The use of Instagram as a mobile-assisted language learning tool. Contemporary Educational Technology, 10(3), 309–323. https://doi.org/10.30935/cet.590108
[73] Kukulska-Hulme, A. & Shield, L. (2008). An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction. ReCALL, 20(3), 271–289. https://doi.org/10.1017/S0958344008000335
[74] Kukulska-Hulme, A. (2009). Will mobile learning change language learning? ReCALL, 21(2), 157–165. https://doi.org/10.1017/S0958344009000202
[75] Duman, G., Orhon, G., & Gedik, N. (2015). Research trends in mobile assisted language learning from 2000 to 2012. ReCALL, 27(2), 197–216. https://doi.org/10.1017/S0958344014000287
[76] Farideh Ataeifar, Firooz Sadighi, Mohammad Sadegh Bagheri & Fatemeh Behjat. (2019). Iranian female students' perceptions of the impact of mobileassisted instruction on their English speaking skill. Cogent Education, 6(1), 1662594. https://doi.org/10.1080/2331186X.2019.1662594
[77] Bardus, I., Herasymenko, Y., Nalyvaiko, O., Rozumna, T., Vaseiko, Y., & Pozdniakova, V. (2021). Organization of foreign languages blended learning in COVID-19 conditions by means of mobile applications. Revista Romaneasca pentru Educatie Multidimensionala, 13(2), 268–287. https://doi.org/10.18662/rrem/13.2/421
[78] Ustun, A. B. (2019). Harmanlanmış öğrenme ortamlarında mobil öğrenmenin etkileri [Effects of mobile learning in blended learning environments]. Bilgi ve İletişim Teknolojileri Dergisi/Journal of Information and Communication Technologies, 1(1), 1–14.
[79] Osifo, A. (2019). Improving collaboration in blended learning environments through differentiated activities and mobile-assisted language learning tools. International Association for Development of the Information Society. https://doi.org/10.33965/ml2019_201903L001
[80] Cheng, C. H. & Chen, C. H. (2018). Developing a mobile app-supported learning system for evaluating health-related physical fitness achievements of students. Mobile Information Systems, Article ID 8960968. https://doi.org/10.1155/2018/8960968
[81] Hung, H. C., Shwu-Ching Young, S., & Lin, K. C. (2018). Exploring the effects of integrating the iPad to improve students' motivation and badminton skills: A WISER model for physical education. Technology, Pedagogy and Education, 27(3), 265–278. https://doi.org/10.1080/1475939X.2017.1384756
[82] Alssaid, A., Ismail, N. A. B., & Hashim, N. B. (2016). The impact of mobile learning application on the lecturer's role and development of learner's motivation towards learning: Empirical study at the faculties physical education – Libya. International Journal of Business and Management. https://doi.org/10.5539/ijbm.v11n9p134
[83] Dana, A., Khajehaflaton, S., Salehian, M. H., & Sarvari, S. (2021). Effects of an intervention in online physical education classes on motivation, intention, and physical activity of adolescents during the covid-19 pandemic. International Journal of School Health, 8(3), 158–166.
[84] Vu, N. N. & Lien, N. T. H. (2021). Mobile learning for physical education students in Vietnam: Promises and challenges. European Journal of Physical Education and Sport Science, 6(11). https://doi.org/10.46827/ejpe.v6i11.3654

[85] Vallerand, R., Pelletier, L., Blais, M., Briere, N., Senecal C., & Vallieres. E. (1992). The academic motivation scale: A measure of intrinsic, extrinsic, and amotivation in education. Educational and Psychological Measurement, 52(4), 1003–1017. https://doi.org/10.1177/0013164492052004025

[86] Natalya L. & Purwanto, C. (2018). Exploratory and confirmatory factor analysis of the academic motivation scale (AMS)–Bahasa Indonesia. Makara Human Behavior Studies in Asia, 22(1), 29–42. https://doi.org/10.7454/hubs.asia.2130118

[87] Liu, Y., Ferrell, B., Barbera J., & Lewis J. E. (2017). Development and evaluation of a chemistryspecific version of the academic motivation scale (AMS-Chemistry). Chemistry Education Research and Practice, 18(1), 191–213. https://doi.org/10.1039/C6RP00200E

[88] Utvær B. & Haugan, G. (2016). The academic motivation scale: Dimensionality, reliability, and construct validity among vocational students. Journal of Vocational Education and Training, 6(2), 17–45. https://doi.org/10.3384/njvet.2242-458X.166217

[89] Orsini, C., Binnie, V., Evans, P., Ledezma, P., Fuentes F., & Villegas. M. J. (2015). Psychometric validation of the academic motivation scale in a dental student sample. Journal of Dental Education, 79(8), 971–981. https://doi.org/10.1002/j.0022-0337.2015.79.8.tb05989.x

[90] Fairchild, A. J., Horst, S. J., Finney S. J., & Barron. K. E. (2005). Evaluating existing and new validity evidence for the academic motivation scale. Contemporary Educational Psychology, 30(3), 331–358. https://doi.org/10.1016/j.cedpsych.2004.11.001

[91] Trakman, G. L., Forsyth, A., Hoye, R., & Belski, R. (2018). Development and validation of a brief general and sports nutrition knowledge questionnaire and assessment of athletes' nutrition knowledge. Journal of the International Society of Sports Nutrition, 15(1), 17. https://doi.org/10.1186/s12970-018-0223-1

[92] Vázquez-Espino, K., Fernández-Tena, C., Lizarraga-Dallo, M. A., & Farran-Codina, A. (2020). Development and validation of a short sport nutrition knowledge questionnaire for athletes. Nutrients, 12(11), 3561. https://doi.org/10.3390/nu12113561

[93] Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and education: The self-determination perspective. Educational Psychologist, 26(3–4), 325–346. https://doi.org/10.1080/00461520.1991.9653137

[94] Deci, E. L. & Moller, A. C. (2005). The concept of competence: A starting place for understanding intrinsic motivation and self determined extrinsic motivation. In A. J. Elliot & C. S. Dweck (Eds.), Hand book of competence and motivation. New York, USA: The Guilford Press.

[95] Utami, L. P. R. A., Suwastini, N. K. A., Dantes, G. R., Suprihatin, C. T., & Adnyani, K. E. K. (2021). Virtual reality for supporting authentic learning in 21st century language classroom. Jurnal Pendidikan Teknologi dan Kejuruan, 18(1), 132–141. https://doi.org/10.23887/jptk-undiksha.v18i1.32376

[96] Yeung, W. K. & Sun, D. (2021). An exploration of inquiry-based authentic learning enabled by mobile technology for primary science. International Journal of Mobile Learning and Organisation, 15(1), 1–28. https://doi.org/10.1504/IJMLO.2021.111594

[97] Cooperstein, S. E. & Kocevar-Weidinger, E. (2004). Beyond active learning: A constructivist approach to learning. Reference Services Review. https://doi.org/10.1108/00907320410537658

[98] Hadibarata, T. & Rubiyatno, R. (2019). Active learning strategies in the environmental engineering course: A case study at Curtin University Malaysia. Jurnal Pendidikan IPA Indonesia, 8(4), 456–463. https://doi.org/10.15294/jpii.v8i4.19169

[99] Zhang, J. H., Zou, L. C., Miao, J. J., Zhang, Y. X., Hwang, G. J., & Zhu, Y. (2020). An individualized intervention approach to improving university students' learning performance and interactive behaviors in a blended learning environment. Interactive Learning Environments, 28(2), 231–245. https://doi.org/10.1080/10494820.2019.1636078

[100] Calderón, A., Meroño, L., & MacPhail, A. (2020). A student-centred digital technology approach: The relationship between intrinsic motivation, learning climate and academic achievement of physical education pre-service teachers. European Physical Education Review, 26(1), 241–262. https://doi.org/10.1177/1356336X19850852

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Article submitted 2023-02-06. Resubmitted 2023-03-14. Final acceptance 2023-03-14. Final version published as submitted by the authors.