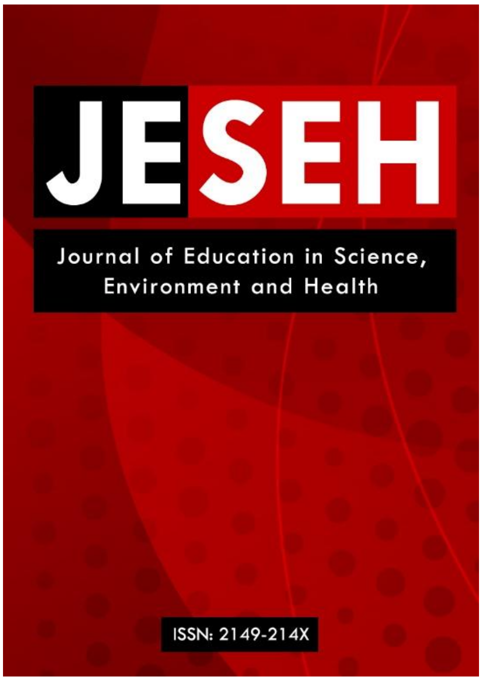

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Abstract

Today, knowledge and technology are produced rapidly. In this case, the aim of educators is to develop appropriate environments instead of presenting information directly to students and to develop students' ability to access and use information by blending it with other information. This situation reveals the importance of concept education in education with technological tools. In this study, it is aimed to understand what and how technological tools have been used to identify or eliminate misconceptions in physics education in the last 10 years. For this reason, 83 studies, including 22 theses and 63 articles, were analyzed in this field between 2010 and 2020. The studies were examined according to the themes of publication year, publication type, purpose, method/pattern, sample, data collection tools, technological tool method/technique used, data analysis method, and the subject studied. As a result of the examinations; it was seen that the studies in this field increased as the year 2020 approached, that they were aimed at eliminating rather than detecting, that the majority of the studies consisted of articles, that they focused on the abstract concepts of physics, which are difficult, that animations and simulations were mostly used, and that quantitative research methods were preferred.

Introduction

In today's world where knowledge is produced rapidly, the goal of educators is to improve students' ability to access information and use it by blending it with other information by preparing appropriate environments to enable students to access information with their own efforts instead of directly giving it to them. For this reason, students should be actively involved in the teaching process. The most specific example where this is observed is in science courses, which include subjects such as earth science, physics, astronomy, chemistry, and biology. Science can be expressed as the effort to examine the events that occur in nature and to make inferences about the events that have not yet been observed with the data obtained or, in short, as people's efforts to understand nature (Fisher, 1985; Gurdal et al., 2001, Erden & Akman, 2011).

All individuals create their own concepts and knowledge through their own lives. In addition, knowledge is constantly increasing with technological and scientific developments, and as a result, the meanings attributed to concepts change and develop over time (Kiray et al., 2015). This situation ensures that conceptual learning still has a very important place in science education and increases the importance of research in this field day by day (Joung, 2009). In order to determine the conceptual knowledge of individuals, researchers have developed various diagnostic and detection tools. Research has revealed that there are various factors affecting students' conceptual knowledge (Clement et al., 1989; Kiray et al., 2015).

Chemistry and physics in science is a subject that many students have difficulty with because it contains abstract concepts. When the researches in the field of science education are examined, it is seen that the topics of concept, misconceptions and conceptual changes gain weight. When we look at the reasons for students' failure in science courses, it can be said that it is due to the fact that the subjects contain complex and abstract concepts. Because the subjects and abstract concepts require more thinking and comprehension activities. (Ayas & Costu, 2001).

Problem Status

In order to ensure that students first make sense of the concepts, as well as the permanence of the concepts, if there is a contradiction between the new concepts learned and the concepts they had before, these situations should be eliminated and meaningful relationships should be established between the previous and new concepts (Unsal, 2019).

When recent researches conducted in science education examined, it is seen that it is aimed to realize meaningful learning in students and to determine learning difficulties in students. For this reason, it is of great importance to identify and eliminate misconceptions in all educational disciplines in order to realize meaningful learning (Committee on Undergraduate Science Education, 1997).

In addition, considering that especially primary school students have difficulty in learning abstract concepts, educational technology tools and especially computers play a very important role in concretizing these concepts in a way that is appropriate to the level of the student and presenting them almost vividly, learning them in depth and observing the events repeatedly. Research on the application of various dimensions of educational technology in teaching shows that educational technology applications have a positive effect on student achievement in many ways. In this regard, it has been determined that various teaching materials (game, analogy, case study, experiment, model) (Aktamis et al., 2002), model-based teaching (Sahin et al., 2001), computer-aided materials (Kibos, 2002) increase students' achievement. Since technology has become an integral part of our lives today, it has become one of the necessities of education. The importance of technology for education has once again emerged in cases such as pandemics, earthquakes, floods, terrorist attacks that affect the whole world, such as Covid 19 (Kayacan & Ulker, 2020).

When such advantages of educational technologies are considered, it is obvious that their use in the detection and elimination of misconceptions will make great contributions to education. For this reason, this study aims to understand the technological tools that have been used in the literature in the field of physics education in the last 10 years to eliminate misconceptions and how they have been used. In this context, answers to the following questions are sought:

- Which technological tools were used to eliminate misconceptions in the field of physics education in literature between 2010 and 2020?
- What is the distribution of the intended use of these technological tools?
- How was the use of technological tools distributed according to physics subjects?

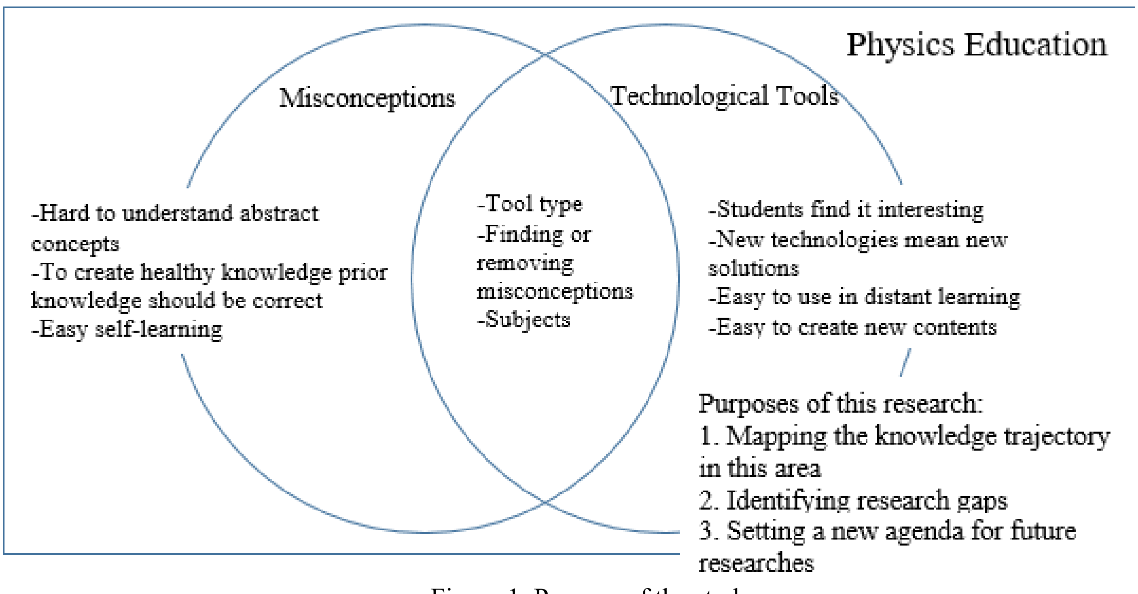

Figure 1. Purpose of the study

Method

Research Design

In this study, a systematic review will be conducted from qualitative research methods. A systematic review is a comprehensive review of all studies published in that field, using various inclusion and exclusion criteria and evaluating the quality of the studies, determining which studies will be included in the review, and synthesizing the findings of the studies included in the review in order to create an answer to a clinical question or a solution to a problem (Burns & Grove, 2007; Centre for Reviews and Dissemination [CRD], 2008; Higgins & Green, 2011; cited in Karacam, 2013).

Systematic reviews can examine quantitative and qualitative evidence, or they can examine two or more types of evidence in a so-called "mixed method systematic review" (Hemingway & Brereton, 2009). Systematic reviews contain more scientific information and are important because they produce stronger evidence. The reasons why systematic reviews contain more scientific information and are accepted can be listed as follows (Moule & Goodman, 2009; Hemingway & Brereton, 2009);

- They are more objective, with fewer biases and errors,
- A literature review is much more comprehensive and reproducible as it is done with a specific methodology,
- The methods used for the literature review are clearly stated in the study,
- The criteria used to select the studies are clearly stated,
- The quality of the studies included in the review is assessed,
- When combining data from studies, even the smallest evidence/effects are included in the review,
- Researchers can repeat the systematic review and confirm their results.
- The number and duties of the researchers who will work in the systematic review research project are determined.

Data Collection

A systematic search was carried out in 10 databases in order to reach the studies in which technological tools used in misconception studies in the field of physics education in the literature. These databases are Google Scholar, ERIC, Ulakbim, Proquest, Scopus (elsevier), Wiley, Web of Science, JSTOR, YOK Thesis Center. Articles and theses published in refereed journals were included in the studies. Due to the recent introduction of technological tools, the search was limited to English and Turkish studies published between 2010 and 2020 to obtain studies on misconceptions in physics education.

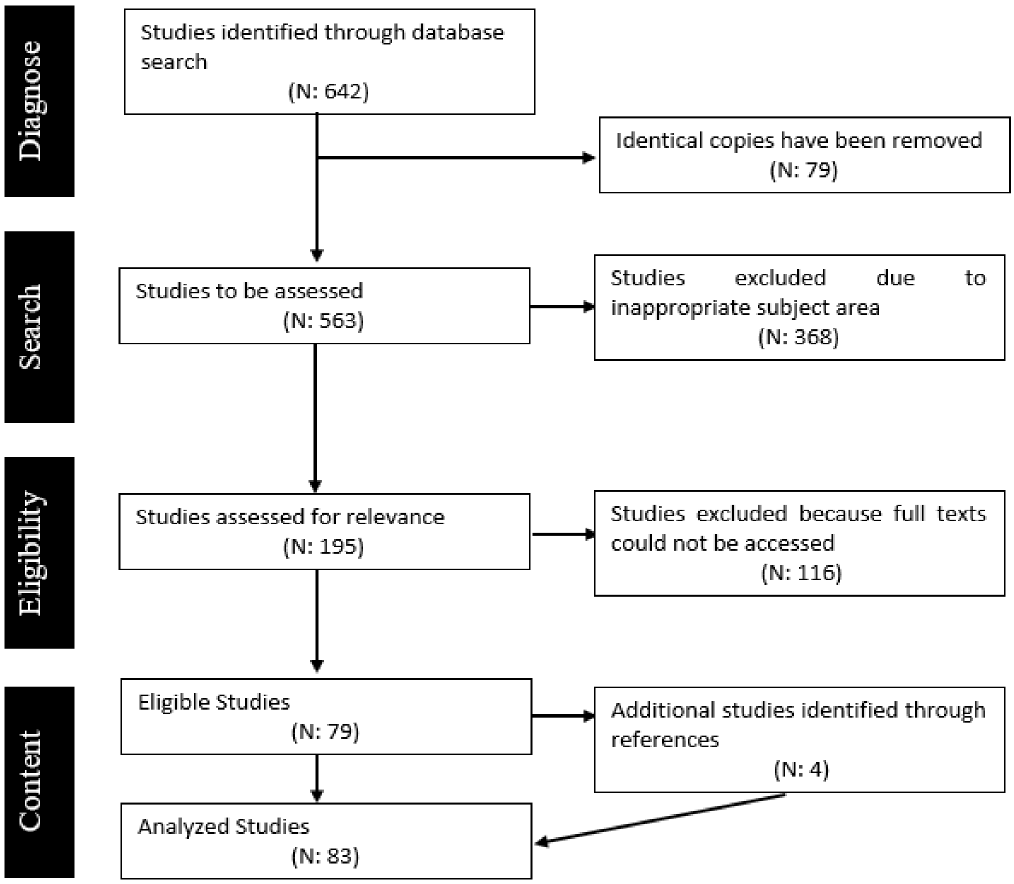

Figure 2. Path diagram (PRISMA model)

The research was conducted by two people. All stages were carried out by these researchers. A multi-stage process was followed in which each study was read and the information retrieved was identified. The literature review followed an iterative process. The reference list of each article found was used as the source of new references. The words physics education, physics education, misconceptions, technological tools, technology, science education were used in the literature review. The total records accessed and the process of eliminating the records are shown below. To create a systematic review research PRISMA diagram is used. PRISMA stands for Preferred Reporting Items for Systematic Reviews and Meta-Analyses. It is an evidence-based minimum set of items for reporting in systematic reviews and meta-analyses. The flow diagram in figure 2 depicts the flow of information through the different phases of a systematic review. It maps out the number of records identified, included and excluded, and the reasons for exclusions (Karacam, 2013).

Validity Reliability

In order to ensure the validity and reliability of the study, two field experts were consulted about the content and themes throughout the process. The experts were asked to code 10 different studies included in the study and the percentage of agreement between the expert's codes and the codes prepared by the author of this study was checked. Sandelowski (1998) states that reliability in studies can also be ensured in this way. Based on this, in order to ensure the reliability of the study, an expert who has both a good command of the qualitative field and conducts science education studies was selected and a part of the data representing the whole data was sent and an opinion was obtained. This percentage of agreement was calculated with the reliability formula suggested by Miles and Huberman (1994) and was calculated as 96%. This result shows that coder reliability is at a sufficient level. In order to ensure the validity of the study, the researcher took care to explain each step of the systematic review process in detail.

The literature review process continued from November 2020 to December 2020. The transfer of the studies reached in the review to the relevant parameters was carried out in January 2021. Therefore, studies published after January 2021 were excluded. Expert opinion was sought in January on the suitability of the relevant studies for the context of the current study, and the findings section of the study was started to be written in January 2021. The studies reached as a result of the review were recorded as full text. Each of these studies was coded in Excel under a certain parameter. These parameters were determined as publication year, publication type, purpose, method/pattern, sample, technological tool used, subject area examined, conclusion and recommendation. These parameters have been used many times in the related literature (Bag & Calik, 2017, 2018; Gul & Sozbilir, 2015; Yildirim et al., 2016).

Data Analysis

Content analysis was used for the analysis. The main purpose of content analysis is to reach concepts and relationships that will help explain the collected data. Data summarized and interpreted through descriptive analysis are subjected to in-depth processing through content analysis and new concepts are discovered. The basic process in content analysis is to bring together similar data within the framework of certain concepts and themes and to organize and interpret them in a way that the reader can understand (Yildirim & Simsek, 2013; Moula & Gooman, 2009). Content analysis is a scientific method that draws attention to objectivity between subjects and allows elements such as validity, reliability, reproducibility, generalizability and testing of hypotheses (Patton, 2014). Frequency tables were created according to the determined criteria. The themes that form a relationship between the data were determined. The studies obtained were analyzed in depth in terms of the classification of technological tools used in diagnosing and eliminating misconceptions.

Results and Discussion

The studies examined within the scope of this study were coded according to the parameters determined and themes were reached. The findings of the themes are explained respectively. Firstly, the publication year and type of the studies are presented in Table 1. According to the coding result in Table 1, while there was no research on concept education using technological tools in science education in 2010, there were 4 in 2011, 5 in 2014, 2016 and 2017, 7 in 2015, 6 in 2012, 8 in 2013, 13 in 2018, 14 in 2019 and 16 in 2020. In addition, 28 studies conducted to determine misconceptions using technological tools and 55 studies conducted to eliminate misconceptions using technological tools were reached. While 22 of these researches are master's and doctoral theses, 61 of them are articles.

Table 1. Codes and frequencies related to year, type and purpose of publication

Detection of misconceptions using technological tools			Elimination of misconceptions using technological tools		
Year of Publication	Research Type	f	Year of Publication	Research Type	f
2010	Article	0	2010	Article	0
	Thesis	0		Thesis	0
2011	Article	2	2011	Article	2
	Thesis	0		Thesis	0
2012	Article	1	2012	Article	4
	Thesis	0		Thesis	1
2013	Article	2	2013	Article	2
	Thesis	1		Thesis	3
2014	Article	0	2014	Article	2
	Thesis	1		Thesis	2
2015	Article	1	2015	Article	3
	Thesis	1		Thesis	2
2016	Article	0	2016	Article	4
	Thesis	1		Thesis	0
2017	Article	2	2017	Article	2
	Thesis	0		Thesis	1
2018	Article	3	2018	Article	7
	Thesis	1		Thesis	2
2019	Article	4	2019	Article	6
	Thesis	1		Thesis	3
2020	Article	6	2020	Article	8
	Thesis	1		Thesis	1
	Total	28		Total	55

The purpose of the studies examined in this study and the codes and frequency distributions created for the subject themes obtained from the studies examined are presented in Table 2.

Table 2. Codes and frequencies related to subject and study purpose

Study Objective	Detection of misconceptions using technological tools	Elimination of misconceptions using technological tools
Codes	f	f
Dynamic	4	7
Optics	1	5
Electricity and Magnetism	4	4
Pressure and Buoyancy	2	4
Fluid Mechanics	2	6
Heat, Temperature and Expansion	6	7
Work, power, energy	1	5
Wave Mechanics	1	2
Matter and Properties	2	3
Motion and Force	3	5
Electrostatic	2	5
Modern Physics	0	2
Total	28	55

According to Table 2, 12 thematic subject areas were identified. It is seen that a total of 11 of the studies conducted to determine misconceptions by using technological tools and to eliminate misconceptions by using technological tools are in dynamics, 6 in optics, 8 in electricity and magnetism, 6 in pressure and buoyancy, 8 in fluid mechanics, 13 in heat and temperature, 6 in energy, 3 in wave mechanics, 5 in matter and its properties, 8 in motion and force, 7 in electrostatics and 2 in modern physics.

The codes and frequencies related to the purpose of the study and the technological tools and equipment used in the related studies are presented in Table 3.

Table 3. Codes and frequencies related to the tools used and the purpose of the study

Study objective	Detection of misconceptions using technological tools	Elimination of misconceptions using technological tools
Codes	f	f
Games / Mobile games	0	2
Web 2.0 learning technologies (e.g. social media, Social Networking systems, Wiki or Blogs)	3	5
Mobile learning (e.g. tablets, iPads, computers, interactive tools/technologies or mobile device)	7	3
Virtual world / virtual reality	0	3
Digital instructions or educational visual aids	0	4
Management systems (e.g. classroom management systems, learning management systems or self-organized learning systems)	6	0
Animations and simulations (e.g. educational animation or computer animation)	0	12
Discussion / Online discussion platforms (e.g. online interaction platform, online collaboration network or collaborative simulation)	4	2
Online learning course delivery, e-learning	0	1
Blended learning (e.g. using technology with face-to-face learning)	3	6
Technology-enhanced feedback system, online feedback system or audio feedback system	5	1
Student response system	0	1
Programming	0	3
Augmented reality (AR) technology	0	2
Robotics	0	9
Online book, e-book or digital storytelling	0	1
Total	28	55

According to the coding in Table 3, 16 technological tools used in the analyzed studies were identified. In the studies conducted to determine misconceptions by using technological tools and to eliminate misconceptions by using technological tools, computer games or mobile games were used in 2 studies, web 2.0 tools in 2, computer games or mobile games in 8, web 2. 0 tools in 10, mobile learning in 10, virtual reality in 3, various digital visuals and instructions in 4, special management systems in 6, animations and simulations in 12, discussion on online platforms in 6, e-learning in 1, blended learning as distance and face-to-face in 9, feedback systems in 6, institution-specific student response system in 1, programming in 3, augmented reality in 2, robotic coding in 9, e-book in 1. In the studies conducted to determine misconceptions using technological tools, it was determined that tools such as games, virtual reality, digital visuals, simulations, e-learning, student response system, programming, augmented reality, robotics and e-books were not used. In the field of eliminating misconceptions by using technological tools, it was seen that only management systems were not used.

The codes and frequencies related to the method and design, sampling, and data analysis methods preferred in the related studies are presented in Table 4. When the methods and designs of the studies are analyzed in Table 4, it is seen that quantitative methods were mostly used. In these studies, quasi-experimental designs with pretest-posttest control groups were generally preferred (f = 29). This design was followed by survey studies (f=22). It is seen that the rate of preference for qualitative research designs is low (f = 6). However, it was stated that both quantitative and qualitative research methods were used together in 2 of the studies. The method and design of 4 studies were not specified.

Table 4. Codes and frequencies of the studies regarding method/pattern, sample level, data analysis method

Themes	Categories	Codes(f)		f
Method/Pattern	Quantitative	Experimental	Weak experimental design (2), quasi-experimental design (29), full experimental design (16)	51
		Survey		22
	Qualitative	Case study		5
		Pattern not specified		1
	Mixed Pattern	Quantitative-experimental		2
	Unspecified			4
	Total			83
Sample	Secondary School Students			27
	High school students			18
	Teacher candidate			35
	Unspecified			3
	Total			83
Data Analysis Method	Qualitative		Descriptive analysis	18
			Content analysis	10
	Quantitative		Descriptive statistical analysis	14
			t-test	16
			ANOVA	13
			ANCOVA	12
			MANCOVA	3
			Mann Whitney *U* test	10
			Tukey Test	7
			Kruskal Wallis test	1
			Wilcoxon signed-rank test	4
	Unspecified			3
	Total			101*

*The high frequency values are due to the fact that more than one data analysis method was selected in the same study.

When the samples of the studies in Table 4 are examined, it is seen that the majority of them (f = 35) were conducted with prospective teachers at the university level. This was followed by secondary school students in 27 studies and high school students in 18 studies. In 3 studies, no information was given about the sample. It is seen that the number of quantitative data analysis methods is also high (f = 83) due to the high use of quantitative methods in the studies. In most of the studies, changes before and after the application were examined in experimental studies. Therefore, this situation led to the excessive use of t-test, ANOVA, ANCOVA (f = 41). Although the data analysis method was not explained in 3 of the studies, it was seen that advanced statistical analyzes were not performed. Regarding qualitative analysis methods, it was observed that descriptive analysis (f = 18) was preferred more than content analysis (f = 10).

Conclusion

As a result of this study, the number of studies, study types, study topics, technological tools and study methods were determined under the misconceptions group according to years.

When evaluated in terms of study type and study year, it was seen that the studies in which technological tools were used both in the detection and elimination of misconceptions increased after 2018. The reason for this is that the technological tools used in education develop and increase in variety as time progresses (Corwther & Price, 2014). Thus, the tool for the need can be found easily and can be used in the desired way by making it appropriate. In addition, technological tools were used more in the elimination of misconceptions (f =55) rather than the detection of misconceptions (f=28). Since the elimination of misconceptions is usually a process (Ulgen, 2001), the convenience of using technological tools during the process may cause such a tendency (Kaya, 2010).

When the distribution of the subjects in the studies is examined, it is seen that the studies detecting misconceptions are concentrated around the subjects of Dynamics (f=4), Heat and Temperature (f=6), Electricity and Magnetism (f=4). Misconception detection studies were centered around the topics of Dynamics (f=7), Fluid Mechanics (f=6), Heat and Temperature (f=7). The fact that the subjects are difficult and contain many abstract concepts makes researchers think that students' misconceptions are much higher in these subjects. In particular, the commonality of Dynamics, Heat and Temperature subjects in the studies on the identification and elimination of misconceptions indicates that students may have the most difficulties in these subjects in their curriculum (Cirkinoglu, 2004; Sabancilar, 2006; Gurbuz, 2008).

In terms of the tools and equipment used, it is noteworthy that Mobile Learning (f=7), Management Systems (f=6) and Technology Enriched Feedback (f=5) Systems were used to identify misconceptions. Since the detection of misconceptions is carried out by using measurement tools, it is noticeable that technological systems that can develop measurement tools are used in these studies. In addition, it was observed that certain technological tools were periodically focused on for misconception detection. However, due to the increase in the studies after 2018, it was determined that the frequency of use of new technological tools was higher than the old technologies. Accordingly, Blended Learning (f=6), Animations and Simulations (f=12) and Robotics (f=9) tools were frequently preferred. The high frequency of these tools instead of newer technological tools such as Augmented and Virtual Reality may be due to the fact that these tools are not yet widely used (Kavanagh et al, 2017). Especially the use of Robotics tools may be due to the widespread use of STEM education between 2014-2019 (Freemen et al. 2019; Mpofu, 2020; Wells, 2019; Tyler, 2020; Li et al., 2020; Yildirim & Gelmez-Burakgazi, 2020; Jamali, 2023).

When the studies are examined in terms of method, sampling and analysis methods, it is seen that quantitative methods are adopted. In general, Experimental (f=55) and Survey (f=22) designs were preferred. When the studies were examined in detail, it was seen that misconception detection studies preferred the Survey design, while experimental studies were preferred in misconception elimination studies. This result is compatible with the nature of the studies (Senemoglu, 2005). In terms of sample, it was determined that pre-service teachers (f=35) and secondary school students (f=27) were preferred the most. When the results obtained from the misconception subject areas and the researcher groups are considered together, the reason for the preference of these samples comes to the forefront as an easily accessible sample (Wessel, 1998; Tekkaya et al., 2000; Kose, 2004; Arslan et al., 2012). Teachers conducting misconception studies in secondary school preferred to conduct research with their own students, and academicians conducting misconception studies at the university preferred to conduct research with their own students. In terms of data analysis, it was determined that there was a homogeneous distribution of quantitative and qualitative methods and designs. Since misconceptions can be identified in a variety of ways, analysis methods appropriate to the nature of the study were adopted (Unsal, 2019). It was observed that parametric and non-parametric tests were used in quantitative analysis methods. The reason for the use of non-parametric tests is mostly due to the fact that experimental studies (f =55) were preferred as a method and small groups were studied (Onen, 2005).

Recommendations

According to these results, it is recommended to carry out identification and elimination studies especially on Modern Physics as a subject area with very few studies. It is recommended to use online learning, e-book or digital storytelling, augmented and virtual reality as the tools used. The small number of these studies shows that meaningful contributions can be made to the field. Newer technological tools can also be preferred. While conducting these studies, methods appropriate to the nature of the study should be selected. Because when the methods of the studies were examined, a homogeneous distribution was observed. In addition, it is recommended to conduct a meta-analysis study in which the reasons for the choice of the subject area and technological tools will be examined in a deeper way.

Scientific Ethics Declaration

* The authors declare that the scientific, ethical, and legal responsibility of this article published in JESEH journal belongs to the authors.

* This research did not require IRB approval because this paper is a systematic review study and content analysis is use as data analysis on articles and thesis's. Also this study was prepared in accordance with scientific ethics rules. At any time, in the event that a situation contrary to this statement regarding the study is detected, we accept and declare that we agree for all ethic and legal consequences that may arise.

Conflict of Interest

* The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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