

## A Systematic Review on The Pedagogical Use of QR Codes

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### Abstract

Technological advancements have facilitated the widespread use of mobile applications across various domains. QR codes are mobile applications that have gained extensive usage in recent years, particularly experiencing a surge since the onset of the COVID-19 pandemic. QR codes are characterized by their high storage capacity and easy readability. QR codes are also used in the field of education. Therefore, this study aimed to provide a systematic review on the pedagogical use of QR codes. Web of Science, ERIC, Scopus, TR Index, YÖK National Thesis Center, and Google Scholar databases were screened to access articles published between 2014 and 2023. The review yielded 155 articles. The sample consisted of 83 articles addressing the pedagogical use of QR codes. The articles were assessed based on distribution by databases, distribution by years, courses using QR codes, research methods and data collection tools, samples, and usage areas of QR codes. The studies were published in ERIC (28%), TR Index (19%), Web of Science (18%), YÖK National Thesis Center (15%), other indices (12%), or Scopus (8%). Most studies were published in 2022. The majority of the articles were from the field of science education. Most articles adopted quantitative research methods. The majority of the articles recruited graduate students. Most articles integrated QR codes into videos.

### Received:

5 March 2024

### Accepted:

10 May 2024

### Published online:

01 October 2024

### Keywords

QR code,  
Mobile Applications,  
QR Code and Education,  
Systematic Review.

**To cite this article:** Sağıt, P., Uçak, E., & Savran Gencer, A. (2024). A Systematic review on the pedagogical use of QR codes. *Journal of STEM Teacher Institutes*, 4(2), 106-126 Retrieved from <https://jstei.com/index.php/jsti/article/view/73>

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## Introduction

Technological advancements and the widespread availability of the Internet have enabled individuals to use an increasing number of mobile devices, making mobile applications more and more available. The influence of technology is evident in various spaces where people spend their time, ranging from hospitals and markets to libraries and restaurants. QR codes, as one of the mobile applications, have gained widespread popularity, particularly during and after the COVID-19 pandemic. QR codes are also popular in education. In Türkiye, QR codes, initially employed to access solutions to questions in test books, have evolved and found diverse applications in education over time.

QR codes were first invented in 1994 by Denso Wave, a subsidiary of a Japanese car company, to monitor and control car manufacturing processes. The widespread adoption of QR codes can be attributed to their ample storage capacity and ease of readability. QR codes are graphical representations consisting of black and white squares that store information, which can be captured by a camera or smartphone. Therefore, QR codes are a two-dimensional and scan-patterned application that enables swift access to information when captured by a camera or smartphone. QR codes can contain links, videos, texts, audio files, e-books, and more (Shin et al., 2012). QR codes are very easy to create and use. Users can download a barcode reader app on their smartphone and simply point the camera at the QR code to access the information embedded within it. QR codes provide a rapid, straightforward, and efficient means of accessing authentic online material or information (Mohammed & Zidan, 2023; Thorne, 2016). It is possible to integrate QR codes into traditional educational materials, such as notebooks and books (Aktaş & Çaycı, 2013). Utilizing QR codes to integrate content (images, photos, websites, videos, etc.) into textbooks ensures a cohesive connection between the topics and associated content within the textbook (Köse, 2019).

Research shows that QR codes contribute to in-class and out-of-class learning. For example, Aktaş & Çaycı (2013) argue that

QR codes enrich learning processes. Add-ons (videos, articles, quizzes, etc.) embedded in QR codes provide supplementary learning opportunities outside the traditional classroom setting. QR codes allow students to quickly access secure information outside the classroom. QR codes embedded in textbooks offer effective and dynamic learning conditions for students (Misnawati et al., 2023). This strategy covers two skills at the same time: listening and reading. Of course, two skills have more benefits than one. Therefore, teachers can use QR codes to offer their students a different learning environment. Another advantage of incorporating QR codes into textbooks is the capability to offer additional resources such as videos, audio files, web pages, and other information that students can access, which may not be directly available within the textbooks. McCabe & Tedesco (2012) state that QR codes motivate students to complete their homework assignments. In-class activities with QR codes make students more engaged and make learning more fun. QR codes promote both individual and collaborative learning and make students more motivated and engaged (Uçak & Usta, 2023; Ünlü, 2023). QR codes can be quickly prepared and updated. They save time and prevent paper waste. They allow people to access information directly. On the other hand, users need the Internet and a smart device to access the information embedded in QR codes. Moreover, they cannot use QR codes prepared in timed applications (Uçak, 2019). According to Ahmed & Zanelidin (2020), education involves challenges that require the use of QR codes. For example, teachers lack basic knowledge and skills regarding technology. Not all teachers have access to the Internet, mobile devices, or tablets. Moreover, they are not innovative enough to deliver knowledge. To tackle these challenges, we should look for practical examples of how QR codes can be integrated in education.

In recent years, there has been a growing body of research into the use of QR codes in education. For example, Celik (2023b) examined the effect of a QR code-based program on the correct pronunciation of English words and vocabulary expansion. Some researchers have focused on the use of technology in music education during the COVID-19 pandemic. For instance, Uludağ

(2023) employed a flipped learning model and technological resources to transform students' initially negative attitudes toward remotely conducted Harmony lessons in music education into positive ones. Studies aiming to gain insights into how technology can be integrated into education are crucial for understanding the impact of these technologies on participants' perspectives. Such studies contribute valuable knowledge about the effectiveness and implications of integrating technology in educational settings. Uçak & Usta (2022) investigated what students and parents thought about the use of QR codes in cooperative learning groups in science teaching. They also investigated what students, teachers, and preservice teachers thought about the integration of QR codes into science games (2023). Güven & Kabaran (2023) created content with digital materials to develop a new instructional design on renewable energy. QR codes integrated into school and home books serve as a valuable tool, enabling students to swiftly access course materials and enhancing their learning experience through increased interactivity. Alharbi & Al Sawy (2022) integrated QR codes into books to access the iEN website, Saudi Arabia's national learning portal. Misnawati et al. (2023) provide a detailed overview of the steps involved in implementing QR codes in books. They focus on enriching listening skills in conjunction with reading and dialogue texts. QR codes can be utilized to enable students to independently conduct laboratory experiments. By integrating QR codes into lab manuals or experiment guides, students can access supplementary resources, instructions, or demonstrations, facilitating a more autonomous and interactive learning experience in the laboratory setting. For example, Normawati et al. (2022) designed a QR code guide for lab activities. Mohammed & Zidan (2023) developed an animated security tracking system with QR codes to monitor student engagement. Such secure tracking systems can provide teachers with a more accurate and reliable way to monitor student engagement. Kızılay (2021) developed a STEAM activity where he embedded links to virtual museums in QR codes to allow all students to visit them. Savitri et al. (2021) used QR codes to develop real science masks. They examined whether the masks helped students develop problem-solving skills and scientific literacy. The students were supposed to scan the

QR codes on the masks and find solutions to the problems embedded in the QR codes. Uçak (2019) developed activities that allowed preservice teachers to use QR codes in different ways within the scope of the "Material Development" course. He asked the preservice teachers what they thought about the pedagogical use of QR codes. Research shows that QR codes are used pedagogically in different fields. However, no research has included a study that offers a broad perspective on the use of QR codes in education. Therefore, this systematic review focused on creating a framework for the use of QR codes in education. We believe that this study will make a significant contribution to the literature and pave the way for further research.

This study, aiming to analyze the pedagogical use of QR codes between 2014 and 2023, answers to the following questions:

- 1) What is the distribution of studies according to databases?
- 2) How are studies distributed over the years?
- 3) What is the distribution of studies according to subjects?
- 4) What is the composition of the study groups in the conducted studies?
- 5) What are the preferred research methods and data collection tools in the conducted studies?
- 6) What are the usage areas of QR codes in the conducted studies?

## Method

This study adopted a systematic review approach. Systematic reviews allow researchers to comprehensively review all published articles based on inclusion/exclusion criteria. Researchers who conduct systematic reviews can assess the quality of studies and summarize their results (Karaçam, 2013; Yıldırım et al., 2021). In employing a systematic review, a researcher seeks to identify and analyze all relevant empirical evidence that aligns with predetermined inclusion criteria. This rigorous

approach aims to address a specific research question or test a hypothesis, ensuring a comprehensive and unbiased synthesis of existing literature (Snyder, 2019). Systematic reviews are more comprehensive and objective than traditional reviews because they recruit studies based on specific criteria. Other researchers can replicate systematic reviews because they have certain criteria (Yılmaz, 2021). This systematic review followed these steps: (1) identifying research questions, (2) screening databases, (3) determining inclusion/exclusion criteria, (4) recruiting articles, (5) analyzing data, (6) summarizing and interpreting findings, and (7) writing a review report (Kitchenham, 2004).

This study conducted a systematic review on the pedagogical use of QR codes. Describing key concepts as inclusion/exclusion criteria and other steps were identified by utilizing the checklist of PRISMA for Scoping Reviews (Tricco, 2018) (see Appendix I). Web of Science, ERIC, Scopus, TR index, Google Scholar, and National Thesis Center databases were screened using the keywords “QR codes in education/eğitimde QR kodlar, QR codes/QR

kodlar, QR codes and education/QR kod ve eğitim/kare kod ve eğitim, and quick response/hızlı yanıt kodu.” The databases were screened to access Turkish or English articles and theses published between 2014 and 2023. The review yielded 155 studies. However, seventy-two studies were excluded because (1) they did not use QR codes for pedagogical purposes, (2) they were reports, or (3) they just mentioned QR codes but did not utilize them. As a result, the sample consisted of 83 studies published in ERIC (n=23), TR index (n=16), Web of Science (n=15), National Thesis Center (n=12), other indices (n=10), or Scopus (n=7). The data were presented in graphs and tables.

### Results

The articles and theses in the sample (studies) on the pedagogical use of QR codes were analyzed. Figure 1 shows the distribution of the studies by databases, while Figure 2 shows the distribution of the studies by publication years.

**Figure 1**  
*The Distribution of the Studies by Databases*

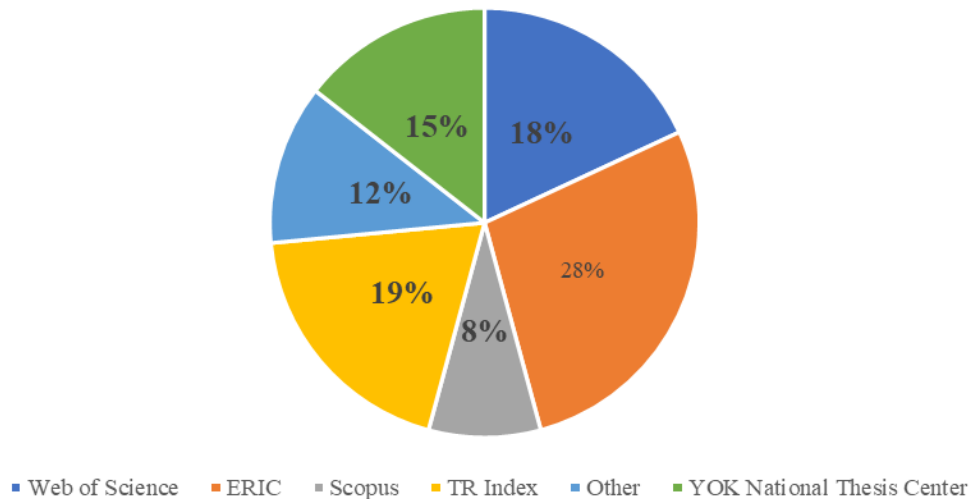


Figure 1 shows the distribution of the studies by databases. Twenty-three studies were published in ERIC (28%). Sixteen studies were published by TR index (19%). Fourteen studies were published by Web of Science (18%). Eleven studies were published by other indices (12%). Twelve studies were published by YOK

National Thesis Center (15%). Seven studies were published by Scopus (8%). Most studies were published in ERIC. Seven studies published by ERIC were conducted in Türkiye (Akbaş et al., 2022; Arıkan & Özen, 2015; Ceylan Çapar, 2021; Çoruhlu & Pehlevan, 2021; Karakuş & Şeyihoğlu, 2022; Uçak, 2019;

Uçak & Usta, 2022). Four studies published by Web of Science were conducted in Türkiye (Celik, 2023b; Durak et al., 2016; Kuru-Gönen & Zeybek, 2022; Uludağ, 2023). Six studies published by other indices were conducted in

Türkiye (Arifoğlu & Çay; 2023; Celik, 2023a; Kızılay, 2021; Morali, 2019; Şimşek & Soysal, 2022; Yılmaz & Canbazoğlu-Bilici, 2017). One study published by Scopus were conducted in Türkiye (Çataloğlu & Ateşkan, 2014).

**Figure 2**  
*The Distribution of the Studies by Publication Years*

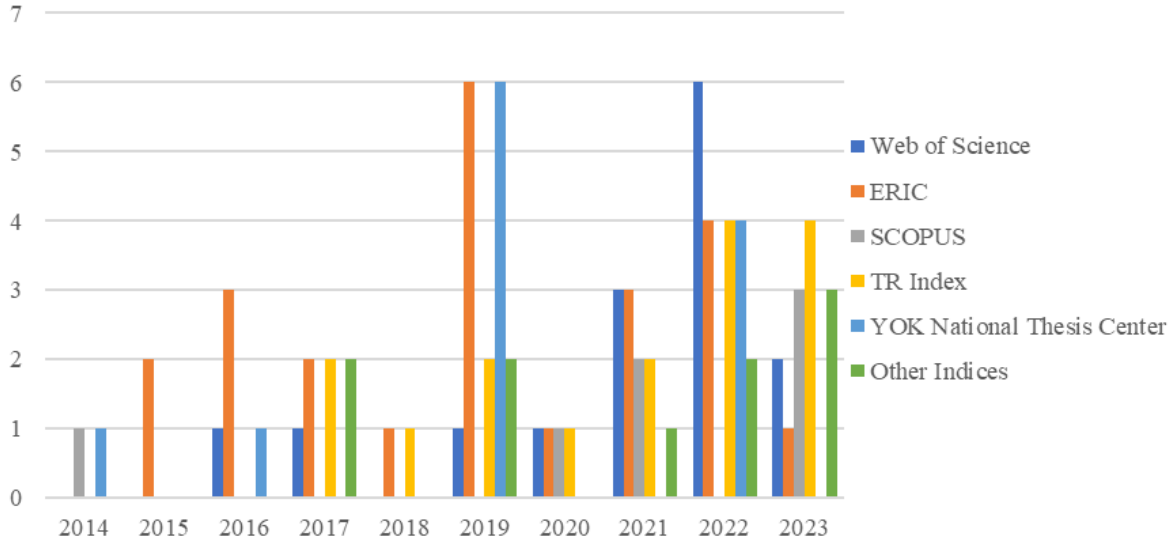


Figure 2 shows the distribution of the studies by publication years (2014-2023). ERIC has published studies on QR codes every year except 2014. Most studies were published in 2022 (n=20). Seventeen studies were published in 2019. Eleven studies were published in 2021. Thirteen studies were published in 2023. Most studies were published in the last five years (n=65), suggesting that QR codes have become

more and more popular in education in recent years.

Table 1 shows the distribution of the studies depending on what courses QR codes were integrated. Most studies integrated QR codes into science courses (n=23). Fourteen studies integrated QR codes into English courses.



**Table 1**

*The Distribution of the Studies by the Integration of QR Codes into Courses*

Theme	Codes	Studies
<b>Courses</b>	Science	(Akar & Yadigaroglu, 2021), (AlNajdi, 2022), (Aslan Tutak et al., 2017)**, (Atwood-Blaine & Huffman, 2017) (Başçı, 2019)*, (Chung et al., 2019), (Çoruhlu & Pehlevan, 2021), (Er Nas et al., 2022), (Güven & Kabaran, 2021), (Güven & Kabaran, 2023), (Güven Demir & Öksüz, 2022)**, (Karahana & Canbazoglu-Bilici, 2017), (Kılıç, 2022)*, (Kızılay, 2021), (Özbay, 2016)*, (Savitri et al., 2021), (Şahin, 2022)*, (Şimşek & Soysal, 2022), (Uçak, 2019), (Uçak & Usta, 2022), (Uçak & Usta, 2023), (Yılmaz & Canbazoglu-Bilici, 2017), (Yılmaz, 2019)*
	English	(Alzubi, 2019), (Arıkan & Özen, 2015), (Avgousti & Hadjistassou, 2019), (Bakla, 2018), (Balintag & Wilang, 2020), (Ceylan-Çapar, 2021), (Celik, 2023a), (Celik, 2023b), (Dukalskaya & Tabueva, 2022), (Hussein et al., 2023), (Misnawati et al., 2023), (Tan & Chee, 2021), (Ulla et al., 2020), (Thorne, 2016)
	Social Sciences	(Abril-López et al., 2021), (Güven Demir & Öksüz, 2022) **, (Karakuş & Seyihoğlu, 2022), (Ramazanoğlu & Solak, 2020), (Ortega-Sánchez & Gómez-Trigueros, 2019)
	Educational Sciences	(Abdul-Rabu et al., 2019), (Ali et al., 2017), (Çataloglu & Ateşkan, 2014), (Usta & Güntepe, 2019)
	Biology	(Akbat et al., 2022), (Chapple et al., 2017), (Kösal, 2019)*, (Köse, 2019)*, (Nunes et al., 2021),
	Mathematics	(Aslan Tutak et al., 2017)**, (Güleç, 2019)*, (Santoso et al., 2019), (Ünlü, 2023)
	Information Technologies	(Akin, 2014)*, (Çetin & Akkoyunlu, 2019)**, (Durak et al., 2016), (Zendler & Klein, 2018)
	Not specified	(Abeywardena, 2017), (Bjelobaba et al., 2022), (Mohammed & Zidan, 2023), (Patil et al., 2023)
	Medical Education	(Mogali et al., 2019), (Noël et al., 2021), (Traser et al., 2015)
	Chemistry	(Ayyıldız & Karabulut, 2022), (Ippoliti et al., 2022)
	Turkish Teaching	(Çetin & Akkoyunlu, 2019)**, (Moralı, 2019)
	Music Education	(Uslu, 2022) *, (Uludağ, 2023)
	Geography	(Çiğdem, 2022)*, (Çiğdem & Koç, 2023)
	Engineering Education	(Ahmed & Zanelidin, 2020), (Normawati, 2022)
	Physical Education	(Fernández-Gavira et al., 2021), (Ünlü, 2022)
	Physics	(Başal, 2019)*
	Green Chemistry	(Lembens et al., 2022)
	Special Education	(Grande & Pontrello, 2016)
	Arabic Teaching	(Nadziro et al., 2023)
	Handicrafts	(Gummesson, 2016)
Graphic Design	(Arifoğlu & Çay, 2023)	
British Cultural History	(Kuru-Gönen & Zeybek, 2022)	
iEN Platform Saudi Arabia Education Portal	(Alharbi & Al Sawy, 2022)	

Note: (\*) indicates theses. (\*\*) indicates that the same citation is repeated in different sections

Chung et al. (2019) organized a scavenger hunt activity for students visiting a zoo. They embedded information about animals

in QR codes and encouraged students to scan the codes during the visit. Atwood-Blaine & Huffman (2017) used the Great STEM Caper to

help students collaborate in pairs to find hidden QR codes. Uçak (2019) developed an activity on the different uses of QR codes within the scope of the "Material Development" course and asked preservice teachers what they thought about the process. Uçak & Usta (2022) developed a cooperative learning model with QR codes and carried out classes within the scope of the "Systems Unit" during the science course. They asked middle school students and their parents what they thought about the use of QR codes in science lectures. Çoruhlu & Pehlevan (2021) uploaded experiment videos about the nature of matter to QR codes and had middle school students watch them. Savitri et al. (2021) designed a science mask with QR codes to enable undergraduate students to turn abstract concepts into concrete representations. Er Nas et al. (2022) uploaded videos on Earth and Universe to QR codes in science experiment guide for students with learning disabilities. Akar & Yadigaroglu (2021) had middle school students create QR codes related to STEM activities. Güven & Kabaran (2021) stated that students and teachers wanted to use QR codes about renewable energy in lessons. In the following years, Güven & Kabaran (2023) uploaded texts, videos, images, and questions about fossil fuels to QR codes for middle school students. Uçak & Usta (2023) used the station technique to design games with QR codes in six learning domains and got middle school students to play them. Karahan & Canbazoglu-Bilici (2017) had science teachers conduct activities to explore QR codes. Şimşek & Soysal (2022) developed an earthquake-themed STEM activity and asked middle school students to

present their projects and activities by uploading them to QR codes. Yılmaz & Canbazoglu-Bilici (2017) had middle school students play games with QR codes within the scope of the "Solar System and Beyond: The Riddle of Space" unit. Alnajdi (2022) investigated the effectiveness of QR codes integrated into textbooks. Kızılay (2021) proposed a STEAM activity to design a virtual astronomy museum for sixth graders. After completing their virtual museums, students embedded the links to their museums in QR codes. Other students could visit the museum by scanning the QR codes. Özbay (2016) found that science teachers preferred QR codes very much. Yılmaz (2019) integrated QR codes into games within the scope of the "Seventh-Grade Solar System and Beyond" unit and examined students' attitudes towards technology and science. Şahin (2022) had middle school students play games about cells and divisions with Learning Apps and uploaded each of these games to QR codes. Kılıç (2022) integrated QR codes about reflection and absorption in mirrors into the textbook and examined seventh-grade middle school students' academic achievement and attitudes towards science course. All in all, there is a growing body of research into the use of QR codes in science education.

Table 2 shows the distribution of the studies by samples. Most studies recruited undergraduate or middle school students. Few studies recruited academics, special education teachers, the public, or parents.

**Table 2**

*The Distribution of the Studies by Study Group*

Theme	Codes	Studies
Study Group	Undergraduate students	(Abril-López et al., 2021), (Abdul-Rabu et al., 2019), (Ahmed & Zaneldin, 2020), (Akbay et al., 2022), (Ali et al., 2017), (Arifoğlu & Çay, 2023), (Aslan-Tutak et al., 2017), (Avgousti & Hadjistassou, 2019), (Başal, 2019)*, (Başçı, 2019)*, (Chapple et al., 2017), (Ceylan-Çapar, 2021), (Celik, 2023a), (Celik, 2023b), (Dukalskaya & Tabueva, 2022), (Durak et al., 2016), (Kuru-Gönen & Zeybek, 2022), (Grande & Pontrello, 2016), (Ippoliti et al., 2022)**, (Kösal, 2019)***, (Mogali et al., 2019), (Nadziro et al., 2023), (Normawati, 2022), (Nunes et al., 2021)**, (Ortega-Sánchez & Gómez-Trigueros, 2019), (Patil et al., 2023), (Santoso et al., 2019), (Savitri et al., 2021), (Traser et al., 2015), (Uludağ, 2023), (Usta & Güntepe, 2019),

Middle school students	(Ulla et al., 2020), (Uçak & Usta, 2023)** , (Uçak, 2019), (Ünlü, 2022), (Ünlü, 2023) (Akar & Yedigaroğlu, 2021), (Alharbi & Al Sawy, 2022)** , (AlNajdi, 2022), (Atwood-Blaine & Huffman, 2017), (Chung et al., 2019)** , (Er-Nas et al., 2022), (Güleç, 2019) * , (Güven & Kabaran, 2023), (Kılıç, 2022)* , (Kızılay, 2021), (Lembens et al., 2022)** , (Ramazanoğlu & Solak, 2020), (Şahin, 2022)* , (Şimşek & Soysal, 2022), (Yılmaz & Canbazoglu-Bilici, 2017), (Uçak & Usta, 2022)** , (Uçak & Usta, 2023)** , (Yılmaz, 2019) *
High school students	(Akın, 2014) * , (Alharbi & Al Sawy, 2022)** , (Çiğdem, 2022)* , (Çiğdem & Koç, 2023), (Gummesson, 2016), (Zendler & Klein, 2018)
Students-Teachers	(Arıkan & Özen, 2015), (Çetin & Akkoyunlu, 2019)** , (Köse, 2019) * , (Güven & Kabaran, 2021), (Karakuş & Seyihoğlu, 2022), (Mohammed & Zidan, 2023)
None	(Ayyıldız & Karabulut, 2022), (Bakla, 2018), (Çataloğlu & Ateşkan, 2014), (Misnawati et al., 2023), (Moralı, 2019), (Thorne, 2016),
Primary school students	(Chung et al., 2019)** , (Çoruhlu & Pehlevan, 2021), (Güven-Demir & Öksüz, 2022), (Hussein et al., 2023), (Tan & Chee, 2021)
Teachers	(Alzubi, 2019), (Karahan & Canbazoglu-Bilici, 2017), (Özbay, 2016) * , (Uçak & Usta, 2023)**
Master's students	(Balintag & Wilang, 2020), (Ippoliti et al., 2022)** ,( Noël et al., 2021), (Nunes et al., 2021)** ,
Academics	(Kösal, 2019)***, (Bjelobaba et al., 2022)
Physical education teachers, special education students, interpreters for the hearing impaired, sports venue officials, and hearing impaired individuals	(Fernández-Gavira et al., 2021)
Visually impaired music teachers, individuals with music education, individuals without music education	(Uslu, 2022)*
Parents	(Uçak & Usta, 2022)**
Library Staff	(Çetin & Akkoyunlu, 2019)**
Distance education students	(Abeywardena, 2017)
Public	(Lembens et al., 2022)**

(\*) indicates theses. (\*\*) indicates that the same citation is repeated in different sections. (\*\*\*) indicate theses repeated in different sections

Table 3 shows the distribution of the studies by research methods and data collection tools.



**Table 3**

*The Distribution of the Studies by Research Methods and Data Collection Tools*

Method		Data Collection Tool	Studies
<b>Quantitative</b>	Non-experimental	Survey	(Abdul-Rabu et al., 2019), (Ahmed & Zanelidin, 2020), (Alharbi & Al Sawy, 2022), (Alzubi, 2019), (Arifoğlu & Çay, 2023), (Avgousti & Hadjistassou, 2019), (Balintag & Wilang, 2020), (Bjelobaba et al., 2022), (Chapple et al., 2017), (Dukalskaya & Tabueva, 2022), (Köse, 2019)*, (Lembens et al., 2022), (Mogali et al., 2019), (Mohammed & Zidan, 2023), (Noël et al., 2021), (Normawati, 2022), (Ortega-Sánchez & Gómez-Trigueros, , 2019), (Sahin, 2022) ***, (Traser et al., 2015), (Çiğdem, 2022)***
	Quasi experimental	Pretest - Posttest	(Akin, 2014)*, (AlNajdi, 2022), (Aslan-Tutak et al., 2017), (Chung et al., 2019), (Celik, 2023b), (Çiğdem, 2022)***, (Çiğdem & Koç, 2023), (Grande & Pontrello, 2016), (Güleç, 2019)*, (Hussein et al., 2023), (Sahin, 2022)***, (Santoso et al., 2019), (Savitri et al., 2021), Zendler & Klein, 2018)
<b>Qualitative</b>	Case Study	Interview	(Akbay et al., 2022), (Ceylan-Çapar, 2021), (Çetin & Akkoyunlu, 2019), (Durak et al., 2016), (Fernández-Gavira et al., 2021), (Gummesson, 2016), (Güven & Kabaran, 2021), (Karakuş & Şeyihoğlu, 2022), (Kuru-Gönen & Zeybek, 2022), (Uçak, 2019), (Ünlü, 2023) (Uçak & Usta, 2022), (Uçak & Usta, 2023)
		Written documents	(Ulla et al., 2020)
		Interview/ Observation	
		Video Drawing test/ Concept test/ Interview Drawing/ Interview/ Concept test/ Open-ended question	(Karahana & Canbazoğlu-Bilici, 2017) (Çoruhlu & Pehlevan,2021) (Er-Nas et al., 2022)
<b>Not specified</b>		Diary	(Yılmaz & Canbazoğlu-Bilici, 2017) (Abeywardena, 2017), (Bakla, 2018), (Çataloğlu & Ateşkan, 2014), (Ippoliti et al., 2022), (Kızılay, 2021), (Misnawati et al., 2023) (Moralı, 2019), (Nunes et al., 2021), (Patil et al., 2023), (Thorne, 2016), (Ünlü, 2022)
<b>Mixed</b>		Observation/ Test	(Abril-López et al., 2021), (Akar & Yadigaroğlu, 2021), (Ali et al., 2017), (Arikan & Özen, 2015), (Atwood-Blaine & Huffman, 2017), (Başal, 2019) *, (Başçı, 2019)*,
		Interview/	(Celik, 2023a), (Güven-Demir & Öksüz, 2022), (Güven & Kabaran, 2023), (Kılıç, 2022)*, (Kösal, 2019)*, (Özbay, 2016)*, (Ramazanoğlu & Solak, 2020), (Uludağ, 2023),
		Survey/	(Usta & Güntepe, 2019), (Şimşek & Soysal, 2022),
		Diary	(Nadziro et al., 2023), (Tan & Chee, 2021), (Uslu, 2022)*, (Yılmaz, 2019)*
<b>Document Review</b>			(Ayyıldız & Karabulut, 2022)

(\*) indicates these. (\*\*) indicates that the same citation is repeated in different sections. (\*\*\*) indicates these repeated in different sections.

Most studies adopted qualitative, quantitative or mixed research designs. Some studies employed document reviews. However, some others did not specify their research designs. Most studies adopted quantitative research designs. Most of those studies preferred non-experimental models and employed surveys. Most of the qualitative studies adopted case studies and employed interviews. Ulla et al. (2020) utilized interviews and observations. Karahan & Canbazoglu-Bilici (2017) focused on videos. Çoruhlu & Pehlevan

(2021) used drawing tests-concept tests-interviews. Er-Nas et al. (2022) utilized drawings-interviews-concept tests-open-ended questions. Yılmaz (2019) and Ali et al. (2017) conducted adopted mixed research designs and used diaries. Most studies conducted surveys and interviews.

Table 4 shows the distribution of the studies by the usage areas of QR codes.

**Table 4**

*The Distribution of the Studies by the Usage Areas of QR Codes*

Theme	Codes	Studies
Usage Areas	Video	(Ahmed & Zaneldin, 2020), (Aslan-Tutak et al., 2017), (Akin, 2014) ***, (Avgousti & Hadjistassou, 2019), (Çoruhlu & Pehlevan, 2021), (Dukalskaya & Tabueva, 2022), (Er Nas et al., 2022), (Gummesson, 2016), (Usta & Güntepe, 2019), (Ünlü, 2022), (Kuru-Gönen & Zeybek, 2022)**, (Ramazanoğlu & Solak, 2020), (Uludağ, 2023), (Ünlü, 2023)
	Activity	(Ali et al., 2017), (Arikan & Özen, 2015), (Balintag & Wilang, 2020), (Başçı, 2019)*, (Chung et al., 2019), (Ceylan-Çapar, 2021), (Celik, 2023b), (Çiğdem & Koç, 2023), (Güven-Demir & Öksüz, 2022), (Karahan & Canbazoglu-Bilici, 2017), (Karakuş & Seyihoğlu, 2022), (Köse, 2019)*
	Game	(Akbay et al., 2022), (Atwood-Blaine & Huffman, 2017), (Fernández-Gavira et al., 2021), (Noël et al., 2021), (Nunes et al., 2021), (Savitri et al., 2021), (Uçak, 2019), (Uçak & Usta, 2022), (Uçak & Usta, 2023), (Yılmaz & Canbazoglu-Bilici, 2017), (Yılmaz, 2019)*
	Creating a book	(Alharbi & Al Sawy, 2022), (Alnajdi, 2022), (Çiğdem, 2022)*, (Grande & Pontrello, 2016), (Güleç, 2019) *, (Hussein et al., 2023) (Kılıç, 2022) *. (Misnawati, 2023), (Nadziro et al., 2023)
	Information	(Abdul-Rabu et al., 2019), (Akin, 2014) ***, (Chapple et al., 2017), (Çetin & Akkoyunlu, 2019), (Kuru-Gönen & Zeybek, 2022)**, (Lembens et al., 2022) (Mogali et al., 2019), (Traser et al., 2015), (Thorne, 2016)
	Redirect to page	(Ayyıldız & Karabulut, 2022), (Bjelobaba et al., 2022), (Celik, 2023a), (Durak et al., 2016), (Kızılay, 2021), (Şahin, 2022)*
	Lab	(Başal, 2019)*, (Kösal, 2019)*, (Normawati, 2022), (Patil et al., 2023)
	Generating ideas about QR Codes	(Abeywardena, 2017), (Bakla, 2018), (Çataloğlu & Ateşkan, 2014), (Moralı, 2019)
	Most used / desired mobile applications (QR codes)	(Alzubi, 2019), (Güven & Kabaran, 2021), (Özbay, 2016) *
	Preparing a Presentation	(Arifoğlu & Çay, 2023), (Şimşek & Soysal, 2022), (Zendler & Klein, 2018)
	Audio	(Uslu, 2022)*, (Tan and Chee, 2021)
	Survey	(Abril-López et al., 2021), (Ulla et al., 2020)
	QR code generation	(Akar & Yadigaroglu, 2021), (Uçak & Usta, 2022)

Student Monitoring	(Mohammed & Zidan, 2023)
Visualization	(Ippoliti et al., 2022)
Text, question, audio, video	(Güven & Kabaran, 2023)
Creating a Blog	(Ortega-Sánchez & Gómez-Trigueros, 2019)
Submitting assignments	(Santoso et al., 2019)

(\*) indicates theses. (\*\*) indicates that the same citation is repeated in different sections. (\*\*\*) indicates theses repeated in different sections.

Table 4 shows the distribution of the studies by the usage areas of QR codes. Most researchers embedded videos in QR codes (Ahmed & Zanelidin, 2020; Akın, 2014; Aslan Tutak et al., 2017; Avgousti & Hadjistassou, 2019; Çoruhlu & Pehlevan, 2021; Dukalskaya & Tabueva, 2022; Er Nas et al., 2022; Gummesson, 2016; Kuru-Gönen & Zeybek, 2022; Ramazanoğlu & Solak, 2020; Uludağ et al., 2023; Usta & Güntepe, 2019; Ünlü, 2022; Ünlü, 2023). They used QR codes to present experiment videos and animations. Some researchers used QR codes for games and activities. They designed games and integrated QR codes into them (Akbat et al., 2022; Atwood-Blaine & Huffman, 2017; Fernández-Gavira et al., 2021; Noël et al., 2021; Nunes et al., 2021; Savitri et al., 2021; Uçak, 2019; Uçak & Usta, 2022; Uçak & Usta, 2023; Yılmaz & Canbazoğlu Bilici, 2017; Yılmaz, 2019). Some researchers handed out papers with QR codes (Ali et al., 2017; Arıkan & Özen, 2015; Balintang & Wilang, 2020; Başçı, 2019; Celik, 2023b; Ceylan Çapar, 2021; Chung et al., 2019; Çiğdem & Koç, 2023; Güven Demir & Öksüz, 2022; Karahan & Canbazoğlu Bilici, 2017; Karakuş & Şeyihoğlu, 2022; Köse, 2019). Some researchers embedded information to QR codes (Abdul-Rabu et al., 2019; Akın, 2014; Chapple et al., 2017; Çetin & Akkoyunlu, 2019; Kuru-Gönen & Zeybek, 2022; Lembens et al., 2022; Mogali et al., 2019; Thorne, 2016; Traser et al., 2015). The researchers integrated QR codes into textbooks and presented them to students. (Alharbi & Al Sawy, 2022; AlNajdi, 2022; Çiğdem, 2022; Grande & Pontrello, 2016; Güleç, 2019; Hussein et al., 2023; Kılıç, 2022; Misnawati, 2023; Nadziro et al., 2023). Some researchers used QR codes to make presentations (Arifoğlu & Çay, 2023; Şimşek & Soysal, 2022; Zendler & Klein, 2018), while others uploaded links to QR codes and redirected students to those pages (Ayyıldız & Karabulut, 2022; Celik, 2023a; Durak et al.,

2016; Ippoliti et al., 2022; Kızılay, 2021; Şahin, 2022). Some researchers used QR codes to send surveys (Abril-López et al., 2021; Ulla et al., 2020). Some of them used QR codes for laboratory equipment, safety precautions, and experimentation (Başal, 2019; Kösal, 2019; Normawati, 2022; Patil et al., 2023). Some researchers concluded that teachers use and want to use QR codes the most (Alzubi, 2019; Güven & Kabaran, 2021; Özbay, 2016). Some researchers used QR codes to teach music (Uslu, 2022) and beginning piano concepts to visually impaired students (Mohammed & Zidan, 2023). Ortega-Sánchez & Gómez-Trigueros (2019) used QR codes to monitor student attendance. Some researchers used QR codes to create blogs (Abeywardena, 2017; Bakla, 2018; Çataloğlu & Ateşkan, 2014; Morali, 2019). Santoso et al. (2019) utilized QR codes to present information about the use of QR codes and to submit assignments.

## Discussion and Conclusion

This systematic review investigated the pedagogical use of QR codes. Web of Science, ERIC, Scopus, TR index, Google Scholar, and YOK National Thesis Center databases were screened to access Turkish or English articles and theses on the pedagogical use of QR codes published between 2014 and 2023 using the keywords “QR codes in education/eğitimde QR kodlar, QR codes/QR kodlar, QR codes and education/QR kod ve eğitim/kare kod ve eğitim, quick response/hızlı yanıt kodu.” The literature review yielded 155 articles and theses (studies). The sample consisted of 83 studies.

The studies were published in ERIC (28%), TR Index (19%), Web of Science (18%), YOK National Thesis Center (15%), other indices (12%), or Scopus (8%). ERIC published studies every year except 2014. Most studies

were published in 2022 (n=20). Seventeen studies were published in 2018. Eleven studies were published in 2021. Thirteen studies were published in 2023. The findings suggest a growing popularity of QR codes in education, indicating a notable interest among researchers in this field.

Most researchers used QR codes for science (n=23) and English education (n=14). These results show that researchers attach great importance to using QR codes in science education. Researchers demonstrate the diverse applications of QR codes in education, showcasing how they can facilitate collaborative interactions in science lessons (Atwood-Blaine & Huffman, 2017; Uçak & Usta, 2022; Uçak & Usta, 2023), enhance instructional materials (Uçak, 2019; Patil et al., 2023; Yılmaz & Canbazoğlu Bilici, 2017), solidify experiential learning (Kızılay, 2021; Savitri et al., 2021), and offer students interactive learning experiences (Akar & Yadigaroglu, 2021; Başçı, 2019; Chung et al., 2019; Çoruhlu & Pehlevan, 2021; Er Nas et al., 2022; Güven & Kabaran, 2023; Karahan & Canbazoğlu-Bilici, 2017; Kılıç, 2022; Şahin, 2022; Şimşek & Soysal, 2022). These findings can provide important data for researchers and educators to assess the impact of QR codes in education and enrich learning experiences.

Most researchers recruited undergraduate or middle school students. Few researchers recruited parents, the public, special education students, academics, and graduate students. Fernández-Gavira et al. (2021) recruited physical education students and special physical education students. They integrated videos into QR codes and redirected students to videos on YouTube. The videos in the games had sign language. Uslu (2022) embedded videos and sounds to QR codes to teach basic piano concepts to visually impaired students. These findings show that a few researchers used QR codes to teach hearing impaired and visually impaired individuals. Abeywardena (2017) aimed to provide information about Print2Screen, an application with QR codes developed for a distance education course. Uçak & Usta (2022) asked parents what they thought about the use of QR codes in education.

Some studies adopted qualitative or quantitative research designs. Some others utilized mixed research designs. A few studies conducted document reviews. Most studies adopted quantitative research designs and employed non-experimental models. Most qualitative studies were case studies. The two studies that adopted mixed research designs also focused on diaries.

QR codes are widely used in education. Most researchers integrated videos to QR codes. Most studies concluded that QR codes are effective in education (Ahmed & Zanelidin, 2020; Akın, 2014; Avgousti & Hadjistassou, 2019; Çoruhlu & Pehlevan, 2021; Dukalskaya & Tabueva, 2022; Durak et al., 2016; Gummesson, 2016; Güven & Kabaran, 2023; Kuru-Gönen & Zeybek, 2022; Ramazaoğlu & Solak, 2020; Uludağ, 2023; Usta & Güntepe, 2019; Ünlü, 2022; Ünlü, 2023). Er-Nas et al. (2022) found that the conceptual understanding of special education students is directly influenced by the emphasis on experiments and activities. However, challenges in knowledge transfer may arise as a result of this focus. These findings suggest that we must design activities and games to transfer knowledge for special education students.

Teachers should use different methods instead of papers to make students more interested in lessons. Some researchers integrated QR codes into activities and used them to increase students' interest and curiosity in lessons. Most studies have concluded that the impact of QR codes is positive (Ali et al., 2017; Arıkan & Özen, 2015; Balintag & Wilang, 2020; Başçı, 2019; Celik, 2023b; Chung et al., 2019; Çiğdem & Koç, 2023; Güven Demir & Öksüz, 2022; Karahan & Canbazoğlu-Bilici, 2017; Karakuş & Şeyihoğlu, 2022; Uçak, 2019; Uçak & Usta, 2022). In other words, activities embedded with QR codes make students more interested and curious. However, some researchers reported negative impacts of QR codes. For example, Ceylan-Çapar (2021) conducted a study on the evaluation of preservice teachers through video feedback. She found that students preferred to present their feedback in writing instead of video feedback. However, students expressed opinions on video feedback rather than QR codes.



The studies on games reported positive results regarding QR codes (Akabay et al., 2022; Atwood-Blaine & Huffman, 2017; Fernández-Gavira, 2021; Nunes et al., 2021; Savitri et al., 2021; Uçak, 2019; Uçak & Usta, 2022, Uçak & Usta, 2023; Yılmaz & Canbazoğlu Bilici, 2017; Yılmaz, 2019;). Most studies integrating information to QR codes reported positive results regarding QR codes (Abdul-Rabu et al., 2019; Çetin & Akkoyunlu, 2019; Kuru-Gönen & Zeybek, 2022; Mogali et al., 2019; Traser et al., 2015; Thorne, 2016; Zender & Klein, 2018). However, Chapple et al. (2017) documented that students' perspectives on the use of QR codes can be complex due to technical issues encountered during scanning, inadequate internet infrastructure, and a hesitancy or shyness toward adopting new technology. Some researchers embedded QR codes in textbooks, which received positive feedback from students (AlNajdi, 2022; Alharbi & AlSawy, 2022; Çiğdem, 2022; Grande & Pontrello, 2016; Kılıç, 2022; Misnawati, 2023; Nadziro et al., 2023). On the other hand, Güleç (2019) reported that QR codes had no impact on students' academic performance and attitudes toward math. However, she found that QR codes encouraged students to learn by themselves.

Some researchers investigated the impact of QR codes on students. Balintag & Wilang (2020) focused on Thai English as a Foreign Language (EFL) students. They revealed that instruction enriched with QR codes had a positive impact, reducing students' anxiety levels and enhancing their writing performance. Çoruhlu & Pehlevan (2021) found that worksheets enriched with various concepts/topics (simple electrical circuits, mixtures, separation methods, fossils, and recycling) had positive effects on students' conceptual understanding. Therefore, they stated that mobile applications (QR codes) and tablets offered students the opportunity to watch the experiments again. Ali et al. (2017) stated that QR codes are simple and helpful applications for learning activities. They noted that QR codes are fun, interesting, impressive, intriguing, enjoyable and a new way for learning. Mogali et al. (2019) showed that the QR code system is a simple and economically viable application that can be used as an effective learning tool in medical museums. Students were positively influenced by using

QR codes, which was associated with easy access to materials and independence of time and space. Traser et al. (2015) examined students' perceptions on the usability of QR codes as learning aids in anatomy courses. Most students responded positively to QR codes and found them more useful than traditional learning aids. QR codes provided them with immediate feedback, allowing them to self-assess their knowledge and get more in touch with the course content. However, the use of QR codes and the frequency with which QR codes were scanned did not significantly contribute to practical exam performance. Overall, it has been suggested that QR codes can be used as an effective learning tool in a variety of academic settings to support student learning. Nunes et al. (2021) presented an educational activity called BarcodingGO with QR codes to teach advanced molecular biology techniques such as e-DNA to undergraduate and graduate students. They believed that this approach was suitable for solving different problems under different situations. They also thought that this approach would greatly increase student engagement in molecular biology courses.

Some researchers addressed what teachers thought about using QR codes in education. Alzubi (2019) sought the views of teachers (n=41) on QR codes. The findings highlighted several factors hindering the widespread use of QR codes, including the need for registration with a valid email address, mandatory payment after a two-week trial period, insufficient ICT literacy, and restrictions on mobile phone use in certain institutions. The participants in the study also expressed that smartphones offer access to technology, boost students' motivation, facilitate creativity, provide opportunities for English language learning, and allow for diverse teaching approaches without time and place constraints, especially in the context of English language teaching. Uçak & Usta (2023) stated that all teachers wanted to use QR codes in their lessons. Researchers have discovered that incorporating QR code games into science lessons not only makes the lessons enjoyable and fun but also promotes lasting learning. This approach successfully integrates technology into the lesson, stimulates curiosity, and enhances motivation to learn.



While many studies indicate positive outcomes, there are also studies highlighting the drawbacks of QR codes. In Arıkan & Özen's study (2015), teachers mentioned that real objects in the classroom were more effective than the use of technology. Difficulties in scanning QR codes, tablet malfunctions (Arıkan & Özen, 2015), internet infrastructure problems, difficulties in preparing QR codes for timed programs, and challenges in creating QR codes (Uçak, 2019) have been identified as negative aspects. However, there are studies suggesting that QR codes are effective pedagogically (Abdul-Rabu et al., 2019; Akbay et al., 2022; Mogali, 2019; Moralı, 2019; Nadziro et al., 2023; Normawati et al., 2022; Traser, 2015; Uçak & Usta, 2023; Usta & Güntepe, 2019; Yılmaz & Canbazoğlu Bilici, 2017) and can enhance students' problem-solving skills and scientific literacy (Savitri et al., 2021). They are also found to be enjoyable and attention-grabbing for students (Tan & Chee, 2021) and can be effective in learning difficult topics (Chung et al., 2019). Studies have concluded that QR codes are effective in games and books (Alnajdi, 2022; Alharbi & Al Sawy, 2022; Blaine & Huffman, 2017; Nadziro et al., 2023; Savitri et al., 2021) and have an impact on student success and make education more effective when used in laboratories and extracurricular learning environments (Başal, 2019; Chapple et al., 2017; Kösal, 2019; Normawati et al., 2022; Patil et al., 2023).

Upon reviewing the studies, it has been noted that QR code-supported learning environments lead to meaningful learning experiences, make learning environments more efficient, positively affect the retention of learning, and support learning (Uçak & Usta, 2022). Ahmed & Zanelidin (2020) stated in their study that mobile devices can replace traditional methods and affect students' academic engagement. Similarly, in another study, Bakla (2018) mentioned that QR codes could be effective in adding innovation to standard classroom practices. Arifoğlu & Çay (2023) stated that QR code technology serves as a bridge between traditional education and the interactive use of mobile devices.

Upon examination of the studies included in the systematic review, it is observed that QR codes are mostly used for videos (14), activities (12), and games (11). It is believed

that making learning environments interesting and fun can make students' learning experiences more effective. Ahmed & Zanelidin (2020) reported positive views from teachers regarding the use of technology in the classroom and stated that using videos as supportive tools would be effective in the learning process. Akin (2014) mentioned that accessing information with QR codes would be fast and easy. Balintag & Wilang (2020) stated in their study that QR codes provide independent learning for students, support collaborative learning, and make learning environments more comfortable. Celik (2023b) concluded in their study that QR codes expand students' English vocabulary. Karahan & Canbazoğlu Bilici (2017) mentioned that QR code activities increase interest and motivation in the lesson, promote active participation, and create a student-centered learning environment. Karakuş & Şeyihoğlu (2022) stated in their study that social studies lessons supported by QR codes contribute to students' understanding of concepts. Uçak & Usta (2023) indicated that QR code games make science lessons enjoyable and fun for students, support long-term learning, and increase motivation for the lesson. Teachers expressed their desire to use QR codes in their lessons.

### Recommendations

- 1) It has been observed that studies focusing on the pedagogical use of QR codes are mostly conducted in the fields of Science and English. Studies can be conducted in other areas as well.
- 2) It is seen that they mostly involve undergraduate and middle school students. Studies can be conducted with other groups besides undergraduate and middle school students.
- 3) Studies on the pedagogical use of QR codes mostly utilize quantitative research methods. Studies can be diversified with other research methods.
- 4) When examining the studies, it is evident that studies with videos in QR codes are predominant. QR codes can be used in various other activities such as homework, classroom boards, laboratories, out of school learning environments, virtual classrooms,

student projects, STEM studies, and science books.

- 5) The studies were analyzed with the identified sub-problems. The other studies can be conducted with different sub-problems.

### Limitations

- 1) The study is limited to the studies between 2014 and 2023.
- 2) Only studies published in English and Turkish are included in the study.
- 3) Study is limited to the freely accessible articles due to the inability to access paid articles.
- 4) The study is limited to the sub-problems identified.
- 5) The study is limited to the databases determined for data collection.

### Conflict of Interest

There is no conflict of interest among the authors.

### Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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Appendix 1

Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist (<https://www.prisma-statement.org/scoping>)

Section and Topic	Item #	Checklist item	Location where item is reported
<b>TITLE</b>			
Title	1	Identify the report as a systematic review.	X
<b>ABSTRACT</b>			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	X
<b>INTRODUCTION</b>			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	X
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	X
<b>METHODS</b>			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	X
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	X
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	X
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	X
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	X
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	X
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	X
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	X
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	X
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	X
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	X
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	

Section and Topic	Item #	Checklist item	Location where item is reported
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	X
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
<b>RESULTS</b>			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	X
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	X
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	X
<b>DISCUSSION</b>			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	X
	23b	Discuss any limitations of the evidence included in the review.	X
	23c	Discuss any limitations of the review processes used.	X
	23d	Discuss implications of the results for practice, policy, and future research.	X
<b>OTHER INFORMATION</b>			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	X
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	X
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	X
Competing interests	26	Declare any competing interests of review authors.	X
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	X