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Cooperative learning with QR codes technology: enhancing cognitive achievement and attitudes among students

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Introduction: Integrating quick response (QR) codes into cooperative learning may streamline access to multimedia, reduce extraneous cognitive load, and improve learning outcomes in technology-rich courses.

Methods: A quasi-experimental single-group, repeated-measures design was used with 30 regularly attending undergraduates in "Technology in Sports." Students completed a cognitive test at pre-, post-, and 1-month follow-up; attitudes were collected post-course via a validated Likert instrument. Instruction employed five cooperative strategies (Think–Pair–Share, Timed Pair Share, Three-Step Interview, Jigsaw, Case Study) supported by QR-linked resources.

Results: Repeated-measures ANOVA showed significant gains from pre- to post-test with retention at follow-up (η^2 = 0.89, α = 0.05). Post vs. follow-up differences were nonsignificant, indicating maintenance. Power analysis indicated $1 - \beta = 1.00$. Attitude scores were positive across cognitive, emotional, and behavioral dimensions.

Discussion: QR-supported cooperative learning improved and sustained cognitive achievement and elicited favorable student attitudes. Thoughtful instructional design, teacher readiness, and high-quality resources appear critical to effectiveness.

Conclusion: Embedding QR technology within cooperative learning is a feasible, learner-centered approach that enhances outcomes and attitudes in higher-education sport-technology courses.

KEYWORDS

e-learning, teaching, education, active learning, QR codes, cooperative learning, educational innovation

Introduction

The massive information revolution of the twenty-first century has brought about advanced technologies that greatly influence the development of education. In order to enhance the effectiveness of educational environments, educators have been working on developing educational systems that incorporate technological innovations and benefit from them. Mobile phones connected to the internet are now considered one of the most significant technological advancements globally, regardless of culture, social status, or economic status. Providing students with efficient access to education anytime, anywhere, according to their preferences and needs, has become imperative. Lan et al. (2010) proposed the use of mobile phone services in educational institutions, a suggestion that has gained widespread support among educators. This concept, known as mobile learning, has become increasingly popular.

E-learning, according to Pahl (2008), is one of the primary modern methods of education as it overcomes time and space limitations and offers solutions that cater to learners' needs. As a concept, e-learning pertains to an electronic learning system, also known as a Learning Management System, a Virtual Learning System, a Content Management System, or a Mobile Learning System. In addition to learning materials, it also provides support for infrastructure resources. The infrastructure facilities within the e-learning system allow for the uploading, storage, access, and transfer of educational content.

In 1994, Denso Wave introduced the QR code to the Japanese car manufacturer Toyota as a type of barcode that can be scanned. QR codes have a higher storage capacity compared to barcodes because they store information both vertically and horizontally, unlike barcodes that only store information horizontally. Mobile phones can be used to decode and read QR codes by using specific programs designed for this purpose (Göksu and Atici, 2013; Qiao et al., 2015; Saravani and Clayton, 2009).

QR codes are useful in education because of their massive storage capacity, which allows students to transition from printed educational materials to digital ones by scanning the QR codes using their smartphones (Robertson and Green, 2012). Numerous studies have demonstrated the effectiveness of QR Code technology in a variety of educational settings. Educators can use this technology to enhance printed educational materials, facilitate learners' access to digital resources, and guide learners through well-structured educational plans. Additionally, QR codes can improve learning effectiveness, boost learners' self-motivation, and enable them to choose preferred learning sources (Abeywardena, 2017; Carrondo and Gil, 2019; Chung et al., 2019; Durak et al., 2016; Ortega-Sánchez and Gómez-Trigueros, 2019; Widyasari et al., 2019; Wu et al., 2018).

The concept of cooperative learning is an educational strategy that encourages students to work together in small, independent groups to achieve a common goal. They are assessed both individually and collectively (Johnson and Johnson, 2009). It is important to distinguish between cooperative and collaborative learning in this context. Cooperative learning involves students working together to accomplish common goals under teacher guidance and instruction, allowing for both collective and individual assessment (Millis and Cottell, 1997). Collaborative learning, on the other hand, focuses on learners and their ability to interact freely. Learners in collaborative learning must search for and navigate resources on their own (Panitz, 1999). Davidson and Major (2014) explain that both terms aim to develop learners' higher-order thinking skills (HOTS).

In several studies, cooperative learning groups have shown significantly better performance compared to non-collaborative groups. Additionally, students who were exposed to cooperative teaching methods reported significantly more positive attitudes toward classroom instruction. Teachers also agreed that cooperative learning is effective for students' academic and social learning, and can provide individualized support for their learning processes. These findings are supported by studies conducted by Abramczyk and Jurkowski (2020), Namaziandost et al. (2020), and Agonafir (2023).

Consequently, the significance of this study lies in proposing an instructional design that combines the benefits of cooperative learning strategies with QR code technology. The study aims to determine if this integration positively impacts students' cognitive development and attitudes toward learning. It is a serious scientific endeavor to utilize digital learning resources such as educational texts, videos, and electronic educational games for the Technology in Sports Sciences course. Student cooperative groups can access these resources by scanning QR codes with a mobile phone, enhancing the printed scientific material for the course. Additionally, pre-prepared task cards will be provided for cooperative learning groups, tailored to the needs and requirements of different lesson stages in the Technology in Sports Sciences course. Therefore, the current study aims to investigate the effectiveness of cooperative learning with QR codes in enhancing students' cognitive achievements and attitudes.

Theoretical framework

Cooperative learning

Cooperative learning involves students working in small groups to achieve common learning goals, assessing their progress individually and collectively (Johnson and Johnson, 2009). Lougheed et al. (2012) describe it as an active learning strategy that engages students in the learning process. Davidson and Major (2014) have found a positive link between cooperative learning and the development of students' higher-order thinking skills (HOTS).

Lev Vygotsky proposed the sociocultural constructivist theory (Bruning et al., 2011). This theory states that knowledge exists in a social context. Eggen and Kauchak (2013) emphasize the importance of activity in learning that arises in directed social situations. Johnson and Johnson (2009) identify two types of social interdependence between individuals: positive interdependence, characterized by individuals striving to achieve common goals, and negative interdependence, occurring when individuals hinder each other's goals. Therefore, the teacher seeks to foster positive social interdependence among students so they can achieve the desired knowledge structure independently.

Haenen et al. (2003) point out that according to Vygotsky, learners can only learn by engaging directly in meaningful activities with more intelligent people. Through interactions with others, learners improve their understanding, knowledge, and develop an understanding of others. Vygotsky also noted that the learner's ability, according to this theory, develops through two levels: the social level, meaning the learners' social educational environment that enhances their learning, and the learner's psychological level, referring to the mental and psychological processes that occur within the learner's mind during interaction with the social educational environment. Thus, this theory focuses on both the external and internal social educational environment as fundamental factors in the formation of knowledge and cognitive development of the individual.

According to Johnson and Johnson (2009), cooperative learning is based on sociocultural theory. They suggest that cooperative learning strategies should have the following five characteristics:

- Positive interdependence: This idea implies that individuals work together toward a common goal, taking responsibility for their own learning as well as that of others, and recognizing that success for one enhances success for all.
- Individual accountability: Each student in the group should be accountable for their own learning and performance, as well as that of the group, to prevent free riding and social loafing.

Performance is evaluated individually, and feedback is provided to identify who needs more support, encouragement, and help.

- Face-to-face promotive interaction: Individuals can help each other overcome challenges, share resources, provide feedback, and build knowledge together. This fosters motivation through respect, interest, and encouragement.
- Interpersonal and small group skills: Members of a group can discuss work, assist each other, and update materials to ensure smooth progress. Each member's unique contributions are essential for group success, as strengths are collaboratively pooled. Responsibility for group cohesion, decision-making, leadership, communication, trust-building, respect, and conflict resolution are crucial.
- Group processing: This allows the group to continuously improve its collaboration over time, focusing on individual accountability, simplifying learning processes, and eliminating non-contributory actions. Teachers set objectives, explain expectations, observe group dynamics, and intervene as needed to enhance learning. Students and groups then carry out their roles in the group process.

In order to ensure that cooperative learning is successful, it is important to have these five fundamental principles in place (Johnson et al., 2000; Sharan, 2015).

Because of the intense focus on promoting teamwork among students, a variety of cooperative learning techniques have been developed to facilitate collaboration. These techniques include Think-Pair-Share (Lyman, 1992), Three-Step Interview, Timed Pair Share (Kagan and Kagan, 2015), Jigsaw (Aronson et al., 1978), Scripted Cooperation (O'Donnell, 1999), Guided Design (Newsome and Tillman, 1990), Concept Mapping (Clayton, 2006), Active Knowledge Sharing (Silberman, 1996), Teammates Consult, Numbered Heads Together (Kagan, 1992), Teams – Games – Tournaments (TGT) (De Vries and Slavin, 1978), Learning Together (Gokkurt et al., 2012), and Throw the Ball (Johnson and Johnson, 1999). These cooperative learning techniques have served as the foundation for numerous other methods, either through the adaptation of their procedures or the creation of new techniques within the same framework.

Gillies and Khan (2008) warned about the negative consequences of improperly implementing cooperative learning techniques. These consequences include some group members not responding as expected, conflicts and compliments occurring within the same group, negativity from certain group members, and a lack of acceptance of the concept of group evaluation among many students. This leads students to reject the idea of assisting their peers and instead concentrate on their individual performance within the group. Furthermore, some teachers may lack an understanding of how to effectively implement cooperative learning.

To address these challenges and ensure that cooperative learning techniques are implemented successfully, Berk and Winsler (1995) suggest that the teacher should identify each student's Zone of Proximal Development (ZPD) by giving a short quiz or conducting an introductory discussion on the topic. During this discussion, the teacher should ask students questions to determine what they already know. It is imperative to encourage group work by creating groups that include students with different skill sets and learning levels. This diversity can increase the amount that students learn from each other. In addition, it is crucial to ensure that each student in the group participates actively. The teacher should try not to provide too much assistance, as this could make the student passive rather than active, reducing the learning experiences gained. Additionally, it is important to encourage students to think aloud. By asking students to think aloud, the teacher can determine their current skills and ensure that they are actively engaged in the learning process.

QR codes technology in education

A QR code is short for Quick Response Code. Robertson and Green (2012) define it as a two-dimensional square with small squares of different sizes and spaces between them at varying distances. These squares contain data stored with a capacity of 4,000–7,000 characters. By using specific applications, mobile phones can scan QR codes and access letters, numbers, texts, symbols, and web links. The QR code is also described by Ortega-Sánchez and Gómez-Trigueros (2019) as a matrix-like system of dots that encodes a wide range of information. It is characterized by three squares at the corners that can be detected by the reading application, as illustrated in Figure 1:

Area (1) Position: includes the squares in the three corners. This allows the QR-Code Reader application to recognize the border of the code and start reading it. The surrounding margins should be white for it to work efficiently and swiftly.

Area (2) QR Code Version: The second area provides information regarding the version used to generate the QR code.

Area (3) Alignment - Borders: The third area mark provides help to the reader application during automatic drawing to correct distortions caused by perspective.

Area (4) Format: The fourth area indicates to the reader application what type of information is being stored (VCARD - URL - text - SMS, etc.).

Area (5) Synchronization: Between the squares in the three corners is the fifth area, which indicates the matrix's size.

QR codes can be considered a valuable tool in mobile learning within education. Learners can use QR codes to access supplementary resources such as text, URLs, or other data, providing them with a

FIGURE 1
QR-code areas.

deeper understanding of a subject. Smartphones with QR code reader apps allow learners to access text, open web pages, send automated SMS messages, and more. QR codes can be easily read and decoded using various free mobile apps. Additionally, QR codes can be integrated into alternate reality games that aim to address educational challenges (Lee et al., 2011). When integrating technology in education, it is crucial to focus more on the learners than on the technology itself. Instead of simply incorporating technology into education and learning, QR codes should enhance learner-centered learning through innovative teaching strategies (Wu et al., 2010). Furthermore, they enable learning outside of the classroom, as school books are not the only source of educational materials (Rikala and Kankaanranta, 2014).

QR codes are also used in a variety of educational activities, allowing for a direct link between the physical world (printed materials) and the virtual world (online resources). This enables teachers to develop or select digital resources that can be filtered according to the age and ability level of the students. This is particularly useful as most, if not all, students already have mobile devices (Skeele, 2013).

According to Rikala and Kankaanranta (2014) study, QR codes can increase students' motivation to learn. They engage students in stimulating and meaningful activities that enhance their learning experience and provide them with authentic tasks inspired by real-world situations. Traser et al. (2015), and Chung et al. (2019) both found that QR codes enhance learning outcomes, facilitate learning effectiveness, and improve learners' attitudes toward courses and educational experiences. As Abeywardena (2017) pointed out, QR codes can bridge the gap between printed scientific material and multimedia. So (2011) and Palazón and Giráldez (2018) explained that the integration of QR codes into printed educational materials improves the relationship between the activity in the book and an additional online activity. QR codes, according to Karia et al. (2019), can be used to link various multimedia resources to reduce learners' cognitive load. Students are given autonomy over their learning, supporting a student-centered approach. This also allows students to assess their own learning, access a variety of resources, and enhance self-motivation. Additionally, it provides opportunities for increased interaction and supports both independent and collaborative learning approaches.

Cognitive load theory (CLT)

Cognitive Load Theory emphasizes that the effectiveness of learning is fundamentally constrained by the limited capacity of working memory, which can process only a small amount of information simultaneously. When instructional materials are overly complex or poorly structured, they may overload this system, resulting in reduced learning efficiency. To facilitate optimal learning, instructional design must carefully manage cognitive demands to avoid overloading the learner's mental resources (Stiller and Bachmaier, 2018; Sweller, 2010).

Sweller (2010) identifies three types of cognitive load: intrinsic, germane, and extraneous. Intrinsic load is tied to the inherent complexity of the material and the learner's prior knowledge. Germane load reflects the effort devoted to building and refining mental schemas that support deeper understanding and long-term retention. Conversely, extraneous load refers to cognitive demands arising from suboptimal instructional design, such as irrelevant content, confusing layouts, or inefficient delivery methods, which unnecessarily occupy working memory and hinder learning (De Jong, 2010; Stiller and Bachmaier, 2018; Sweller, 2010).

In previous work, it was shown that the integration of 3D hologram technology within structured, reciprocal teaching environments significantly reduced extraneous load and enhanced students' skill acquisition by enabling them to visualize complex movements in manageable segments (Rakha, 2023a). The findings suggested that immersive technologies, when embedded in well-structured pedagogical strategies, can enhance mental model formation and reduce cognitive strain during motor learning.

Building on these findings, the current study applies the same theoretical lens to a new learning context: cooperative learning supported by QR code technology. QR codes, by providing instant access to targeted multimedia content (e.g., videos, diagrams, or instructions), can reduce the extraneous cognitive burden associated with locating or decoding information. When integrated into cooperative tasks, this technology promotes shared information processing, peer-assisted learning, and more efficient engagement with instructional material—thereby optimizing germane cognitive load and supporting schema development.

This approach, grounded in CLT, seeks to examine whether QR-enhanced cooperative learning environments can similarly improve cognitive achievement and foster positive learning attitudes among students, particularly in knowledge-intensive or digital-rich settings.

Instructional approach in the present study

The instructional approach employed in the present study is grounded in cooperative learning principles enriched by QR code technology, aiming to foster meaningful student interaction, shared responsibility, and active engagement with digital resources. This design seeks to enhance cognitive achievement and promote positive learning attitudes by integrating structured cooperative techniques with easily accessible multimedia content.

A set of well-established cooperative learning strategies was implemented throughout the intervention, each selected for its ability to foster peer interaction, critical thinking, and individual accountability. These included:

- Think–Pair–Share: This strategy encourages individual accountability followed by peer interaction and group synthesis. Students first scanned a QR code linking to a thought-provoking question, short video, or infographic. They independently reflected on the material, paired up to discuss their interpretations, and finally shared synthesized responses with the class. QR-linked content provided diverse entry points for understanding, fostering metacognitive reflection and collaborative refinement.
- Timed Pair Share: Designed to ensure balanced participation and active listening, students were paired and given timed intervals to discuss a prompt. QR codes guided the discussion by presenting digital tasks such as diagrams, brief tutorials, or concept images. This structure not only enhanced oral expression

and listening but also grounded conversations in shared digital content, allowing students to anchor their responses in consistent resources.

- Three-Step Interview: This triadic structure promotes deeper communication and role rotation. Students formed groups of three and rotated between the roles of interviewer, interviewee, and recorder. QR codes presented varied perspectives or real-world contexts (e.g., videos, expert quotes, or case outlines) to frame the interviews. This fostered inclusive dialogue, strengthened interpersonal skills, and supported collaborative knowledge construction.
- Jigsaw Strategy: Jigsaw is centered on positive interdependence, where each student is responsible for mastering and teaching a segment of the material. QR codes were used to provide individualized digital content (videos, articles, infographics) for each "expert" student. After studying their assigned piece, students returned to their home groups and taught their peers. This method not only ensured full participation but also deepened learning through peer explanation, with QR content supporting clarity and consistency.
- Case Studies: This group-based strategy immerses students in complex, real-world scenarios. QR codes granted access to digital case files—videos, documents, or simulations—allowing teams to analyze, discuss, and propose solutions. By engaging with multimedia sources, students collaborated on critical thinking, applied theoretical knowledge to authentic problems, and developed evidence-based reasoning in a cooperative setting.

As shown in Figure 2, the instructional design incorporated five cooperative learning techniques, each supported by QR code technology that enabled students to interact with multimedia content, explore learning materials, and collaborate more effectively.

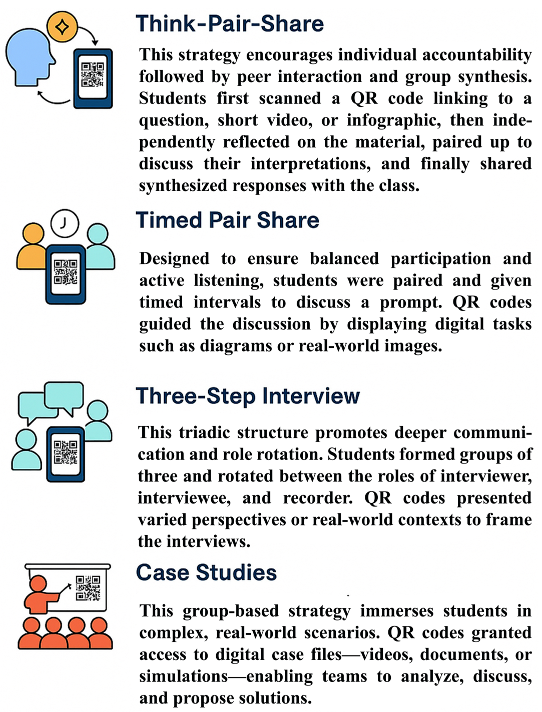

FIGURE 2
Cooperative learning techniques enhanced by QR code technology.

QR codes were embedded in instructional materials such as worksheets and activity guides, allowing students to scan and access supplementary digital content including videos, interactive models, and online simulations. These resources were directly aligned with the learning objectives of each cooperative task, supporting student autonomy and inquiry-based learning.

The teaching process unfolded in four main phases:

- Orientation and Preparation: Students were introduced to the learning objectives, cooperative roles, and how to use QR codes.
- Engagement with Content: Learners participated in structured cooperative strategies, scanning QR codes to access materials as needed.
- Facilitation and Monitoring: The teacher guided group interactions, clarified misunderstandings, and encouraged critical thinking.
- Reflection and Presentation: Groups shared findings, discussed learning outcomes, and reflected on the collaborative process.

This integrative instructional model aligns with the principles of Cognitive Load Theory, aiming to reduce extraneous cognitive load through efficient access to learning materials while increasing germane load by supporting active schema construction. It also draws upon prior findings indicating the effectiveness of technology-supported collaborative methods in enhancing student performance and engagement (Rakha, 2023a).

Materials and methods

Bias mitigation measures and ethical protocols

Given that the researcher also served as the course instructor, specific methodological safeguards were implemented to ensure objectivity and minimize potential bias throughout the study.

- The research was reviewed and approved by the Research Ethics Committee of the Department of Physical Education and Kinesiology, College of Education, Qassim University (Approval No. 01452142024). Prior to participation, all students received a written informed consent form that detailed the study's objectives, significance, procedures, voluntary nature, and participants' right to withdraw at any time. The final section of the form included a clear prompt allowing participants to indicate whether they agreed or declined to participate.
- The course was conducted over a full academic semester, comprising 2 contact hours per week for 12 weeks, following institutional academic guidelines. To ensure the neutrality of evaluation, cognitive achievement assessments (pretest, posttest, and follow-up) were graded by an independent faculty member from the same department who specializes in physical education pedagogy. The follow-up test was administered after the final course grades were released to eliminate any perception of pressure or bias.

- Students' attitudes were measured using an anonymous self-report instrument distributed via Google Forms. No identifying information was collected, ensuring full confidentiality and encouraging honest, unbiased responses.
- All data collected were handled with strict confidentiality. Responses were anonymized using coded identifiers, and no personal data were stored. Digital responses were collected through secure platforms and stored in encrypted, password-protected folders accessible only to the research team. The data were used exclusively for research purposes and were not shared with any third party, thus preserving the privacy and security of participant information throughout the study.
- The study followed a quasi-experimental single-group repeated measures design, ensuring equal learning opportunities for all students. A repeated-measures ANOVA was employed to analyze changes over time within the same group.

Design

A quasi-experimental design was utilized, with one experimental group receiving repeated measures. QR code technology, along with cooperative learning techniques, was implemented in this group. Cognitive achievement levels were measured at multiple points (pre, post, and during a follow-up) using cognitive tests to assess the long-term impact of the teaching strategy. A follow-up measurement was conducted after a month-long break from teaching and learning.

> *RQ$_1$*: Are there statistically significant differences, at a significance level of 0.05, among the repeated measurements (pre, post, and follow-up) of the learning effect for the students in the experimental group?
>
> *Ha:* Based on the repeated measurements (pre, post, and follow-up assessment of the learning effect) for the students in the experimental group, there are statistically significant differences in cognitive achievement levels.

To investigate students' attitudes regarding the QR code technology incorporated with cooperative learning techniques used in teaching the "Technology in Sports Science" course, a descriptive method was conducted. An online survey was designed with closed and open-ended questions to investigate students' attitudes regarding the proposed teaching strategy. The following question was asked:

> *RQ$_2$*: What are the attitudes of students toward cooperative learning with QR code technology used in the "Technology in Sports Science" course?

An overview of the conceptual structure guiding this study is provided in Figure 3, highlighting the relationships among the key variables and the flow of the research process.

Study population and sample

The sample size for this study consisted of 33 students who were enrolled in the course "Technology in Sports Sciences" during the 2nd semester of the 2023/2024 academic year. This is an elective course that meets for one theoretical credit hour per

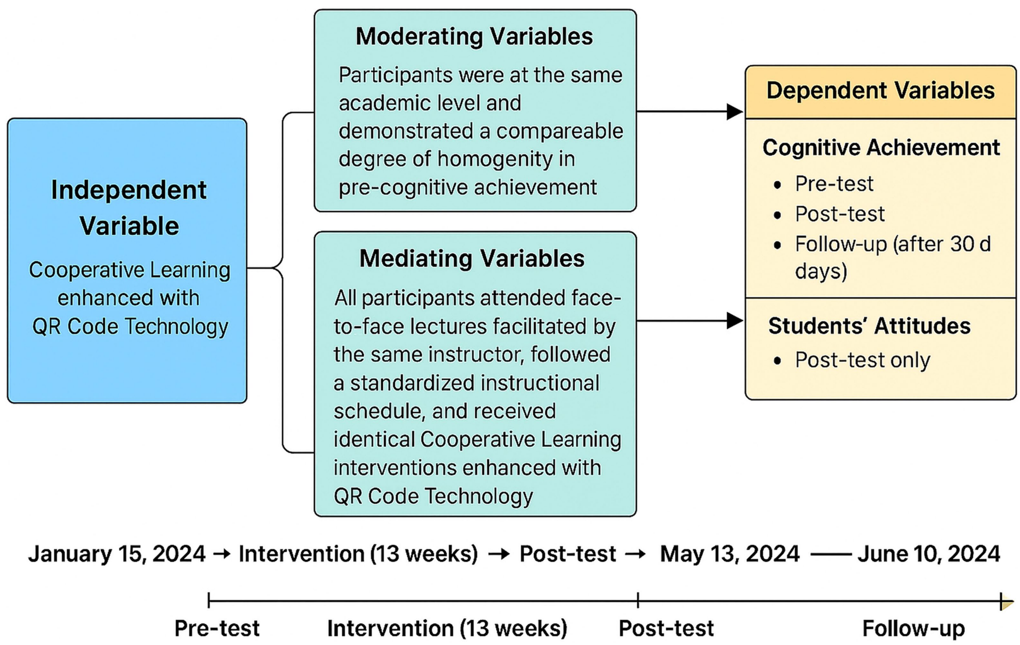

FIGURE 3
Conceptual framework of the current study.

week (two face-to-face hours) and is part of the Bachelor of Sports Sciences and Physical Activity program offered by the Department of Physical Education and Kinesiology at Qassim University College of Education. Three students who had poor attendance records were excluded from the experiment, leaving a total of 30 students in the experimental group. All 30 students provided informed consent to participate in the study. The course was taught to them in accordance with the university-approved description, utilizing QR code technology integrated with cooperative learning techniques.

Data collection tools

The cognitive achievement test

Based on the approved course description, a cognitive achievement test was developed to meet the current study's objective. The test was conducted as follows:

The table of specifications (TOS)

According to Gronlund (1998), teachers can create balance in testing by aligning the relative weights of learning outcomes, content, and assessment purposes. Using the following formulas, the number of topic questions and their scores are calculated (Rakha, 2023b):

$$\text{Topic relative weight}\,(\%) = \begin{pmatrix}\text{Total number of teaching}\\ \text{hours or days}\\ \text{allocated to a specific topic}\end{pmatrix} / \begin{pmatrix}\text{The number of hours}\\ \text{allotted to teaching}\\ \text{the entire course}\end{pmatrix} \times 100$$

$$\text{Learning outcomes category relative weight}\,(\%) = (\text{number of learning outcomes in the category}) / (\text{total number of learning outcomes in the course}) \times 100$$

$$\text{The number of test items in the category of learning outcomes for each topic} = \text{Proposed total number of test items} \times \text{Topic relative weight} \times \text{Learning outcomes category relative weight}$$

$$\text{The Learning outcomes category score for each topic} = \text{Final score proposed for the test} \times \text{Topic relative weight} \times \text{Learning outcomes category relative weight}$$

The TOS for the cognitive test is detailed in Table 1.

Formulating and validating test items

In order to assess various levels of thinking, the items were originally created as true-false questions, matching questions, multiple-choice questions, and essay questions based on the TOS. Five experts in physical education curriculum and methodologies reviewed the test items to confirm the content validity of the test (Hays and Revicki, 2005).

Analyzing the difficulty and discrimination indexes

According to Gregory (2015), difficulty indexes are a useful technique for determining whether test items require revision or removal. A question's ideal difficulty level falls between 0.30 and 0.70, with an average of 0.50. According to Bichi (2016), the difficulty index is calculated as follows: $P = R/N$, where R is the number of examinees who answered the question correctly, and N is the total number of examinees.

Discrimination index measures how well a test item distinguishes between high-scoring and low-scoring examinees, denoted by the symbol (d). The upper and lower bands are typically calculated based on 10–33% of the highest and lowest scores of examinees. For normally distributed scores, it is recommended to compare the top 27% with the bottom 27%. In cases where results are more evenly distributed than a normal curve, a percentage around 33% is preferable. The calculation of (d) is as follows: $d = (U - L)/N$, where U represents examinees who answered the question correctly and were in the top quartile, L represents examinees who answered the question correctly and were in the bottom quartile, and N represents the total number of examinees in the top or bottom quartiles. Ideally, a discrimination index should range from −1.00 to +1.00. In cognitive achievement tests, an index greater than 0.20 is considered acceptable. Any item showing negative discrimination will be excluded (Gregory, 2015).

Bichi (2016) interprets d in the following manner:

- If d is greater than or equal to 0.40, the item functions without any issues and operates exceptionally well.
- If d falls between 0.30 and 0.39, the item is considered adequate and requires little to no adjustment.
- If d is between 0.20 and 0.29, the item requires revision because it is considered marginal.
- If d is less than or equal to 0.19, the item must be removed or completely rewritten.

Sixteen students who completed the Technology in Sports Sciences course in the first semester 2023/2024 and were not included in the basic sample for the current study took the initial form of the cognitive achievement test to determine the test's difficulty and discrimination indexes. The results indicated that the difficulty indexes (P) ranged from 0.32 to 0.46, while the discrimination indices (d) ranged from 0.30 to 0.46.

Reliability

The reliability of the cognitive achievement test was evaluated using Cronbach's Alpha coefficient. The coefficient obtained was 0.81, indicating good reliability (Taber, 2018). The final version of this test is included in Appendix A.

A self-assessment tool for evaluating students' attitudes toward QR code technology when integrated with cooperative learning techniques

To assess students' attitudes toward QR code technology when integrated with cooperative learning techniques, a self-assessment tool was created. According to Conner et al. (2021), attitudes were evaluated across three dimensions: cognitive, emotional, and behavioral. The final self-assessment tool consisted of 13 items, each rated on a five-point Likert scale: strongly agree, agree, neutral,

TABLE 1 Table of specification (TOS).

Topics	Items & scores	Learning outcomes (LOs)						Total number of items	Test final score	Topic relative weight (%) from 26 teaching face to face hours
		Remembering	Understanding	Applying	Analyzing	Evaluating	Creating			
		8 LOs	3 LOs	8 LOs	2 LOs	2 LOs	2 LOs			
The use of virtual reality technologies in sports (6 h)	Items	2.22	0.83	2.22	0.55	0.55	0.55	6.92	13.85	23.08
	Scores	4.43	1.66	4.43	1.11	1.11	1.11			
Artificial Inelegance in sport (3 h)	Items	1.11	0.42	1.11	0.28	0.28	0.28	3.46	6.92	11.54
	Scores	2.22	0.83	2.22	0.55	0.55	0.55			
Arbitration in sports: technological applications (5 h)	Items	1.85	0.69	1.85	0.46	0.46	0.46	5.77	11.54	19.23
	Scores	3.69	1.38	3.69	0.92	0.92	0.92			
A sport's health and technology (6 h)	Items	2.22	0.83	2.22	0.55	0.55	0.55	6.92	13.85	23.08
	Scores	4.43	1.66	4.43	1.11	1.11	1.11			
Incorporating technology into sports management (6 h)	Items	2.22	0.83	2.22	0.55	0.55	0.55	6.92	13.85	23.08
	Scores	4.43	1.66	4.43	1.11	1.11	1.11			
Total number of items		9.60	3.60	9.60	2.40	2.40	2.40	30		
Test final score		19.20	7.20	19.20	4.80	4.80	4.80		60	
Relative weight of the learning outcomes (26 LOs) %		32.00	12.00	32.00	8.00	8.00	8.00			100

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disagree, and strongly disagree. These responses were then assigned values of 5, 4, 3, 2, and 1, respectively. To establish the validity and reliability of the tool, the following methods were utilized:

(a) *Content validity*: An initial evaluation round was conducted by five arbitrators, all of whom held PhDs in educational technology and physical education teaching methods. Several items were revised based on their feedback and recommendations.
(b) *Internal consistency validity*: An exploratory sample of 16 students, who were not part of the original sample, was evaluated using the proposed self-assessment tool after being exposed to QR code technology and cooperative learning techniques. The correlation of each item with its corresponding axis was determined. The students completed the assessment through an online Google Form. Subsequently, the Pearson correlation between each item and its axis was calculated. A significant positive correlation was discovered between each item and its axis, with $r(14) = 0.70–0.92$, $p < 0.01$. These findings suggest a high level of internal consistency (Schober et al., 2018).
(c) *Reliability*: The reliability of the tool was assessed using Cronbach's alpha coefficient. The values ranged from 0.79 to 0.94, exceeding the acceptable threshold of 0.70, which indicates good reliability (Taber, 2018).

A QR code-based learning program that incorporates cooperative learning techniques.

The ADDIE model (Branch, 2009) was used to design the educational program, incorporating QR code technology along with cooperative learning techniques:

1 Analysis: This stage involved designing and specifying the following:
   a *The primary objective* is to enhance the level of cognitive achievement related to the topics covered in the sports technology course.
   b *Student characteristics:* The study sample consisted of individuals aged 19–23. According to Spano (2004), students in this age group possess the ability to set and achieve goals, articulate their ideas, maintain a clear sense of their roles in life, demonstrate a strong work ethic, and assume individual responsibility. They exhibit cognitive development, often discuss their experiences and experiments, and can explain concepts logically and objectively. As a result, they are equipped to solve problems, engage in discovery, think critically, and make inferences through both collaborative and competitive learning. Additionally, they utilize visual media and technology to enhance their understanding and thinking processes.
   c *Educational activities:* A teacher and a student participate in the following activities:
   - Teacher Activities: During the cooperative learning strategy, the teacher reviews the lesson objectives, provides students with exercises, guides them in using an educational website that incorporates QR code technology, and explains their roles in utilizing task cards. Following the lesson sequence and procedures, the teacher instructs students to scan QR code stickers using a smartphone application to access the digital resources available on the website. In addition to explaining the cooperative learning strategy and the integration of technology in education, the teacher also monitors the cooperative work groups and assists them in achieving the desired objectives.
   - Student Activities: Using the QR Code Reader application on a smartphone, students can access the digital resources on the educational website. They should follow the lesson procedures and guidance provided by the teacher. As part of a cooperative work group, students are responsible for completing tasks outlined on task cards. They should interact with educational videos, answer questions while watching, and participate in electronic activities in accordance with the lesson sequence. This will help them track their notes and progress effectively.
   d *The educational content is as follows:* The development of the educational content was guided by a description of the technology in the sports course, approved by the Department of Physical Education and kiensology at Qassim University. Topics covered include Virtual Reality in Sports, Artificial Intelligence in Sports, Arbitration in Sports: A Technological Approach, Sports Health and Technology, and Integrating Technology into Sports Management.
2 Design: During this stage, the following elements were designed and defined:
   a *Behavioral objectives design:* Following Bloom's taxonomy, 26 cognitive behavioral objectives were identified and categorized into the six cognitive levels outlined in the TOS (Bloom et al., 1956).
   b *Teaching strategies:* To engage the experimental group with the educational website supported by QR Code technology, a variety of cooperative learning strategies were employed. These included Think–Pair–Share, Timed Pair Share, Three-Step Interview, Jigsaw Strategy, and Case Studies (Johnson and Johnson, 2009).
   c *Formative assessment strategy:* Using TechSmith Camtasia (Camtasia, 2023), multiple-choice questions were embedded in educational videos to serve as formative assessment tools. According to the video scenario, playback is paused at specific intervals, prompting a question that the student must answer to continue watching. If the student answers correctly, they receive immediate reinforcement; if they answer incorrectly, they receive instant feedback. Additionally, the Wordwall website was utilized to design interactive electronic activities (Wordwall, 2023).
   d *Design of task cards:* The task cards included instructions, lesson objectives, teaching strategies, tasks, and time allocations for each task. These elements guided the students in the experimental group during their cooperative learning activities. According to Mosston and Ashworth (1986), task cards help students engage in tasks more effectively, enhancing efficiency and productivity in the educational process. They also reduce the need for repetitive instruction from teachers and empower students to take responsibility for their own learning.

e *Time frame:* The study plan for the Technology in Sports course, along with the credit hours allocated for each topic, was followed as outlined in the previous TOS.

3 Development

a QR code design: QR codes were generated using the website https://www.qrcode-monkey.com/. This free website produces highly accurate codes. With its various design options, QR codes can be customized to reflect their intended use (Qrcode monkey, 2023).

b The educational website was developed using the following software:

- The Website X5 v16 Professional program is used for creating and designing web pages, inserting digital resources, establishing links, and publishing websites on the Internet (WebSite X, 2023).
- TechSmith Camtasia version 2019.0.10 is a program used for creating educational videos (Camtasia, 2023).
- Production of web-based educational activities and training sessions utilizing the website https://wordwall.net/ (Wordwall, 2023).

c Educational and technological standards must be considered when designing educational websites. As Lencastre and Chaves (2008) assert, effective websites provide reliable content and are easy to navigate. A well-designed website should adhere to established quality standards. Egger (2001), Roy et al. (2001), Lee and Kozar (2012), Huang and Benyoucef (2014), and Panda et al. (2015) have identified the most important criteria for website design: consistency, learnability, simplicity, ease of navigation, readability, content relevance, supportability, interactivity, credibility, and remote presence.

4 Implementation: From January 22, 2024, to May 6, 2024, the experiment was conducted every Monday. This was accomplished by combining QR code technology with cooperative learning techniques. The pre-test was given on January 15, 2024, and the post-test occurred on May 13, 2024. After the post-test, an online questionnaire was sent out to assess student attitudes toward QR code technology as a tool integrated into cooperative learning. A follow-up assessment was carried out after a one-month break from instructional and learning activities.

Statistical analysis

IBM SPSS Statistics for Windows (2017; version 25) was utilized to conduct the subsequent statistical analyses: frequency, percentage, mean, standard deviation, Shapiro–Wilk, repeated measures ANOVA, Mauchly's test of sphericity, and Bonferroni's post-hoc test (Field, 2013). Furthermore, a post-hoc power analysis was carried out using the G*Power 3.1 tool (Verma and Verma, 2020).

Results

Research question 1. Are there statistically significant differences, at a significance level of 0.05, among the repeated measurements (pre, post, and follow-up) of the learning effect for the students in the experimental group?

TABLE 2 Tests of normality.

Measurements	*M*	*SD*	Shapiro–Wilk		
			W	*df*	*p*
Pre	37.03	5.23	0.95	30	0.16
Post	51.80	4.23	0.94	30	0.13
Follow-up	51.16	4.72	0.97	30	0.55

> *Ha:* The analysis of repeated measurements, including pre-, post-, and follow-up assessments of the learning effect for students in the experimental group, indicates statistically significant differences in cognitive achievement levels.

A repeated measures ANOVA was performed to assess the effect size, classified as low, medium, or high, of integrating QR code technology with cooperative learning techniques on the cognitive achievement of 30 participants enrolled in the Technology in Sports course.

Table 2 presents the outcomes of the Shapiro–Wilk test conducted on repeated measures of cognitive achievement at three time points: pre-test, post-test, and follow-up. The results yielded the following statistics: ($W = 0.95, p = 0.16$); ($W = 0.94, p = 0.13$); and ($W = 0.97, p = 0.55$). Given that the p-values exceed the threshold of 0.05, the null hypothesis cannot be rejected. Consequently, it can be concluded that the repeated measures of cognitive achievement are normally distributed.

Based on the data presented in Table 3, Mauchly's test was performed to evaluate the assumption of sphericity, $\chi^2(2) = 33.72$, $p < 0.001$. As a result, the null hypothesis of sphericity was rejected. The degrees of freedom for the Greenhouse–Geisser correction were subsequently adjusted in accordance with this finding.

Table 4 demonstrates that the integration of QR code technology into cooperative learning significantly influences cognitive achievement, as evidenced by statistical analysis ($F(1.18) = 230.60$, $p < 0.001$, $\eta^2 = 0.89$). Consequently, participants' cognitive achievement exhibited variability across the repeated measures (Pre, Post, and Follow-up).

In Table 5 and Figure 4, post-hoc pairwise comparisons adjusted using the Bonferroni correction revealed that cognitive achievement scores at the post-measurement were significantly higher than those at the pre-measurement ($p < 0.001$). Additionally, follow-up measurements of cognitive achievement demonstrated significantly higher scores compared to the pre-measurement ($p < 0.001$). Conversely, there were no significant differences in cognitive achievement scores between the post- and follow-up measurements ($p = 0.17$).

The post-hoc power analysis

The G*Power 3.1 tool was utilized to perform a post-hoc power analysis. A sample size of $n = 30$ was employed for a one-way repeated measures ANOVA (within-subjects ANOVA), with an effect size ($\eta^2 = 0.89$) at a significance level of $\alpha = 0.05$. The results indicated that the power analysis ($1 - \beta = 1.00$) exceeded 0.80, suggesting a significant effect size (Faul et al., 2009). Consequently, the findings from this sample size can be reliably generalized to the entire population, as illustrated in Figure 5.

TABLE 3 Mauchly's test of sphericity.

Within subjects effect	Mauchly's W	Approx. χ^2	*df*	*p*	Epsilon		
					Greenhouse–Geisser	Huynh-Feldt	Lower-bound
Cognitive achievement	0.30	33.72	2	0.00	0.58	0.59	0.50

TABLE 4 Tests of within-subjects effects.

Greenhouse–Geisser	Type III sum of squares	df	Mean square	*F*	*p*	Partial η^2
Cognitive achievement	4,182.07	1.18	3,554.92	230.60	0.00	0.89
Error	525.93	34.11	15.42			

TABLE 5 Pairwise comparisons.

(I) Cognitive achievement	(J) Cognitive achievement	Bonferroni Post-hoc test		
		Mean Difference (I-J)	Std. Error	*p*
Pre	Post	−14.77*	0.90	0.00
	Follow-up	−14.13*	0.95	0.00
Post	Pre	14.77*	0.90	0.00
	Follow-up	0.63	0.32	0.17
Follow-up	Pre	14.13*	0.95	0.00
	Post	−0.63	0.22	0.17

*The mean difference is significant at the 0.05 level.

Research question 2. What are students' attitudes toward the integration of QR code technology with cooperative learning techniques in the course "Technology in Sports Sciences"?

The Student Attitudes Questionnaire was administered to the study sample via a Google Form following the post-cognitive achievement test. This questionnaire aimed to assess attitudes toward QR code technology as a tool integrated into cooperative learning. The results are as follows:

Table 6 shows a strong cognitive attitude (strongly agree) toward the integration of QR code technology as a tool for cooperative learning. The results indicate that item three received the highest ranking ($M = 4.48$, $SD = 0.62$), suggesting that QR code technology in cooperative learning has effectively enhanced students' retention and comprehension of course material. In the second position, item one ($M = 4.45$, $SD = 0.56$) illustrates that QR code technology has simplified scientific content presentation.

The results related to the affective and cognitive attitude axes are consistent, as demonstrated by the high levels of positive attitudes demonstrated by the experimental group. Their responses predominantly indicated strong agreement. Items seven and eight received the highest scores, with mean values of ($M = 4.58$, $SD = 0.61$) and ($M = 4.58$, $SD = 0.75$), respectively, positioning them at the top of the overall attitude scale. This suggests that the integration of QR code technology with cooperative learning techniques has promoted equitable participation among students during lessons and enhanced their motivation to learn. Item six, with a mean of ($M = 4.33$, $SD = 0.82$), ranked second, indicating that the incorporation of QR code technology as a tool within cooperative learning has facilitated improved communication among peers.

Furthermore, the results from the behavioral attitude axis indicated a strong agreement among respondents. Item 11 ($M = 4.58$, $SD = 0.66$) received the highest ranking, suggesting that the integration of QR code technology into cooperative learning has significantly enhanced the efficiency with which individuals and their teams approach assignments. Item 12 ($M = 4.55$, $SD = 0.67$) ranked second, indicating that the incorporation of QR code technology alongside cooperative learning techniques has the potential to improve the monitoring and evaluation of both individual and collective learning progress.

Discussion

The current study found that integrating QR Code technology into cooperative learning significantly enhances cognitive achievement. The proposed cooperative learning program, supported by QR Code technology, achieved an effect size of 0.98. A post-hoc pairwise comparison using Bonferroni correction revealed that cognitive achievement scores in the post-measurement were significantly higher than those in the pre-measurement. Furthermore, follow-up measurements of cognitive achievement indicated significantly higher scores compared to pre-measurements. This confirms that QR Code technology is a valuable tool for enhancing cooperative learning techniques. One reason for this positive impact is the use of QR Code stickers in educational contexts. They have positively influenced students' learning motivation and enriched the teaching and learning processes by facilitating electronic educational activities and linking them to printed educational content. Similarly, So (2011), Rikala and Kankaanranta (2014), Del Rosario-Raymundo (2017), and Palazón and Giráldez (2018), and have found that QR codes effectively enhance students' motivation to learn by connecting printed scientific materials with electronic educational resources available on the Internet. This connection allows learners to easily access educational experiences and activities in an organized way, ultimately helping them achieve their learning goals.

In addition, the integration of QR code technology into cooperative learning techniques such as Think-Pair-Share, Jigsaw, Three Steps for Interview, Team Competition with Games, Learning Together, and Ball Throwing enhanced cognitive achievement in the experimental group. As a result of this cooperative learning experience, participants gained a deeper understanding of the topics

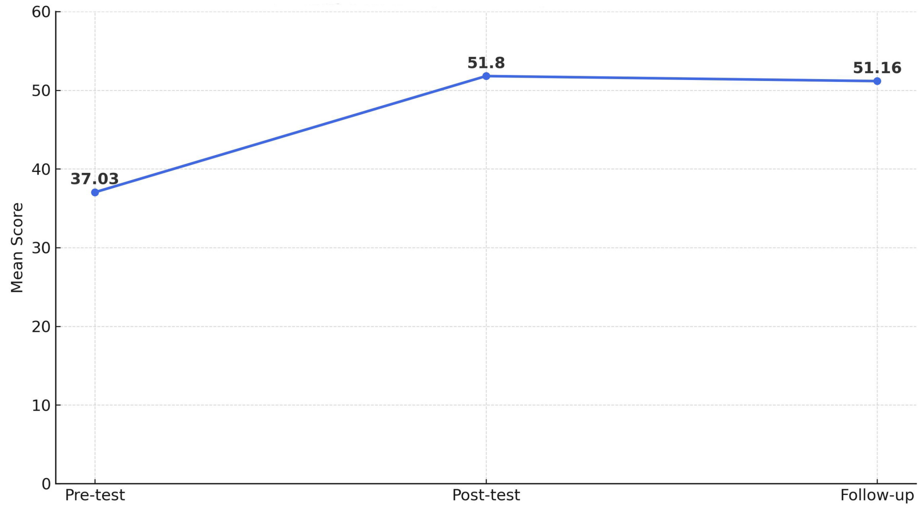

FIGURE 4
Mean scores of students' cognitive achievement across pre-test, post-test, and follow-up.

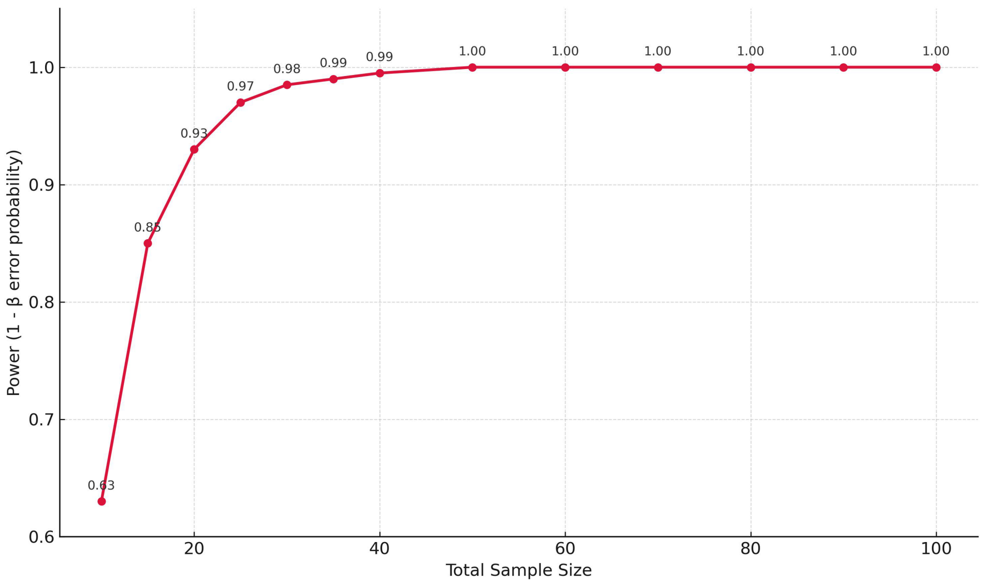

FIGURE 5
Power analysis for repeated measures ANOVA based on sample size.

covered in the Technology in Sports course, which require high levels of problem-solving and critical thinking skills. It is consistent with the findings of Gokkurt et al. (2012), Tran (2013), Korkmaz and Öztürk (2020), Völlinger and Supanc (2020), Wang et al. (2020) and Rakha (2023b), which demonstrate that cooperative learning techniques enhance students' critical thinking, problem-solving speed, and productivity.

The use of QR codes to support task cards enabled the experimental group to achieve learning outcomes by standardizing the work of cooperative groups, distributing roles among members, and establishing an organized timeframe for their tasks. Furthermore, cooperative groups improved evaluation and feedback processes by documenting their interactions and presenting them to the teacher and classmates. This created a competitive environment among the groups, motivating each to excel in showcasing their activities and outcomes. These findings align with the suggestions made by Nurkhin and Pramusinto (2020), which indicate that cooperative learning techniques necessitate active student participation in learning activities, reflection on acquired knowledge, and the development of critical and creative thinking skills. Furthermore, they underscore the importance of placing students at the center of the learning process and fostering their collaborative abilities. In contrast to traditional lectures, Apkarian et al. (2021) and Junejo et al. (2022) assert that cooperative learning

TABLE 6 Descriptive statistics of students' attitudes toward QR code technology as an integrated tool in cooperative learning.

Items	*M* *SD*	Rank	Level
Axis 1. Cognitive attitude			
The integration of QR code technology with cooperative learning techniques has facilitated the simplification of scientific content.	4.45 0.56	4	High
The integration of QR code technology with cooperative learning techniques has been shown to improve students' retention and comprehension of course material.	4.48 0.62	3	High
The integration of QR code technology with cooperative learning techniques has significantly enriched the learning experience and facilitated greater engagement in hands-on activities.	4.42 0.79	5	High
The integration of QR codes with cooperative learning techniques facilitated the acquisition of feedback from both peers and the instructor.	4.36 0.74	7	High
Axis 2. Affective attitude			
The integration of QR code technology with cooperative learning techniques was found to be enjoyable.	4.21 0.89	9	High
The integration of QR code technology with cooperative learning techniques has facilitated improved communication among peers.	4.33 0.82	8	High
The integration of QR code technology with cooperative learning techniques facilitated equitable participation among students in the lessons.	4.58 0.61	1	High
The integration of QR code technology with cooperative learning techniques enhanced motivation for learning.	4.58 0.75	1	High
Axis 3. Behavioral attitude			
QR codes can be readily scanned using a mobile phone, facilitating prompt and seamless access to educational tasks and activities.	4.45 0.75	4	High
The multimedia content accessible via QR codes is diverse and effectively engages learners by incorporating images, videos, as well as both static and animated graphics.	4.39 0.79	6	High
The integration of QR code technology with collaborative learning techniques has facilitated individuals and their teams in approaching assignments with notable efficiency.	4.58 0.66	1	High
The integration of QR code technology with cooperative learning techniques has the potential to improve the monitoring and evaluation of both individual and collective learning progress.	4.55 0.67	2	High

techniques facilitate the implementation of student-centered learning activities, such as knowledge construction and problem-solving exercises. According to Johnson and Johnson (2008), cooperative learning encourages students to engage actively rather than passively. A study conducted by Hang and Van (2020) found that innovations in teaching and learning formats and methods enhance students' creativity. Therefore, it is essential for both lecturers and students to develop active and creative teaching and learning strategies.

The results of the current study align with those of Wang et al. (2020), Cho et al. (2021), and Warsah et al. (2021). These studies demonstrated that cooperative learning strategies significantly enhance academic achievement, interpersonal relationships, diversity awareness, and critical thinking skills. Furthermore, the findings are consistent with the research conducted by Walker (2003), Johnson and Johnson (2009), Harris and Bacon (2019), Rossi et al. (2021), and Chen et al. (2022). In these studies, cooperative learning was shown to improve students' communication skills, thereby enhancing their ability to acquire knowledge independently. The positive interactions among students within a group foster increased engagement and active participation.

Additionally, the implementation of formative assessment activities conducted through educational videos and online resources enabled the teacher to monitor the progress of students in the experimental group. Consequently, the zone of proximal development was identified. The cooperative learning techniques employed for the experimental group served as an educational scaffold, assisting students in advancing to higher cognitive levels. According to Vygotsky and Cole (1978), educational scaffolds are strategies, instructional procedures, or supportive activities used to identify learners' zones of proximal development. Thus, students can develop greater knowledge, skills, and values by collaborating in groups and articulating their thoughts.

Furthermore, there was no statistically significant difference in cognitive achievement between the experimental group's post-measurements and follow-up measurements after a one-month hiatus. The findings align with those of Stiller (2007), De Jong (2010), Plass et al. (2010), Sweller (2010), Stiller and Bachmaier (2018), and Costley and Fanguy (2021). These studies suggest that a positive learning environment and cognitive enhancements, such as the integration of QR Code technology with cooperative learning techniques, contribute to the development of robust cognitive abilities. These abilities create cognitive schemas that improve information processing and enhance working memory, resulting in a strong cognitive framework in long-term memory. Consequently, the experimental group was able to maintain their cognitive level despite a one-month break from teaching and learning activities.

In response to the second question, students enrolled in the "Technology in Sports" course exhibited a positive attitude across all dimensions—cognitive, behavioral, and emotional—due to the implementation of a cooperative learning strategy enhanced by QR code technology. These favorable attitudes were attributed to the integration of QR codes, as supported by the findings of studies conducted by Latif et al. (2011), Yahya et al. (2018), Abdul Rabu et al. (2019), Tan and Chee (2021), and Anggraeni et al. (2022), which indicate that QR code technologies significantly influence students' motivation, abilities, and skills. Furthermore, this integration enhances academic achievement and promotes active learning by introducing a valuable element into the educational process.

As a result of integrating QR code technology and cooperative learning techniques in the current study, positive social interactions among students within their respective groups were enhanced. Their attitudes improved due to increased engagement and active participation in the learning process. These findings align with the results of studies conducted by Korkmaz and Öztürk (2020), Völlinger and Supanc (2020), Dewi and Muhid (2021), and Bizimana et al. (2022), all of which confirmed that collaborative learning positively influences learners' attitudes by enhancing their ability to work together with peers to master academic tasks.

Limitations

In cooperative learning, teachers must monitor student participation to ensure that all students contribute equally to the tasks outlined on the group's task card. Furthermore, to facilitate the prompt display of educational videos and e-learning activities via QR code stickers, it is essential to have adequate internet bandwidth. This approach helps both students and teachers avoid frustration and prevents the wastage of valuable learning time. A persistent challenge in achieving the teacher's goals to enhance the effectiveness of the classroom environment is student engagement. A clear understanding of their responsibilities and expectations may pose an obstacle to fulfilling the teacher's ambitions.

In addition to the aforementioned challenges, it is also important to recognize certain pedagogical considerations. First, the frequent use of mobile devices may foster a degree of technological dependency among students, potentially reducing their ability to maintain focus or to solve problems in the absence of digital tools (Costley and Fanguy, 2021; Lan et al., 2010). Second, although the current study was implemented in a higher education setting with adequate resources, not all schools or institutions—particularly in low-resource environments—can guarantee stable internet connectivity or equal access to smartphones. Nevertheless, the instructional model proposed in this study remains adaptable, as printed QR codes can be used to link learners to pre-downloaded videos or assignments, thereby offering a viable and low-cost solution that maintains the benefits of cooperative and technology-supported learning even in under-resourced contexts (Abdul Rabu et al., 2019; Abeywardena, 2017).

Conclusions and implications for future research

The study examined the impact of QR code technology combined with cooperative learning on students' cognitive achievement and attitudes in the "Technology in Sport" course. Results showed significant improvements from pre- to post-measurements, with follow-up measurements confirming the effectiveness of the integration. After a one-month break from learning, the experimental group maintained their cognitive levels, indicating sustained achievement. Students also displayed positive attitudes toward the learning approach, encompassing cognitive, emotional, and behavioral factors. Effective implementation requires selecting an appropriate instructional design model, evaluating learners' needs, and providing training in cooperative learning techniques. Access to suitable devices and a reliable internet connection is essential, and teachers must be trained in integrating QR code technology, including activity reviews and student feedback in evaluations.

Future research could further explore the long-term impact of QR code–enhanced cooperative learning across diverse educational levels and subject areas, including primary and secondary education. Comparative studies between institutions with varying levels of digital infrastructure may also provide deeper insights into the adaptability of the model in different contexts. In addition, practical interventions could examine teacher training programs focused on integrating QR codes into cooperative learning, as well as the development of low-cost digital and printed resources to support schools in under-resourced environments.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The research was reviewed and approved by the Research Ethics Committee of the Department of Physical Education and Kinesiology, College of Education, Qassim University (Approval No. 01452142024). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AR: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/feduc.2025.1655913/full#supplementary-material

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