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National and International Advances in Physics Education in the Last Three Years: A Thematic Review

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ABSTRACT

For research areas to advance, researchers are required to carry out studies that are in line with the inadequacies in the field and to have a grasp of the studies in the field. One of the most important means of identifying inadequacies in a field is to review studies between certain years. In this sense, it is important to analyze the publications of significant journals in physics education. The purpose of this study is to conduct a thematic review of the literature related to physics education studies in certain journals published within the scope of Social Sciences Citation İndex in 2013-2015. The articles obtained from the literature were analyzed using a generated matrix. The matrix consists of general specifications (type of journal, years and demographic properties) and content sections (aims, research methods, variables, samples, physics subjects and results). According to the findings, in terms of physics concepts, the studies were conducted mostly on the concept of energy and included mostly undergraduate student participants. Regarding the results, it is suggested, both in physics and science education studies, that materials that are to be used with approaches, such as context-based learning, inquiry-based leaning, and argumentation-based learning, need to be enhanced and that additional studies that investigate the effects of these approaches on learning environments are needed.

Keywords: Journal; physic education; thematic review; three years.

INTRODUCTION

The development of any field depends on the area of research, educational applications and the theoretical and practical innovations brought to the field. In this case, the development is subjected to the comprehension of the present status in the relevant field, and starting from this, to the identification of the innovations brought to the field. In other words, in order to ensure that the field will be updated continuously, it is important to realize the drawbacks and the defects in the present situation or the gaps in the field and to promote alternatives to solve these deficiencies. Researchers also need to be in line with evolving databases to stay up to date by following scientific works such as theses, articles, and books published via various editorial boards (Gilbert and Trudel 2004). In these scientific works, it is shown that numerous researchers mutually structure the issues related to historical research for the

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development of the relevant area and their implications and the latest approaches brought in the field and their implementation in practice (Lin, Lin and Tsai 2014). In this structuring process, researchers publish their findings in academic journals or books and provide a communication network between scientists by sharing information with other scientists (Cohen and Manion 1990; McDermott and Redish 1999; Tsai and Lydia Wen 2005). To ensure communication among scientists and to put forth the present status, an outline of the data gathered from different research investigations is required at regular intervals (Gilbert and Trudel 2004; Hofmann 2001; Karamustafaoglu 2009). This may evolve in two ways. The first is an evaluation of the results obtained from a study by other researchers, and the second is a review of previously published studies of a specific field under distinct categories, including certain periods of time (Bacanak, Degirmenci, Karamustafaoglu and Karamustafaoglu 2011; Byra and Goc Karp 2000; Cohen, Manion and Morrison 2007; Silverman and Skonie 1997). In particular, to ensure a clear visibility of the final status in the relevant field, it is important to systematically analyze the publications in academic journals at certain intervals and to present them periodically to notify researchers. Within this framework, it can be stated that a systematic analysis of the published articles in physics education is also important.

Silverman and Ennis (1996) divided physics education into three subfields, namely, physics teaching, teacher training and physics curriculum. The study of curricula/programs in physics investigates the sub-topics and factors that affect physics education; studies concerning teacher training investigate the training of prospective physics teachers and the improvement of this training; studies concerning physics teaching, on the other hand, investigate the improvement of teaching methods, techniques and strategies and how these are applied in practice to improve the quality of physics education (Anderson and Barnett 2013; Chatoupis and Vagenas 2011; Chen, Chang, Lai and Tsai 2014; Dega, Kriek and Mogese 2013; Guisasola, Almudi and Zuza 2013; Kulo and Bodzin 2013; Lemmer 2013; Leuchter, Saalbach and Hardy 2014; Liu, Ryoo, Linn, Sato and Svihla 2015; Martinez, Perez, Suero and Pardo 2013; Uzunboylu and Asiksoy 2014). Physics education teacher training focuses on the processes (teachers' class structure, student and teacher operations during the lesson, etc.), the social dynamics (learning environment and teacher-student or student-learner interactions) and learning outcomes (motor skills, attitudes, knowledge, etc.) (Silverman and Ennis 1996; Silverman and Skonie 1997). As for the physics education teaching, studies seem to primarily focus on the teaching methods and cognitive levels (Kayhan and Koca 2004; Uzunboylu and Asiksoy 2014).

In a literature review, Byra and Goc Karp (2000) analyzed the qualitative research methods used in physics education studies. Silverman and Skonie (1997), on the other hand, analyzed published studies focusing on the physics education teaching in terms of the various variables. In another study, Silverman (1987) investigated the research methods and trends in research topics of doctoral dissertations published in physics education in 1975-1984. As a result of this research, he stated that half of the published dissertations compare teaching methods, some researchers lacked systematic observations in spite of their focal points on comparing teaching methods, and most of these researches did not take place in an informal school context. However, since 1984, there has not been a literature review of the studies directly focusing on physics education (Silverman and Manson 2003). Instead, literature reviews have concentrated on the investigation of physics education in distinct sub-fields rather than the general analysis of physics education studies. There has not been a recent general literature study on physics teaching. The study will review the literature in six journals with a high influence in physics/science education and that are within the scope of SSCI in 2013-2015. In this respect, the purpose of this literature review is to evaluate the physics education studies in the following journals: Journal of Research in Science Teaching, Science Education, Studies in Science Education, International Journal of Science Education, Journal of Science Education and Technology.

Review Focus Questions

The focus questions for our review of the literature are as follows:

1. What are the general features of the studies and authors?
2. What are the aims of the studies in physics education?
3. What research methods, variables, samples and concepts are used by the studies in physics education?
4. What results are found by the studies in physics education?

METHODS

A thematic review of physics education studies carried out in the last three years is available in this study. A literature review is an analysis of systematically gathered visual and audio works of a particular topic, such as writings, documents, maps, pictures, photos, etc. (Author 2014). A meta-analysis, on the other hand, is a method used to reach a synthesis considering the results of these studies by taking into account the studies of a particular purpose or a subject (Buyukozturk, Kilic Cakmak, Akgun, Karadeniz and Demirel 2012). A thematic review is was selected for this study because thematic reviews provide, by using a thematic matrix, the identification of each study, the set of general trends and the display of the characteristics of each study clearly by indicating the differences and the similarities (Calik, Ayas and Ebenezer, 2005; Kurnaz and Calik 2009). This study is focused on the analysis of each article individually and the identification of the trends in the field. For this purpose, the matrix developed by Authors (2015) is used to analyze physics education studies. The final version of the matrix is used after some additions and extractions. The matrix used in this study includes two fundamental themes: general features and content features. General features include journal name, years of the studies and demographic properties (number of authors and author nationality). Content features include aims, research methods, variables, samples, physics subjects and results.

Within the scope of this study, six journals with a high influence in physics education were selected. These journals, which are included in social sciences citation index (SSCI), are as follows: Journal of Research in Science Teaching, Science Education, Studies in Science Education, International Journal of Science Education and Journal of Science Education and Technology. However, in the last three years, there have not been any physics education Studies in Science Education. For these selected journals, first, the relevant physics education studies were downloaded. There were 279 articles published between 2013 and 2015. Because of the challenge of analyzing the articles and because an in-depth analysis was not possible, the year range was restricted, and studies in 2013-2015 were selected for the review. As a result of the literature searchs, 132 articles were found in these journals over the last three years. However, during the analysis, some articles were found to be irrelevant, and in total, 70 articles were analyzed. During the article review, it was noted whether physics or physics terms were present in the article titles or in the key words. Despite all the literature searchs, it is natural that some of physics education studies went unnoticed. This situation, which arose while literature searching the studies, is among the limitations of the study. The physics education articles found in the literature searchs are marked as (*) in the bibliography section. These studies were generally used in the discussion section; however, studies that were not used were marked as (**) in the bibliography. The 70 articles that were found were analyzed using the revised matrix. The data that was obtained was analyzed using descriptive statistical methods (frequency and percentage) and a content analysis method. A descriptive analysis is generally used in the general features section of the matrix, and a content analysis is used in the content features section of the matrix. In the process of the content analysis, at first, the data obtained from the studies were coded, and later, applicable codes were brought together to form themes. Frequency and percentage (%) rates regarding the generated codes and themes were calculated.

FINDINGS

In this section of the study, general and content features are stated. The findings related to general features and context features.

1. What are the general features of the studies and authors?

Frequency and percentage values related to physics education studies in the six journals analyzed within the research content are shown in Table 1.

Table 1. *Data regarding the publishing years of the studies*

Publishing Year	IJSE f	IJSE %	JSET f	JSET %	JRST f	JRST %	SE f	SE %	Total f	Total %
2015	15	21.4	-	-	2	2.9	-	-	17	24.3
2014	10	14.3	5	7.1	2	2.9	3	4.3	20	28.6
2013	16	22.9	8	11.4	5	7.1	4	5.7	33	47.1
Total	41	58.6	13	18.6	9	12.9	7	10.0	70	100.0

In Table 1 is showed that The International Journal of Science Education contained 41 physics education studies, while the Journal of Science Education and Technology contained 13 studies in the field. The frequency and percentage values related to the distribution of physics education research in the last three years are given in Table 1. As a result of the analysis, for 2013, 33 articles were found, for 2014, 20 articles were found, and for 2015, 17 articles were found.

Table 2. *Data regarding the number of authors of the studies*

Number of Authors	IJSE f	IJSE %	JSET f	JSET %	JRST f	JRST %	SE f	SE %	Total f	Total %
1	4	5.7	1	1.7	-	-	1	1.4	6	8.6
2	18	25.7	7	10.0	2	2.9	1	1.4	28	40.0
3	11	15.7	1	1.4	4	5.7	1	1.4	17	24.3
4	6	8.6	2	2.9	2	2.9	3	4.3	13	18.6
5	1	1.4	2	2.9	-	-	1	1.4	4	5.7
6	1	1.4	-	-	1	1.4	-	-	2	2.9
Total	41	58.6	13	18.6	9	12.9	7	10.0	70	100.0

The numbers of authors are shown in Table 2, and the countries of the authors are shown in Table 3. Table 4 shows that 8.6% of the studies have a single author, 40.0% have two authors, 24.3% have three authors, 18.6% have four authors, 5.7% have five authors and 2.9% have six authors. Table 5, on the other hand, shows that the physics education research was carried out by 38.40% Americans, 8.9% English, 7.9% Germans, 5.8% Spanish and 4.2% Israelis. Only one physics education research study was conducted in Turkey.

Table 3. *Data regarding the countries of the authors*

Countries of the authors	IJSE		JSET		JRST		SE		Total	
	f	%	f	%	f	%	f	%	f	%
America	28	14.7	14	7.4	15	7.9	16	8.4	73	38.4
England	15	7.9	2	1.1	-	-	-	-	17	8.9
Germany	12	6.3	-	-	3	1.6	-	-	15	7.9
Spain	7	3.7	4	2.1	-	-	-	-	11	5.8
Israel	-	-	8	4.2	-	-	-	-	8	4.2
Austria	2	1.1	1	0.5	4	2.1	-	-	7	3.7
South Africa	5	2.6	-	-	1	0.5	-	-	6	3.2
France	3	1.6	-	-	2	1.1	-	-	5	2.6
Singapore	4	2.1	1	0.5	-	-	-	-	5	2.6
Swedish	5	2.6	-	-	-	-	-	-	5	2.6
Canada	3	1.6	-	-	1	0.5	-	-	4	2.1
China	-	-	-	-	-	-	4	2.1	4	2.1
Brazil	4	2.1	-	-	-	-	-	-	4	2.1
Taiwan	-	-	3	1.6	-	-	-	-	3	1.6
Cyprus	3	1.6	-	-	-	-	-	-	3	1.6
Netherlands	3	1.6	-	-	-	-	-	-	3	1.6
Greece	2	1.1	-	-	-	-	-	-	2	1.1
Ethiopia	-	-	-	-	2	1.1	-	-	2	1.1
Hong Kong	-	-	-	-	2	1.1	-	-	2	1.1
Norway	-	-	-	-	-	-	2	1.1	2	1.1
İtaly	2	1.1	-	-	-	-	-	-	2	1.1
Brunei	2	1.1	-	-	-	-	-	-	2	1.1
Turkey	-	-	1	0.5	-	-	-	-	1	0.5
Portugal	-	-	-	-	-	-	1	0.5	1	0.5
Zambia	1	0.5	-	-	-	-	-	-	1	0.5
Chile	1	0.5	-	-	-	-	-	-	1	0.5
Lebanon	1	0.5	-	-	-	-	-	-	1	0.5
Total	103	54.2	34	17.9	30	15.8	23	12.1	190	100.0

2. What are the aims of the studies in physics education?

Table 4. *Data regarding the aims of the studies*

Theme	Code	f	%	f	%
Investigating the efficiency of Method/ Technique	The efficiency of using simulation	3	4.3	17	24.3
	The efficiency of inquiry-based learning	3	4.3		
	The efficiency of video game technology	1	1.4		
	The efficiency of TGA-based interactive animation	1	1.4		
	The efficiency of language variation	1	1.4		
	The efficiency of writing-teaching activities	1	1.4		
	The efficiency of mind- maps	1	1.4		
	The efficiency of trite threat	1	1.4		
	The efficiency of sequential learning materials	1	1.4		
	The efficiency of collaborative learning model	1	1.4		
	The efficiency of small group argumentation	1	1.4		
	The use of thought experiments	1	1.4		

	The efficiency of blended learning model	1	1.4		
Case Definition	Analysis of the cases for the use of metaphor	2	2.9	16	22.9
	Analysis of teacher discourse	2	2.9		
	Analysis of teacher's emotional state/attitude changes	2	2.9		
	Analysis of in-class scientific discussions	2	2.9		
	Analysis of the cases regarding uncertainty/certainty /accuracy of the input	1	1.4		
	Identifying the pedagogical basis of ideas	1	1.4		
	Analysis of teachers' classroom experiences	1	1.4		
	Analysis of the resolution process of physics problems	1	1.4		
	Analysis of the cases regarding the formation of critical relation	1	1.4		
	Analysis of blended professional development course	1	1.4		
	Analysis of teachers' perception of physics/methods they use	1	1.4		
Research studies	Identfying student's understanding of the subject (motion, speed, etc.)	4	5.7	14	20.0
	Investigating conceptual learning (mechanics, simple circuit, energy etc).	4	5.7		
	Investigating the noesis of online troubleshooting activities	1	1.4		
	Investigating virtual and hands-on laboratories	1	1.4		
	Studying on eliminating misconceptions	1	1.4		
	Investigating student skills of the nature of science	1	1.4		
	Investigating the effect of literature on professional development	1	1.4		
	Investigating language use	1	1.4		
Survey	Identifiying student views (speed change, light emission etc).	3	4.3	13	18.6
	Identifying/comparing the levels of learning	2	2.9		
	Investigating the factors affecting physics/chemistry intake	2	2.9		
	Expectations/perceptions of females/males regarding physics education	2	2.9		
	Investigating gender differences in physics	1	1.4		
	Investigating expectations from physics	1	1.4		
	Investigating the reasons of the reduction in the number of physics reading	1	1.4		
	Investigating the relationship between gender and academic achievement	1	1.4		
Material Design	Designing activities for evidence/theory	1	1.4	10	14.3
	Designing enhanced science program	1	1.4		
	Evaluation of contextual-based course for data analysis	1	1.4		
	Designing materials for the use of temsiltriarchic model	1	1.4		
	Designing conceptual framework for physics concepts	1	1.4		
	Experiment design	1	1.4		
	STEM model design	1	1.4		
	Designing two-stage measuring tool	1	1.4		
	Designing scale for reasoning	1	1.4		

	Anayzing the relation of epistemology, sociology, learning (theoretical)	1	1.4		
Total		70	100.0	70	100.0

Table 4 shows the data regarding the aims of the physics education studies in the reviewed journals. The aims of the studies are included under the headings as investigating the efficiency of methods/techniques, case definition, research studies, survey and material design. Efficiency of simulation use was performed in 4.3% of the studies, and efficiency of inquiry-based learning was performed in 4.3% of the studies. It was also observed that 2.9% of the cases related to metaphor use, 2.9% dealt with changes in teachers' emotional state/attitude, 2.9% were on in-class scientific discussions, and 2.9% were on teacher discourse. Moreover, the data show that 5.7% of the studies were carried out to identify the students' understanding of the subject, and 5.7% were to investigate conceptual learning. Of the physics education studies, 4.3% focused on identifying student views, 2.9% on identifying/comparing levels of learning, 2.9% on investigating the factors affecting physics/chemistry intake, and 2.9% on perceptions/expectations of males/females of physics education.

3. What research methods, variables, samples and concepts are used in the studies in physics education?

Table 5. *Data regarding research methods*

Research Method	**IJSE**		**JSET**		**JRST**		**SE**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Experimental/empirical design	5	7.9	2	3.2	2	3.2	-	-	9	14.3
Quasi-experimental design	1	1.6	2	3.2	3	4.8	2	3.2	8	12.7
Mixed method	4	6.4	4	6.4	-	-	-	-	8	12.7
Material desgin (follow-up)	6	9.5	1	1.6	-	-	-	-	7	11.1
Qualitative research	5	7.9	1	1.6	-	-	1	1.6	7	11.1
Survey mehod	4	6.4	1	1.6	-	-	1	1.6	6	9.5
Case study	2	3.2	1	1.6	1	1.6	2	3.2	6	9.5
Desciptive (scale development)	3	4.8	-	-	-	-	-	-	3	4.8
Multiple case study	1	1.6	-	-	1	1.6	-	-	2	3.2
Multi level model	2	3.2	-	-	-	-	-	-	2	3.2
Phenomenographic research	2	3.2	-	-	-	-	-	-	2	3.2
Comparative case study	-	-	-	-	1	1.6	-	-	1	1.6
Litarature review	-	-	-	-	-	-	1	1.6	1	1.6
Design-based research methodology	-	-	1	1.6	-	-	-	-	1	1.6
Total	35	55.6	13	20.6	8	12.7	7	11.1	63	100.0

Table 5 shows that the research methods used in studies include experimental/empiric method (14.3%), quasi-experimental design (12.7%), mixed methods (12.7%), material design (follow-up) (11.1%) and qualitative research methods (11.1%). The methods preferred by the studies published in the International Journal of Science Education include the following: material design (follow-up) (9.5%), experimental/empirical design (7.9%) and qualitative research methods (7.9%). While in the studies in the Journal of Science Education and Technology, mixed methods were preferred (6.4%), 4.8% of the studies in the Journal of Research in Science Teaching used a quasi-experimental design. In addition, 3.2% of the studies found in Science Education were quasi-experimental designs, and 3.2% were case studies. Moreover, some studies did not include a methods statement.

Table 6. *Data regarding variables/themes of the studies*

Variables/Themes			IJSE		JSET		JRST		SE		Total	
			f	%	f	%	f	%	f	%	f	%
Qualitative		Student understanding	6	7.3	-	-	-	-	-	-	6	7.3
		The use of material	2	2.4	2	2.4	2	2.4	1	1.2	5	6.1
		Learning environments	3	3.7	1	1.2	-	-	-	-	4	4.9
		Views regarding usage	-	-	2	2.4	-	-	-	-	2	2.4
		Attitude/beliefs	2	2.4	-	-	-	-	-	-	2	2.4
		Conceptual blending	2	2.4	-	-	-	-	-	-	2	2.4
		Concept metaphors	2	2.4	-	-	-	-	-	-	2	2.4
		Course discourse	2	2.4	-	-	-	-	-	-	2	2.4
		Teacher expectations	-	-	-	-	1	1.2	-	-	1	1.2
		Student participation	-	-	-	-	1	1.2	-	-	1	1.2
		Problem solving process	-	-	-	-	-	-	1	1.2	1	1.2
		Critical relation	-	-	-	-	-	-	1	1.2	1	1.2
		Course selections	1	1.2	-	-	-	-	-	-	1	1.2
Quantitative	Effect	Conceptual understanding	7	8.5	5	6.1	1	1.2	2	2.4	15	18.3
		Learning	2	2.4	-	-	2	2.4	-	-	4	4.9
		Conceptual change/development	1	1.2	-	-	1	1.2	-	-	2	2.4
		Misconceptions	2	2.4	-	-	-	-	-	-	2	2.4
		Motivation	1	1.2	-	-	1	1.2	-	-	2	2.4
		Attitude	1	1.2	1	1.2	-	-	-	-	2	2.4
		Metacognition	2	2.4	-	-	-	-	-	-	2	2.4
		Success	-	-	-	-	1	1.2	-	-	1	1.2
		Scientific inquiry	-	-	-	-	-	-	1	1.2	1	1.2
		Self-efficacy	-	-	1	1.2	-	-	-	-	1	1.2
		Pedagogical content knowledge	1	1.2	-	-	-	-	-	-	1	1.2
		Skill	1	1.2	-	-	-	-	-	-	1	1.2
		Data analysis	1	1.2	-	-	-	-	-	-	1	1.2
	Survey	Identifying the relationship between demographic features and learning outputs	4	4.9	-	-	-	-	-	-	4	4.9
		Designing measuring tools	3	3.7	-	-	-	-	-	-	3	3.7
		Identifying levels of learning	2	2.4	-	-	-	-	-	-	2	2.4
		Identifying case and cause	1	1.2	-	-	-	-	-	-	1	1.2
		The use of the conceptual metaphor	1	1.2	-	-	-	-	-	-	1	1.2
		Identifying perceptions	1	1.2	-	-	-	-	-	-	1	1.2
		Identifying motivations	-	-	-	-	-	-	1	1.2	1	1.2
		Identifying conceptual	1	1.2	-	-	-	-	-	-	1	1.2

	development										
	Factors affecting course selection	1	1.2	-	-	-	-	-	-	1	1.2
Total		53	64.6	12	14.3	10	12.2	7	8.5	82	100.0

The data regarding the variables/themes in the physics education studies are given in Table 6. As shown in the table, though the variables/themes are represented in similar numbers in the qualitative and quantitative studies, there are relatively more quantitative studies. The efficiency of a method used in quantitative studies seems to be the most investigated topic. In addition, 18.3% of the studies investigated the effectiveness of a method on conceptual understanding, 4.9% investigated learning, 2.4% investigated motivation, 2.4% investigated misconceptions and 2.4% investigated metacognition. Also, in some quantitative studies, among the basic variables are identifying the relationship between demographic features and learning outputs (4.9%) and designing measuring tools (3.7%). Qualitative studies, on the other hand, focus on student insights/understanding (7.3%), the use of material (6.1%), and learning environments (4.9%).

Table 7. *Data regarding the sample sizes in the studies*

Sample Size	**IJSE**		**JSET**		**JRST**		**SE**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
0-30	11	16.9	2	3.1	4	6.2	1	1.5	18	27.7
31-100	4	6.2	2	3.1	1	1.5	3	4.6	10	15.4
101-200	4	6.2	5	7.7	2	3.1	-	-	11	16.9
201 and more	17	26.2	4	6.2	2	3.1	3	4.6	26	40.0
Total	36	55.4	13	20.0	9	13.8	7	10.8	65	100.0

Some study groups and samples in the physics education studies consisted of 201 or more participants (40.0%), 0-30 participants with (27.7%), 101-200 participants (16.9%) and 31-100 participants (15.4%). Of the studies published in the International Journal of Science Education, 26.2% had 201 or participants, and 16.9% had 0-30 participants. Of the studies in the Journal of Science Education and Technology, 7.7% consisted of 101-200 participants, while 6.2% of the studies in the Journal of Research in Science Teaching consisted of 0-30 participants. The studies in Science Education, on the other hand, were conducted with 31-100 or 201 and above participants in 4.6% of the cases.

Table 8. *Data regarding the types of samples*

Type of samples	**IJSE**		**JSET**		**JRST**		**SE**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Teacher	6	7.2	3	3.6	2	2.4	1	1.2	12	14.5
Teacher Candidates	5	6.0	-	-	-	-	1	1.2	6	7.2
Master Student	1	1.2	-	-	-	-	-	-	1	1.2
Undergraduate	10	12.0	4	4.8	4	4.8	1	1.2	19	22.9
High School Student	11	13.3	2	2.4	1	1.2	3	3.6	17	20.5
Primary/ Middle School Student	8	9.6	5	6.0	2	2.4	2	2.4	17	20.5
Student	3	3.6	1	1.2	-	-	1	1.2	5	6.0
Department	3	3.6	1	1.2	2	2.4	-	-	6	7.2
Total	47	56.6	16	19.3	11	13.3	9	10.8	83	100.0

As shown in Table 8, 22.9% of the studies included undergraduate student participants, 20.5% had high school students, 20.5% had primary/middle school students and 14.5% included teachers. Of the studies published in the International Journal of Science Education, 13.3% included high school students and 12.0% undergraduate students. Moreover, 6.0% of the studies in the Journal of Science Education and Technology included primary/secondary school students, 4.8% of the studies in the Journal of Research in Science Teaching included undergraduate students, and 3.6% of the studies in Science Education included high school students.

Table 9. *Data regarding the physics concepts in the studies*

Physics Concepts	**0-30**		**31-100**		**101-200**		**201 ve üzeri**		**Total**	
	f	**%**	**f**	**%**	**f**	**%**	**f**	**%**	**f**	**%**
Energy	-	-	2	4.4	4	8.7	6	13.0	12	26.1
Force and motion	1	2.2	-	-	2	4.4	3	6.5	6	13.0
Electricity	-	-	2	4.4	2	4.4	1	2.2	5	10.9
Magnetism	-	-	-	-	2	4.4	2	4.4	4	8.7
Speed	1	2.2	-	-	1	2.2	-	-	2	4.4
Light	1	2.2	-	-	-	-	1	2.2	2	4.4
Mechanics	-	-	-	-	1	2.2	1	2.2	2	4.4
Atomic physics	1	2.2	-	-	-	-	1	2.2	2	4.4
Thermodynamic	1	2.2	-	-	-	-	1	2.2	2	4.4
Bolye’s law	-	-	1	2.2	-	-	-	-	1	2.2
Simple machines	-	-	1	2.2	-	-	-	-	1	2.2
Optics	-	-	-	-	1	2.2	-	-	1	2.2
Ohm's law	-	-	-	-	1	2.2	-	-	1	2.2
Pressure	-	-	-	-	-	-	1	2.2	1	2.2
Sound	-	-	-	-	1	2.2	-	-	1	2.2
Theory of relativity	-	-	1	2.2	-	-	-	-	1	2.2
Color	-	-	-	-	-	-	1	2.2	1	2.2
Float and sink	-	-	-	-	-	-	1	2.2	1	2.2
Total	5	10.9	7	15.2	15	32.6	19	41.3	46	100.0

Table 9 shows the relationship between the physics concepts and the number of participants. In the analyzed studies, 26.1% focused on energy, 13.0% on force and motion, 10.9% on electricity, and 8.7% on magnetism. However, some studies were not included in this table due to a lack of specific physics concepts. Also, it was not possible to analyze some studies in terms of this variable because they did not focus on a specific physics concept in the survey or qualitative studies such as questionnaires. Of the studies of the energy concept, 13.0% consisted of 201 or more participants and 8.7% had 101-200 participants. For the force and motion concepts, on the other hand, 6.5% consisted of 201 or more participants and 4.4% of 101-200 participants. In addition, 41.3% of the studies were carried out with 201 or more participants with and 32.6% with 101-200 participants. In this sense, it is clear that in general, the physics concepts were studied with multiple participants.

4. What results are found by the studies in physics education?

Table 10. *Data regarding the results of the studies*

Theme	Code	f	%	f	%
Cognitive Aspect	Positive effect on conceptual understanding	7	12.3	22	38.6
	Teaching concepts positively	4	7.0		
	Providing better learning	4	7.0		
	Increase in success	2	3.5		
	Providing in-depth learning	1	1.8		
	Supporting the teaching of difficult concepts	1	1.8		
	Positive effect on data analysis	1	1.8		
	Negative effect of difficult concepts on learning	1	1.8		
	Unattainable distinction between macroscopic and microscopic definitions of concepts	1	1.8		
	Increase in discussion skills	1	1.8		
Case Definition	Differences in age-related learning	2	3.5	16	28.1
	Males' preference in physics more than females	2	3.5		
	Differences in teacher's lecture	2	3.5		
	Effect of teacher experiences on teaching/method	2	3.5		
	High school students' uncertainity of job selection	1	1.8		
	Differences in students' problem-solving processes	1	1.8		
	Effect of teachers' physical and social cues on participation tothe lesson	1	1.8		
	The effect of school type on physics intake	1	1.8		
	Males are better at trite threats	1	1.8		
	Females are less experienced in physics	1	1.8		
	Differences in physics teaching according to programs	1	1.8		
	Necessity of proficiency in concept teaching	1	1.8		
Efficiency of methods	Effectiveness of metaphors	2	3.5	9	15.8
	Positiveness of teaching through modeling	1	1.8		
	Effectiveness of inquiry	1	1.8		
	Importance of pedagogy for critical thinking	1	1.8		
	Learning effect of pedagogical studies	1	1.8		
	Utilization of activities	1	1.8		
	Effectiveness of laboratory on physics teaching	1	1.8		
	Effectiveness of mind-maps	1	1.8		
Correlational Relations	Connection between school mark and success	1	1.8	6	10.5
	Connection between gender and success	1	1.8		
	Connection between motivation and level of physics	1	1.8		
	Connection between reasoning and decision-making	1	1.8		
	Connection betw. teacher competence and conceptual understanding	1	1.8		
	Association of critical potential with the subject	1	1.8		
Affective aspect	Positive effect on emotional states	1	1.8	4	7.0
	High level of student satisfaction	1	1.8		
	Positive attitude development	1	1.8		
	Increase in motivation.	1	1.8		
Total		57	100	57	100.0

Table 10 shows the main results obtained from the physics education studies. The data are grouped under themes of cognitive aspect, case definition, efficiency of methods, correlational relations and affective aspect. The results obtained from the studies show a positive effect on conceptual understanding (12.3%) and on concept teaching (7.0%), the provision of better learning (7.0%) and an increase in success (3.5%). The results also show differences in age-related learning (3.5%), males' preference for physics over females' (3.5%), differences in teachers' lectures (3.5%), the effect of teacher experiences on teaching/method (3.5%) and the effectiveness of metaphors (3.5%).

DISCUSSION and CONCLUSION

According to the findings obtained from this study, 42 studies on physics education were published in the International Journal of Science Education and 13 in the Journal of Science Education and Technology. However, there have not been any publications in Science Education that were directly related to physics education. These journals that have the most impact in science/physics education field focus on science education studies. Looking at the number of articles published in these journals, the International Journal of Science Education publishes 18 issues per year and 7 articles on average in each issue; the Journal of Science Education and Technology publishes 6 issues per year and 10 articles on average in each issue; the Journal of Research in Science Teaching publishes 10 issues per year and 4-5 articles on average in each issue; and Science Education publishes 6 issues per year and 3 articles on average in each issue. In this sense, it is normal that the number of publications in physics is, at this state, parallel to the total number of articles of these journals in the analyzed year range. As it is understood, it is an expected result that the International Journal of Science Education, which publishes 126 articles on average per year, has the highest number of physics education studies. Considering the studies in Science Education, the purpose of the journal is to publish review articles of the highest quality that provide analytical syntheses of research into key topics and issues in science education. Therefore, it is thought that the journal includes review studies in science education; however, these studies are not within the aforementioned years.

Analyzing the distribution of the physics education studies according to the years, in 2013, there were 34 articles; in 2014, 20 articles; and in 2015, there were 17 articles. İt is observed that while the physics education studies are the highest in 2013, in 2014, there was a decrease in the number. Although the number was the lowest in 2015, it was not possible to reach all studies due to unpublished issues from this year, so in this sense, this number may be much higher in 2015. Karamustafaoglu (2009) stated that there was an increase in the number of published articles in physics education between 2005-2011 in the journals he analyzed as a part of his study. In this sense, the contribution of the studies to literature for field training becomes crucial, and an increase in the number of articles is therefore expected. Though there are differences in our study in the number of physics education articles according to the different years, 25-30 physics education articles were published on average in the analyzed journals. Uzunboylu and Asiksoy (2014) stated that the number of articles during different years were quite close to each other in their study in which they investigated physics education research between 2008-2012.

As it is understood, the physics education articles analyzed in the study generally consisted of two authors, followed by three or four authors. Bacanak et al. (2011), who analyzed science education articles in terms of the number of authors, and Uzunboylu and Asiksoy (2014), who did the same type of analysis in physics education, stated that the studies mostly consisted of one or two authors. In this sense, as a result of our study, it can be stated that there are more studies conducted by two authors than studies conducted individually or by groups. According to the findings obtained from in our study, the vast majority of physics education studies are conducted by American citizens. One of the most important reasons for this situation is that America constitutes various states, and outstanding universities are located in these states. In parallel with this, it is thought that a lot more publications come out of these scientifically advanced states, namely America. It is observed that, after America, physics studies are conducted by the citizens of England, Germany, Spain and Israel. The situation is thought to arise from the fact that these countries value academic studies and that they have various specialist researchers. However, there is only one physics education study carried out in Turkey that appears in these journals. In this sense, it is sad that Turkey has a single physics education study in these journals that ranks among the most important indices. The fact that there are far fewer articles from countries such as Chile, Lebanon, Portugal and Turkey shows that these countries have limited contributions to the literature through these journals. In this sense, it can be stated that countries with more publications, such as America and England, contribute far more to the field through these journals. However, the crucial point is that all countries are known to conduct academic studies in physics education. On the other hand, it is thought that there may be fewer physics education studies in these journals due to the limited publications of some countries such as Turkey.

The analysis of physics education studies in the journals used in this study include the following aims: investigating method/technique efficacy, case definition, research studies, survey and material design. In this sense, it can be stated that most of the studies focus on case determination, designing activities, and the short- and long-term effects of these activities on conceptual understanding and change. The effectiveness of simulation use (Chen et al. 2014; Dega et al. 2013) and the effectiveness of inquiry-based teaching (Kulo and Bodzin 2013; Liu et al. 2015) were investigated in physics education studies. In this sense, it is observed that simulation and animation, which gained importance with the advance of technology, are also emphasized in physics education studies. Moreover, an inquiry approach, which occupies an important position and has ongoing importance, is also frequently studied in physics education research. In this sense, it can be stated that simulations and inquiry are the most used methods in physics education on the basis of teaching methods. In addition to this, the aims of the physics education studies were specified as identifying students' understanding of the subject (Guisasola et al. 2013; Lemmer 2013) and investigating conceptual learning (Ding, Chabay and Sherwood 2013). Moreover, physics education studies place an emphasis on identifying student views (Hast and Howe 2013a). In this sense, it becomes crucial to investigate participant perceptions, views or conceptual understandings of a particular situation or concept. A remarkable point here is that the studies conducted on misconceptions (Helm 1980; Yildiz and Buyukkasap 2006), on analyzing the effect of constructive learning (Akdeniz and Akbulut 2010; Thomaz and Gilbert 1989), and on focusing on achievement (Halloun 1996; Wambugu and Changeiywo 2008) which were frequently studied in previous years, seem to have decreased. On the other hand, enriched materials and teaching designs, of which educational technologies become a part, have started to gain importance. For instance, these types of materials include web-based materials, simulation-based materials, video game-based materials, and 3D materials. In this sense, within the theoretical framework of material design, the studies based on a single theory have become limited, while enriched or blended materials have gained importance.

It is observed in physics education studies that the methods used include experimental/empirical methods (Kukliansky and Eshach 2014; Neumann, Viering, Boone and Fischer 2013; Shemwell, Chase and Schwartz 2015), quasi-experimental designs (Akpinar 2014; Chen, Hand and McDowell 2013; Fung and Yip 2014), mixed methods (Peppler and Glosson 2013), material designs (Howe, Ilie, Guardia, Hofmann, Mercer and Riga 2015; Vieira and Kelly 2014) and qualitative research methods (Danielsson and Warwick 2014; Emig, Mcdonald, Zembal-Saul and Strauss 2014; Velentzas and Halkia

2013). As it is understood, the most preferred research method in physics education studies is the experimental method or quasi-experimental design. Uzunboylu and Asiksoy (2014) stated in their studies that quantitative methods, including the experimental method, are the most used methods in physics education articles. Moreover, it is thought as a result of our study that mixed methods are also increasingly becoming important, and they will be used more in the future. Moreover, it can be stated that in the studies, qualitative methods were not preferred as much as quantitative methods. Looking at this issue by journal, the International Journal of Science Education used material designs (follow-ups), experimental/empirical designs and qualitative study methods as research methods in their published studies. In this sense, the physics education studies in this journal were carried out with the aim of designing materials that are in line with a model or approach and implementing activities related to this. While mixed methods were preferred in the studies in the Journal of Science Education and Technology, quasi-experimental designs were preferred in the studies in the Journal of Research in Science Teaching. In the physics studies in these journals, on the other hand, the quantitative research methods were usually the focus. Moreover, the studies in Science Education were carried out as quasi-experimental designs and as case studies. It is also found that in some studies in these journals, the method section was not specified.

In the studies related to variables/themes in physics education studies that though the variables/themes in the qualitative and quantitative studies were similar to each other, there were quantitative studies. The efficacy of a method was mostly investigated through quantitative studies. This situation seems to be normal in parallel with research methods used in studies and the generally used experimental method. In physics education studies, the effectiveness of the methods on conceptual understanding (Anderson and Barnett 2013; Leuchter et al. 2014; Martinez et al. 2013), learning (Geller, Neumann, Boone and Fischer 2014; West and Wallin 2013), motivation (Mujtaba and Reiss 2013), misconceptions (Martinez-Borreguero, Pérez-Rodríguez, Suero-López and Pardo-Fernández 2013), and metacognition (Thomas 2013) were investigated. Looking at the variables/themes, conceptual understanding and learning are at the forefront. In this respect, conceptual understanding takes the place of achievement, which was frequently used in previous years. Conceptual understanding has come to the foreground in parallel with the aim of providing meaningful learning related to daily life, which is among the main goals of teaching programs. In this sense, it is thought that conceptual understanding, instead of achievement, should be regarded as a variable in the studies. Moreover, in some quantitative studies, main variables include identifying the relationship between demographic features and learning output (Adamuti-Trache, Bluman and Tiedje 2013) and designing a measuring tool (Sakschewski, Eggert, Schneider and Bögeholz 2014; Taasoobshirazi and Farley 2013). In the process of designing a measurement tool, the former tools in the literature, such as attitude and motivation, have been replaced by the tools regarding the 21st century skills or more cognitive gains. The studies are focused on metacognition, reasoning or designing two-stage scales. Moreover, as a result of the analysis of the physics education studies, it can be stated that studies of overall attitude have been replaced by the identification of attitudes towards specific methods. Qualitative studies, on the other hand, are focused on student insights/ understanding (Décamp and Viennot 2015; Lancor 2014; Yerushalmi, Puterkovsky and Bagno 2013), the use of material (Rutten, van der Veen and van Joolingen 2015) and learning environments (Kuo, Hull, Gupta and Elby 2013). Studies are generally focused on identifying participant insights in physics concepts such as velocity, speed, or energy. In this sense, carrying out in-depth studies related to physics concepts and identifying how these concepts are perceived are among the frequently used subjects.

An analysis of the samples and study groups in physics education research shows that some studies include 201 or more participants (Bøe and Henrıksen 2013; Chu and Treagust

2014; Jeppsson, Haglund and Amin 2015; Sasson and Cohen 2013; Tsurusakı, Calabrese Barton, Tan, Koch and Contento 2013), 0-30 participants (Eshach, Wu, Hwang and Hsu 2014; Harlow, Bianchini, Swanson and Dwyer 2013), 101-200 participants (Berger and Hänze 2015) and 31-100 participants (Lancor 2015). In this sense, though there are differences in the number of participants, the studies mostly include 201 or more participants. In this sense, if quantitative studies are to be carried out in these journals, comprehensive studies with greater numbers of participants are required. The physics education studies were conducted with the participation of undergraduate students (Brookes and Etkina 2015; Close and Scherr 2015; Darrah, Humbert, Finstein, Simon and Hopkins 2014; Goertzen, Brewe and Kramer 2013), high school students (Bigozzi, Tarchi, Falsini and Fiorentini 2014; Marchand and Taasoobshirazi 2013; Tiberghien, Cros and Sensev 2014), primary/middle school students (Oon and Subramaniam 2013; Papadouris and Constantinou 2014), and teachers (Hazari, Cass and Beattie 2015; Ritchie et al. 2013; Taylor and Booth 2015). Uzunboylu and Asiksoy (2014) state in their study that physics research was conducted with the participation of secondary school students, teachers and students of the faculty of education. This study was also conducted frequently with undergraduate students.

Physics education studies frequently focus on the subjects of energy (Cheong, Joharib, Said and Treagust 2015; Dreyfus, Gupta and Redish 2015; Seraphin, Philippoff, Parisky, Degnan and Warren 2013), force and motion (Fulmer, Liang and Liu 2014; Hast and Howe 2013b), electricity (Peppler and Glosson 2013) and magnetism (Shemwell et al. 2015). Energy, force and motion, electricity and magnetism are among the mostly studied subjects. Similarly, Uzunboylu and Asiksoy (2014) confirmed that mechanics and electrical physics subjects are studied more than other subjects. They thought that this resulted from the fact that these concepts are critically important both for the participants' learning and for the future. Moreover, in sciences, physics consists of abstract concepts that are difficult to perceive. Thus, subjects such as energy, force and motion, are among the most frequently taught subjects because they are abstract. It is observed that physics concepts are generally studied with numerous participants. Our analysis shows that the electricity and force and motion concepts were generally studied with 201 or more participants. This situation is thought to arise from the fact that the data obtained from numerous participants at the stage of concept perception and learning are crucial for generalizability.

The main results obtained from the physics education studies are grouped under themes of cognitive aspect, case definition, effectiveness of methods, correlational relations and emotional aspect. The results confirm that conceptual understanding (Anderson and Barnett 2013; Ding et al. 2013) and concept teaching (West and Wallin 2013) fostered better learning (Sin 2014). There is also a strong emphasis on conceptual understanding and cognitive development. In this sense, the studies investigating the effects of designed materials and methods on cognitive gains of the participants maintain their importance. However, these studies focus on conceptual learning, rather than achievement. In addition, our results show that there were differences in age-related learnings (Hast and Howe 2013a), and in teacher lectures (Jawahar and Dempster 2013), that males' preference for physics was greater than females' (Gill and Bell 2013), and that the metaphors were effective (Dreyfus et al. 2015). A remarkable point here is the in-depth investigation of some cases (gender, age etc.) that were stated generally by literature search studies. In this sense, it is considered important for research to investigate the reasons for the general cases stated in the literature searching studies and to obtain profound information regarding these cases.

Recommendations

In thes physics education studies, the publications were published mostly by the citizens of America, England and Germany. The countries of Turkey, Portugal, Chile and Lebanon, on the other hand, each published a single study. It is necessary for each country to carry out research in parallel with the development of their educational systems and to increase publications in the journals regarded as important in the literature.

As Soslu (2013) indicates, practical activities and teaching methods are both effective; in addition, it is important to organize various activities, including novice approaches and methods. Studies for designing interactive simulations and 3D materials and checking their effects are important, and there are deficiencies in this matter in the field. Thus, it is necessary to conduct studies related to enhanced web-based materials in the era of increasingly growing educational technologies. Moreover, while the studies that ground their theoretical framework on a single theory in material development have become limited, enriched or blended learning approaches that include more than one method have gained importance. As a result, both physics education and more general science education studies are expected to examine the enhanced materials that are used with approaches such as context-based learning, inquiry-based learning, argumentation-based learning and investigating the effects of these methods in learning environments. Conceptual understanding, which has frequently appeared recently, continues to gain importance and is in the process of being better understood by researchers. Moreover, the studies regarding 21st century skills, which have become crucial in education in recent years, seem to be rare, and therefore, examining these types of studies would be significant for the literature.

As interdisciplinary approaches are becoming increasingly crucial, it is suggested that researchers from various departments (physics-chemistry-biology-mathematics and engineer, sociologist, philosophy etc..) carry out joint research. In conclusion, the studies were conducted on the participants' perceptions of the main physics concepts and on how the participants make sense of these concepts. In these studies, in-depth information was obtained and detailed results were stated. It is important to increase these types of studies and to study the physics concepts that have not been worked on. Moreover, the prominent diversity issue needs to be reflected in physics education studies, and studies regarding diversity need to be conducted.

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