JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

THE SCOPE OF SCIENCE PROCESS SKILLS AND THE 5E EDUCATIONAL MODEL IN SCIENCE EDUCATION

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Abstract. *Science education focuses on the methods of thinking about and using process skills rather than memorizing scientific facts. 5E educational model aims to learn by discovering scientific knowledge and engaging students in learning environments. The aim of this study was to examine the articles in the field of education related to the 5E educational model and science process skills (SPS) according to some criteria. The search in databases was carried out to cover the articles conducted in the last twelve years (2010-2021). Over the last 12 years, 522 articles on the 5E educational model and science process skills have been examined. In this descriptive content analysis study, randomized sampling came to the fore as the preferred sampling method, lower-secondary school students as the sample type, 11-50 as the sample size, and studies in which the effectiveness of a method was tested as the research type, lower-secondary school science as the research discipline, quasi-experimental as a research design, achievement tests as data collection tools, and frequency/percentage/charts were frequently used in data analysis.*

Keywords: *descriptive content analysis, 5E educational model, science education, science process skills*

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Introduction

Science process skills (SPS), which are fundamental components of science, have a great impact on students' learning and optimal use of science in their academic careers and personal lives, and lower-secondary school students have a high level of SPS (Rao, 2008). One of the ways of teaching science is the process approach. A process approach to science teaching relies on examining what a scientist does. The processes are derived from the study of what a scientist does and are called the process skills of science. Some of these skills are observing, measuring, inferring, manipulating variables, stating hypotheses, constructing graphs and tables of data (Rezba et al., 1995).

SPS are essential skills for mastering science (Prayitno et al., 2017). Raj and Devi (2014) defined SPS as the methods and techniques needed to learn science acquisitions, explore natural phenomena, and look at events from a different perspective. Monhardt and Monhardt (2006) defined these skills as skills that are suitable for many science disciplines but can be adapted to different situations. According to Carin and Bass (2001), these skills are the basic components of thinking. Individuals are expected to use and apply these skills in situations they encounter in their daily lives (Huppert et al., 2002). According to Nunaki et al. (2020), the application of SPS in the teaching and learning process has critical importance due to the acceleration of scientific change and confronting the difficulties of the problem (facing the challenges of the problem). Gaining SPS to students is considered among the main objectives of science education today (NRC, 2000). SPS is an important purpose of education as well as being a tool for learning science and understanding scientific studies (Anagün & Yaşar, 2009). In this context, SPS forms the basis of science lessons, in which individuals come to conclusions by questioning and researching, it is very important to acquire these skills in science lessons (Myers et al., 2004).

https://doi.org/10.33225/jbse/22.21.1101

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

It is difficult for students to acquire SPS and science concepts learning in a meaningful way through direct instruction. For this reason, students should be engaged in learning environments where they can use and develop their SPS in activities and experiments (Turgut et al., 1997). Different methods and models can be used to gain these skills. According to Colburn and Clough (1997), the 5E educational model is a well-known model for applying scientific processes and concepts to real situations. In classroom environments integrated with this model, it becomes easier for students to learn science concepts and their SPS levels improve (Budprom et al., 2010). The 5E educational model got its name from the number and initials of the model's stages. These stages are Engage, Explore, Explain, Elaborate, and Evaluate. It is also called Rodger Bybee's 5E Model because of the initials of words (Bybee et al. 2006). The 5E educational model is built on the outcomes of research determined by national science education standards (Boddy et al., 2003, p. 28). This model was included in the Turkish curriculum in 2004 and has been gradually put into practice since 2005, and has been reflected in textbooks, student workbooks, and teacher guidebooks (MNE, 2005). The 5E educational model included in the curriculum contributes to the development of the skills necessary to think about basic information and to learn, analyze and synthesize this information (Yoon & Onchwari, 2006).

SPS is very important for every person, not only in science activities but also related to the problems of human life. Education should be a necessity in schools for the development of students' SPS (Sukarno & Hamidah, 2013). This study proposes the necessity of a recent review focusing on either SPS or 5E learning model which continuously evolves and takes on a significant part in the science education field. Therefore, the purpose of this study was to address a recent and comprehensive review of the literature on both the SPS and the 5E educational model in science learning and teaching. Accordingly, this study summarizes what is currently known, possible gaps in the current literature, and suggestions for future studies.

Research Methodology

General Background

Descriptive content analysis was adopted in this study. Descriptive content analysis is a method with wide applicability in educational research (Fraenkel et al., 2012). The main purpose of the descriptive analysis is to identify tendencies (Cohen et al., 2007). As the name suggests, it refers to the design in which research is conducted using descriptive statistics, mainly frequencies and percentages. In this study, WOS, ERIC, and ULAKBİM were chosen as the databases to be researched. It was aimed to reach the articles browsed in the science citation index and social sciences citation index with the web of science database, to reach the articles browsed in the education field index ERIC database, and to reach the national articles in the ULAKBİM database. Of course, joint articles have been identified in these databases, in such cases, the WOS, ERIC, and ULAKBİM database order was followed in categorizing the articles. It was known that there were articles on the topics browsed in these three different databases. For this reason, it was desired to conduct a more comprehensive study by including other databases in addition to the WOS. All the articles were browsed using the following keywords: "scientific process skills", "science process skills", "5E model", "5E learning model" and "5E educational model". The scope of the research was limited to the 5E educational model and SPS, and the study period took approximately eight months for data collection and data analysis.

Data Collection

The essential steps involved in a review of the literature include defining the research problem as precisely as possible; selecting the WOS, ERIC, and ULAKBİM as databases to be searched; deciding on the examination of the articles conducted in the last twelve years; formulating search terms as "5E model", "5E learning model", "5E educational model", "scientific process skills", "science process skills". Search in databases was limited in the last twelve years (2010 to 2021). Keywords in the articles were reviewed to decide whether the articles reached through the relevant databases were on SPS and the 5E educational model. Articles on SPS other than the 5E educational model and science subjects (i.e., language or geography) were excluded from the research, except for other related STEM disciplines (technology and engineering). Applying the exclusion criteria left 522 articles, 136 from WOS, 149 from ERIC, and 237 from ULAKBİM. The total number of articles remaining to be analyzed is shown in Table 1.

https://doi.org/10.33225/jbse/22.21.1101

Table 1
Total number of WOS, ERIC, and ULAKBİM articles for 5E educational model and SPS

	5E Educational Model	Science Process Skills	Total
WOS	67	69	136
ERIC	18	131	149
ULAKBİM	100	137	237
Total	185	337	522

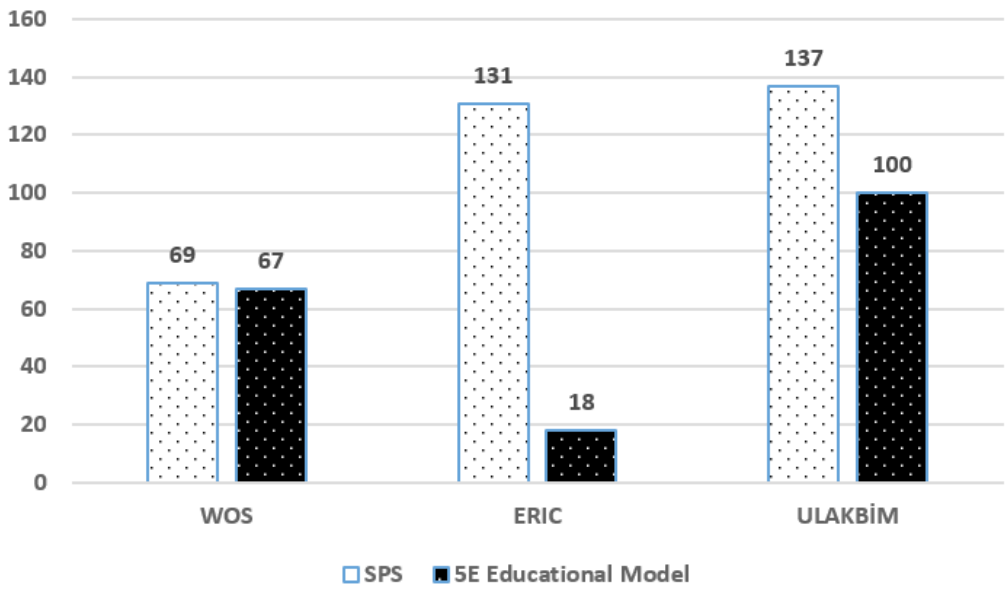
Data Analysis

After examining the content of the articles covered in the study, ways to categorize the information presented in each of the 522 articles were sought. The coding form (see Appendix) developed by researchers of the study was based on 1) Research area, 2) Sampling Methods, 3) Sampling Type, 4) Sample Size, 5) Research Type, 6) Research Discipline, 7) Research Methods, 8) Data Collection Tools 9) Data Analysis. Then, a total of 522 articles were distributed to six experts in the field of science education. In order to check its reliability, first of all, the categories and the criteria for these categories were agreed upon. Then, the researchers formed categories. Of course, there were some discrepancies among the researchers regarding the determined categories. These discrepancies among categories were resolved through discussions among researchers. Researchers met every week and discussed the appropriateness of their coding for the categories discussed by using the coding form assigned to them. The inter-rater kappa coefficient was found to be 0.84.

Research Results

Articles on the 5E educational model and SPS were analyzed according to the categories of the research area, sampling methods, sampling type, sample size, research type, research discipline, research methods, data collection tools, and data analysis. Figure 1 shows the frequency distribution of the "research area" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

Figure 1
Distribution of "Research Area" by 5E Educational Model and SPS according to Databases

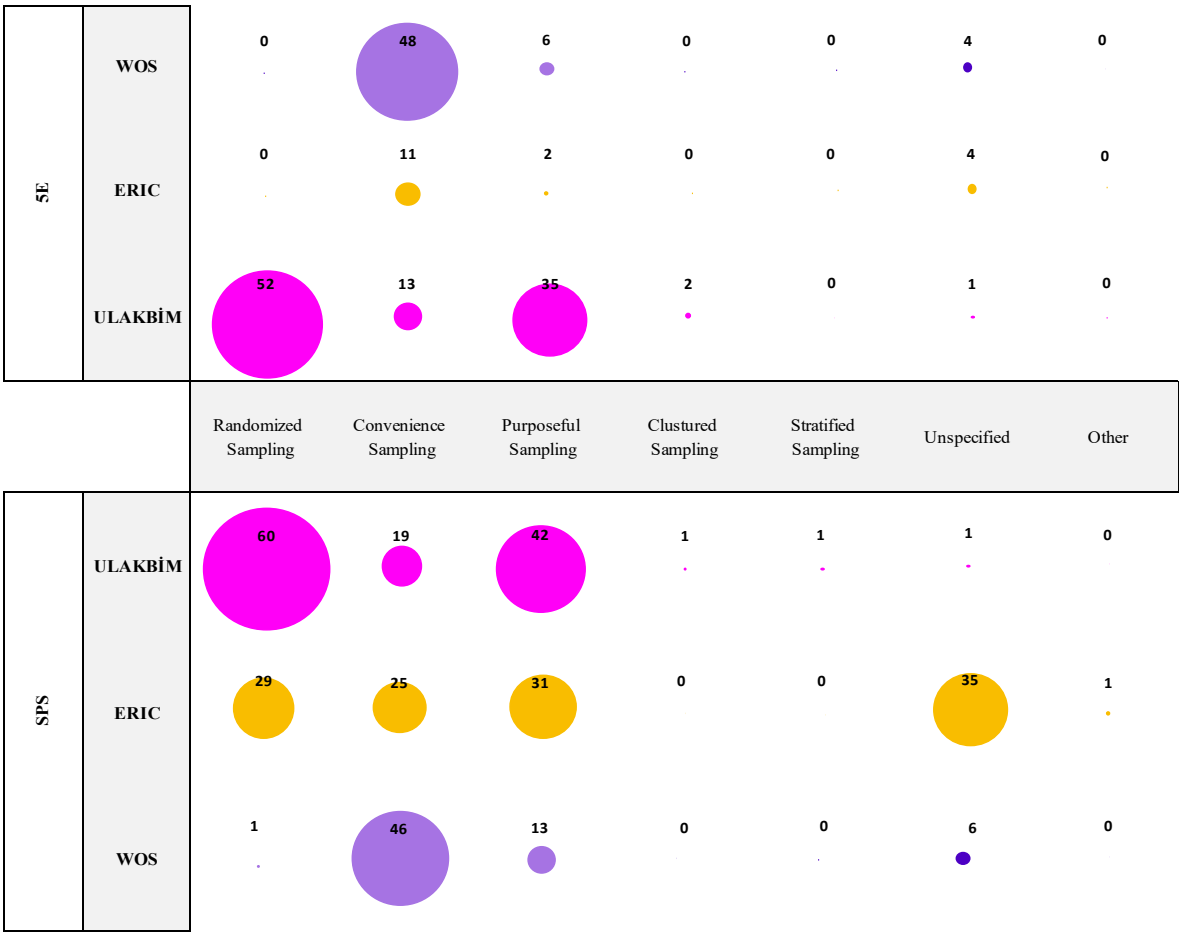


https://doi.org/10.33225/jbse/22.21.1101

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In the last 12 years, a total of 337 articles were identified about SPS, 69 of which were in the WOS, 131 in the ERIC, and 137 in the ULAKBİM database. Regarding the 5E educational model, a total of 185 articles were identified, 67 of which were in the WOS, 18 in the ERIC, and 100 in the ULAKBİM database. It was noteworthy that the number of articles published on SPS was higher than those on the 5E educational model in the last 12 years. In addition, it was seen that the highest number of articles (*n*=237) related to these research areas were conducted in journals browsed in the ULAKBİM database. It was also determined that the number of articles published in WOS journals in both fields was almost the same. The number of articles on SPS browsed in the ERIC database (*n*=131) was considerably higher than those on the 5E educational model (*n*=18) (Figure 1). Figure 2 shows the frequency distribution of the "sampling methods" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

Figure 2
Distribution of "Sampling Methods" by 5E Educational Model and SPS according to Databases



When Figure 2 was examined, convenience sampling was the most preferred sampling method in articles on the 5E educational model (*n*=48) and SPS (*n*=46) in the WOS database. Likewise, convenience sampling was the most preferred sampling method in articles on the 5E educational model (*n*=11) in the ERIC database and in articles on SPS (*n*=25) in the ERIC database. Randomized sampling (*n*=52) was the most preferred sampling method in articles on the 5E educational model in the ULAKBİM database. Correspondingly, randomized sampling (*n*=60) was the most preferred sampling method in articles on SPS in the ULAKBİM database. Figure 3 shows the frequency distribution of "sampling type" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

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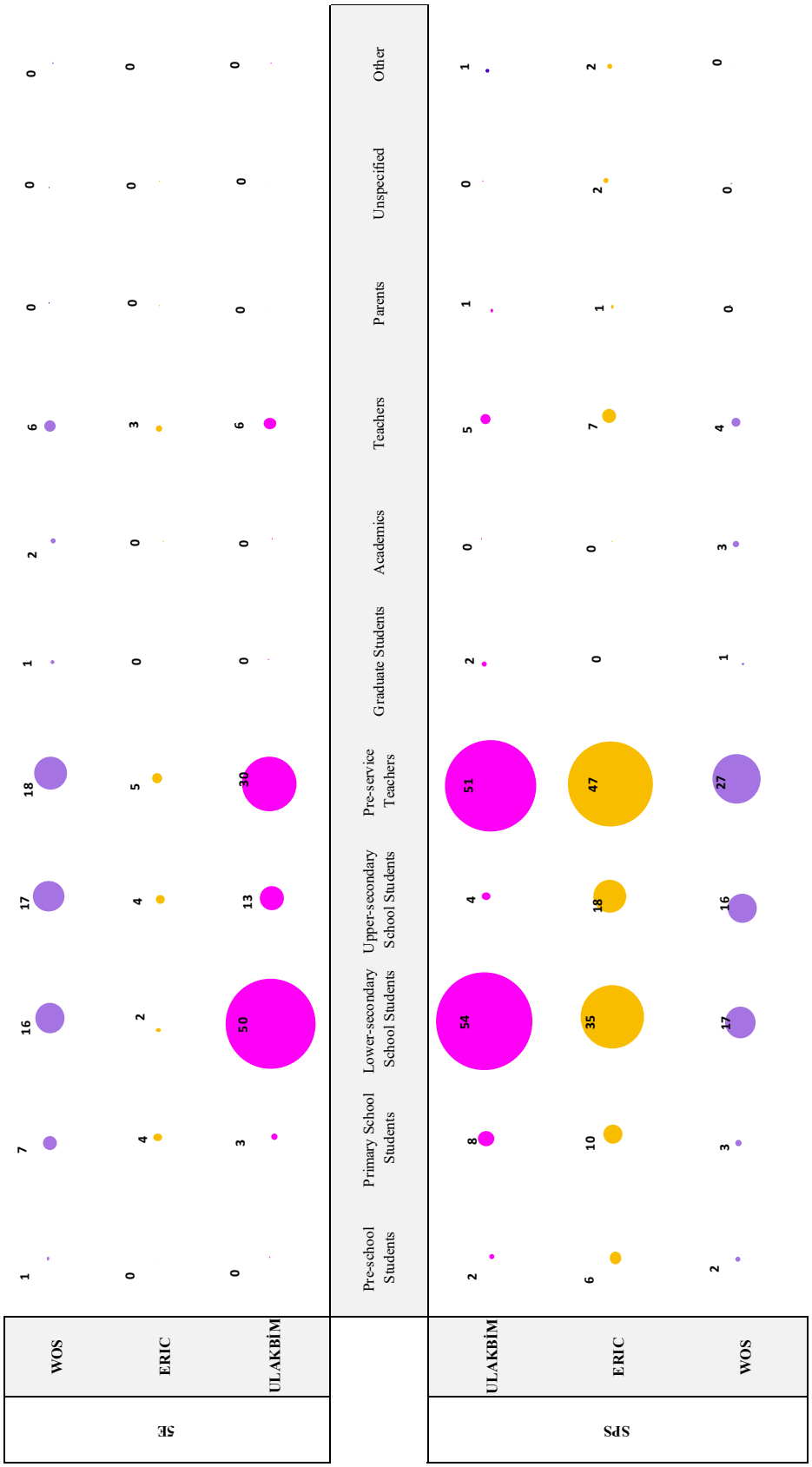

Figure 3
Distribution of "Sampling Type" by 5E Educational Model and SPS according to Databases

https://doi.org/10.33225/jbse/22.21.1101

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Figure 3 shows that articles browsed in the ULAKBİM database were mostly conducted with lower-secondary school students (*n*=50), pre-service teachers (*n*=30), and upper-secondary school students (*n*=13) for the 5E educational model. When we look at the articles browsed in the WOS database, it was seen that the articles on the 5E educational model were mostly conducted with pre-service teachers (*n*=18), upper-secondary school students (*n*=17), and lower-secondary school students (*n*=16). The number of articles on the 5E educational model browsed in the ERIC database was much less than the articles browsed in other databases covered in the study and there was no distinct difference in the number of articles published by sampling type.

In the ERIC database, it was determined that articles on the 5E educational model were conducted with pre-service teachers (*n*=5), upper-secondary school students (*n*=4), primary school students (*n*=4), and lower-secondary school students (*n*=2), respectively. Like the 5E educational model, it was seen that articles on SPS were mostly conducted with lower-secondary school students (*n*=54) in the articles browsed in the ULAKBİM database and followed by articles with pre-service teachers (*n*=51). On the contrary, in the ERIC database, it has been determined that articles on SPS were mostly conducted with pre-service teachers (*n*=47), lower-secondary school students (*n*=35), and upper-secondary school students (*n*=18), respectively. Similarly, it was determined that articles on SPS were mostly conducted with pre-service teachers (*n*=27), lower-secondary school students (*n*=17), and upper-secondary school students (*n*=16) respectively in the articles browsed in the WOS database. Figure 4 shows the frequency distribution of "sample size" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

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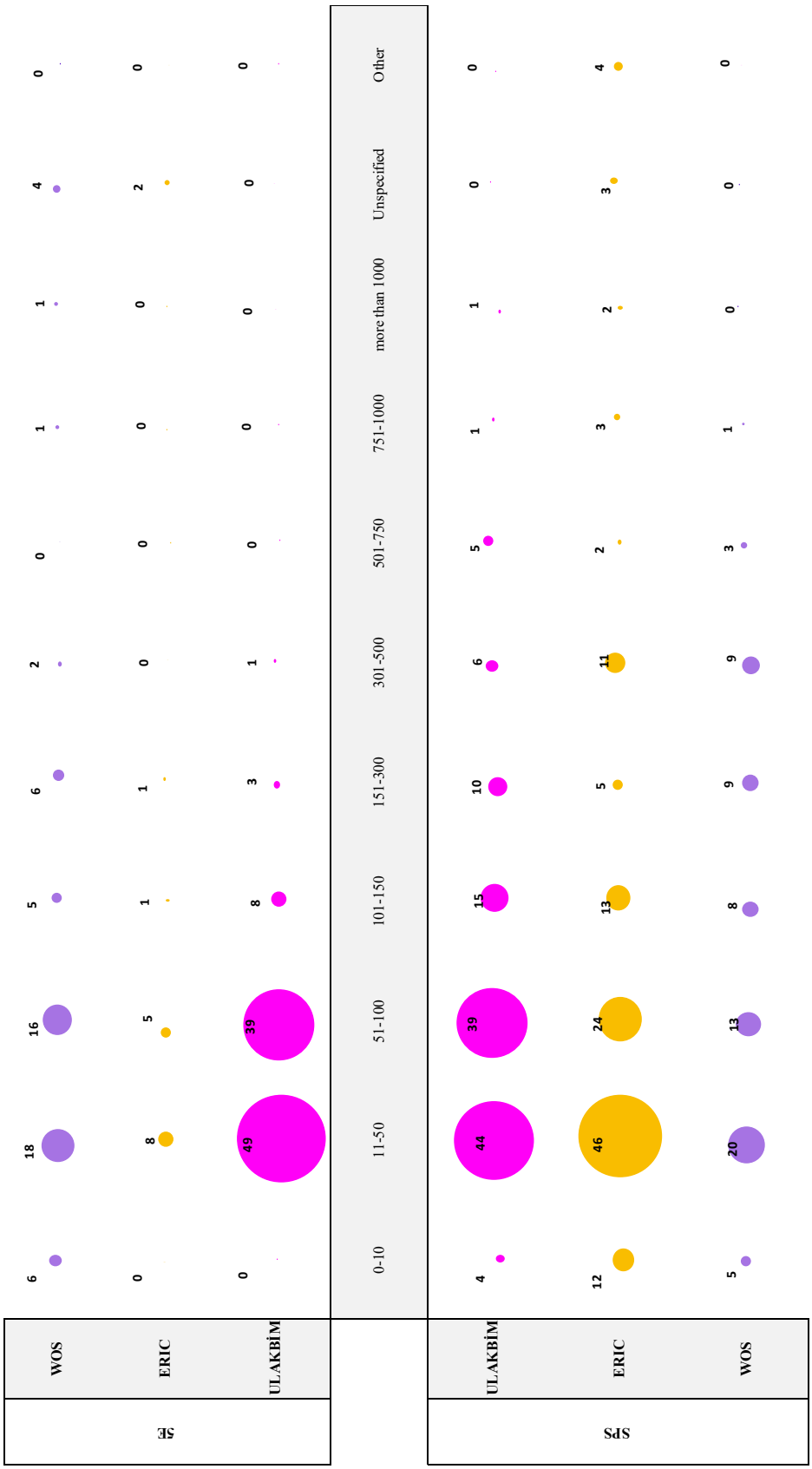
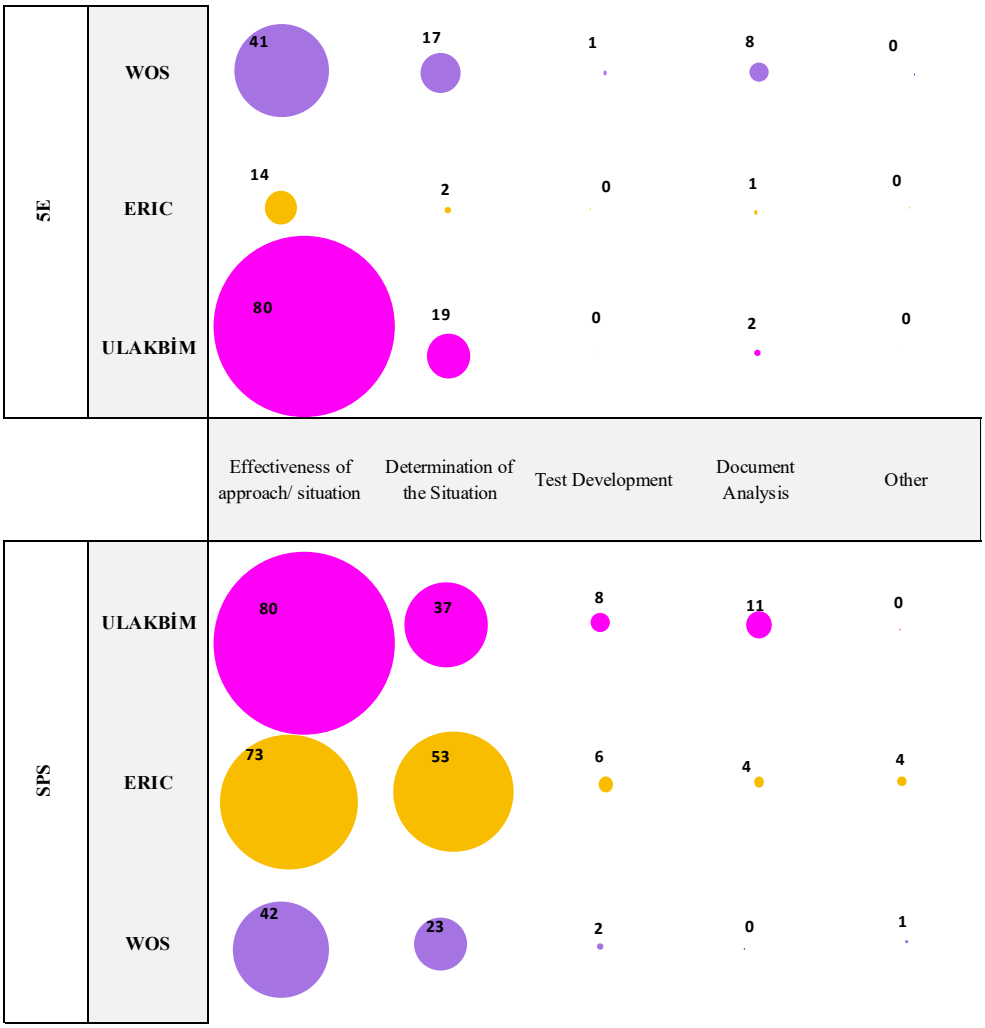


Figure 4
Distribution of "Sample Size" by 5E Educational Model and SPS according to Databases

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In Figure 4, it was seen that the most preferred sample size on both the 5E educational model and SPS in all databases covered in the study was between 11-50, followed by the sample sizes between 51-100 and 101-150. For the 5E educational model, it was seen that the sample size was mostly preferred between 11-50 in the articles browsed in the ULAKBİM database (*n*=49), in articles browsed in the WOS database (*n*=18), and in articles browsed in the ERIC database (*n*=8), respectively. Furthermore, it was determined that the articles on SPS were mostly preferred to be published in articles browsed in the ULAKBİM database (*n*=44), articles browsed in the ERIC database (*n*=46) and articles browsed in the WOS database (*n*=20). Figure 5 shows the frequency distribution of "research type" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

Figure 5
Distribution of "Research Type" by 5E Educational Model and SPS according to Databases



According to Figure 5, it was seen that articles on the 5E educational model and SPS were mostly related to articles on the effectiveness of a method. It was seen that the number of articles browsed in the ULAKBİM database (*n*=80) investigating the effectiveness of a method on the 5E educational model was higher than the articles published in the WOS database (*n*=41) and ERIC database (*n*=14). Likewise, it has been determined that the articles investigating the effectiveness of a method regarding SPS were mostly in the articles browsed in the ULAKBİM database (*n*=80), followed by the articles browsed in the ERIC database (*n*=73) and the articles browsed in the WOS database (*n*=42). Figure 6 shows the frequency distribution of "research discipline" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

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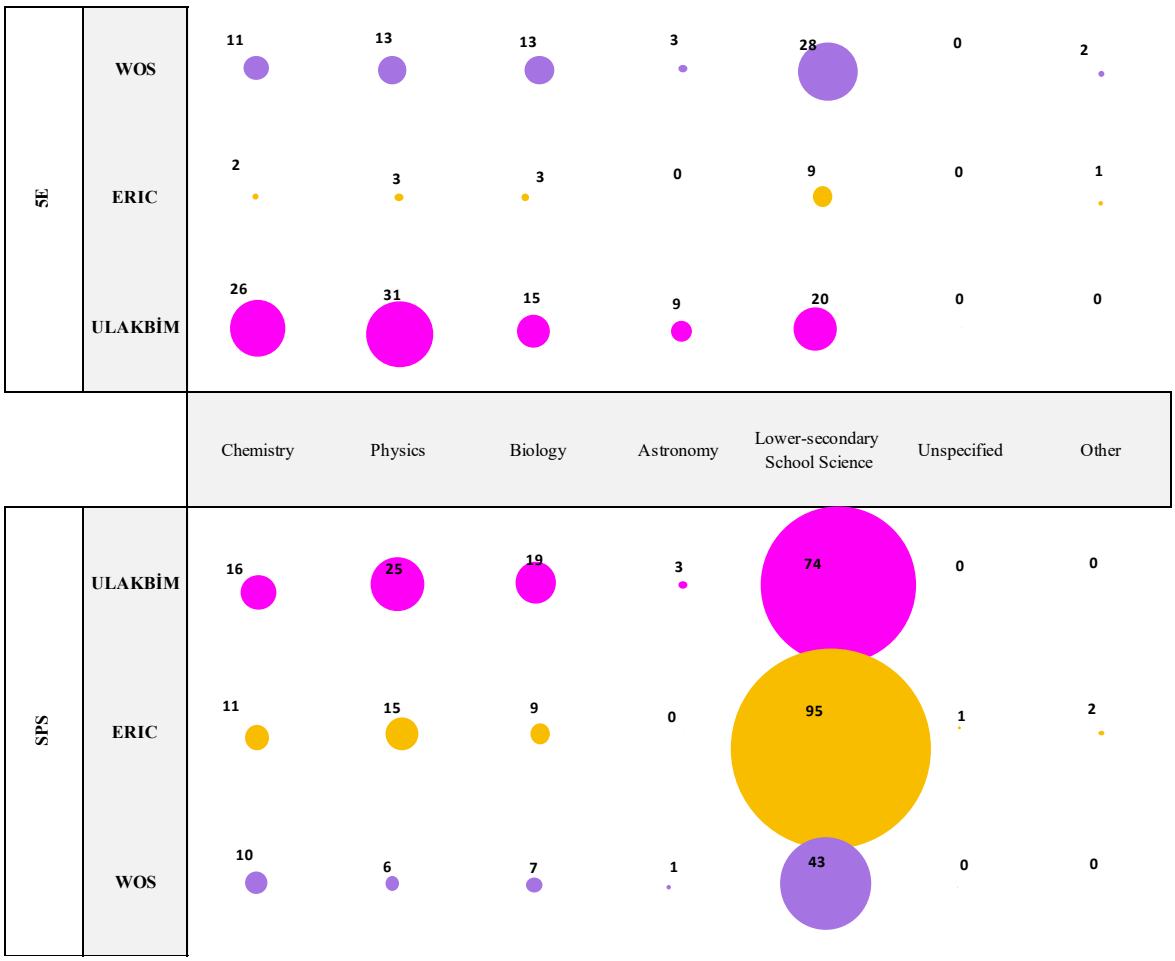
Figure 6
Distribution of "Research Discipline" by 5E Educational Model and SPS according to Databases



According to Figure 6, it has been determined that the articles on the 5E educational model were mostly published in the field of physics (*n*=31) browsed in the ULAKBİM database, while the articles browsed in the WOS database (*n*=28), and the ERIC database (*n*=9) were in the field of science. In addition, it was determined that the articles on SPS were mostly conducted in the field of lower-secondary school science and these articles were browsed in the ERIC database (*n*=95), ULAKBİM database (*n*=74), and WOS database (*n*=43), respectively. Figure 7 shows the frequency distribution of "research methods" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

https://doi.org/10.33225/jbse/22.21.1101

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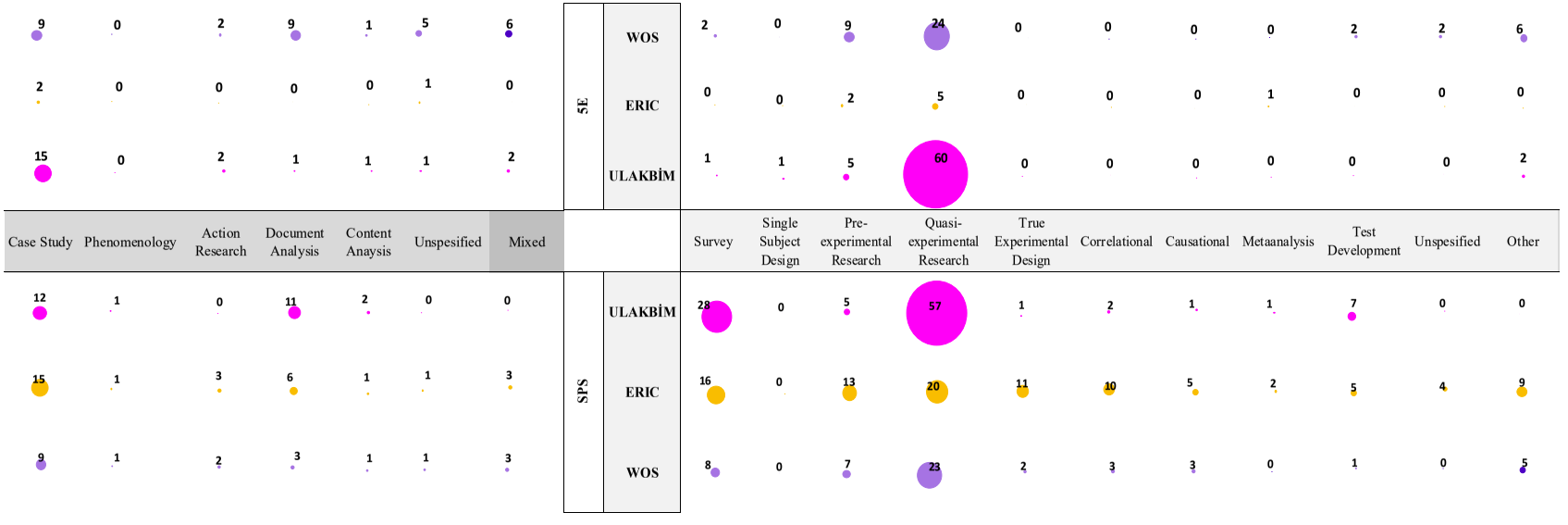
Figure 7

Distribution of "Research Methods" by 5E Educational Model and SPS according to Databases



According to Figure 7, it was seen that the quasi-experimental research method was mostly preferred in the articles on the 5E educational method and SPS in all databases covered in this study. It was noteworthy that the articles on the 5E educational method were mostly published in the journals browsed in the ULAKBİM database, and qualitative studies in this database were mostly about case studies (*n*=15). The number of articles browsed in the ULAKBİM database was followed by the articles browsed in the WOS database (*n*=24) and it was seen that case studies (*n*=9) and document analysis (*n*=9) methods were the commonly used research methods in qualitative studies on the 5E educational method. In the ERIC database, few articles were found on the 5E educational model compared to other databases, and most of them (*n*=5) were related to quasi-experimental research.

Like the 5E educational method, quasi-experimental research has been the most preferred method in all databases in articles on SPS. The quasi-experimental research (*n*=57) was the most preferred method in the ULAKBİM database and there were also qualitative studies about case studies (*n*=12) and document analysis (*n*=11) in this database. In the WOS database, quasi-experimental research (*n*=23) was also the most preferred research method in the articles on SPS, and case study (*n*=9) and document analysis (*n*=3) were the most preferred qualitative research methods as well. Likewise, quasi-experimental research (*n*=20) was the most preferred research method in the articles browsed in the ERIC database, and case study (*n*=15) and document analysis (*n*=6) were the most preferred qualitative research methods. Figure 8 shows the frequency distribution of "data collection tools" on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

https://doi.org/10.33225/jbse/22.21.1101

Journal of Baltic Science Education, Vol. 21, No. 6, 2022
ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

https://doi.org/10.33225/jbse/22.21.1101

Journal of Baltic Science Education, Vol. 21, No. 6, 2022
ISSN 1648-3898 /Print/
ISSN 2538-7138 /Online/

Figure 8

Distribution of "Data Collection Tools" by 5E Educational Model and SPS according to Databases

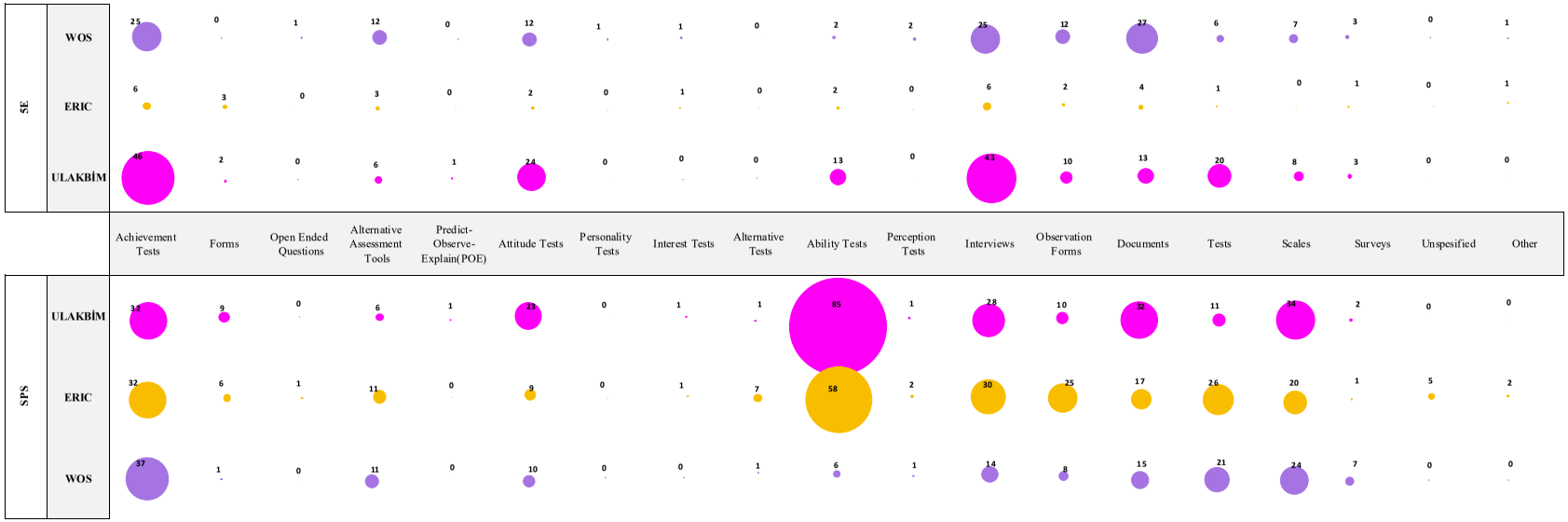


Figure 8 shows that achievement tests (*n*=46) and interviews (*n*=43) were preferred as data collection tools in the articles browsed in the ULAKBİM database related to the 5E educational method. While the documents (*n*=27), achievement tests (*n*=25), and interviews (*n*=25) were the commonly used tools in the articles on the 5E educational model browsed in the WOS database, achievement tests (*n*=6) and interviews (*n*=4) were mostly preferred as data collection tools in the journals browsed in the ERIC database. In addition, ability tests (*n*=85) were the data collection tool commonly used in journals browsed in the ULAKBIM database in articles on SPS, followed by scales (*n*=34), achievement tests (*n*=32), documents (*n*=32), and interviews (*n*=28), respectively. While achievement tests (*n*=37) and scales (*n*=24) were commonly preferred in articles on SPS browsed in the WOS database, it was seen that ability tests (*n*=58), achievement tests (*n*=32), and interviews (*n*=30) were mostly preferred as data collection tools in articles browsed in the ERIC database. Figure 9 shows the frequency distribution of "data analysis" methods on the 5E educational model and SPS articles in WOS, ERIC, and ULAKBİM databases.

Figure 9

Distribution of "Data Analysis" by 5E Educational Model and SPS according to Databases

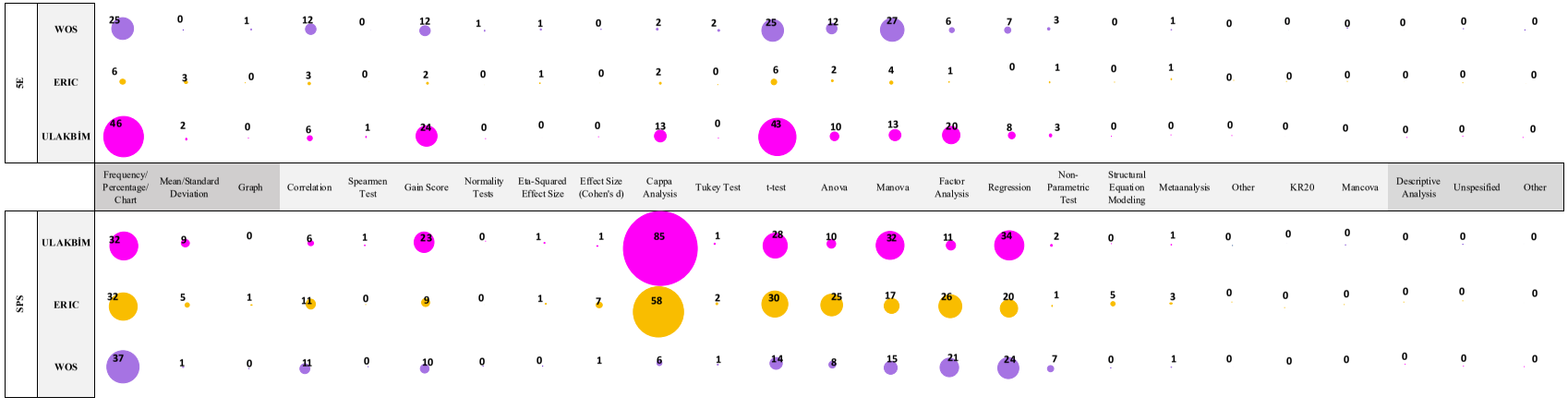


Figure 9 shows that the use of frequency/percentage/chart (*n*=46), *t*-test (*n*=43) and gain score (*n*=24) were the most widely used data analysis methods in the articles browsed in the ULAKBİM database on the 5E educational method. In the articles on the 5E educational model browsed in the WOS database, MANOVA (*n*=27), *t*-test (*n*=25) and frequency/percentage/chart (*n*=25) were widely used in data analysis methods, and similarly in the articles browsed in the ERIC database, frequency/percentage/chart (*n*=6) and *t*-test (*n*=6) were commonly used for data analysis. As for SPS, cappa analysis (*n*=85) was widely used in articles browsed in the ULAKBİM database, and it was followed by regression (n=34), frequency/percentage/chart (*n*=32), MANOVA (*n*=32), and t-test (*n*=28) data analysis methods. In the articles browsed in the WOS database, it was observed that the frequency/percentage/chart (*n*=37) method came to the fore in data analysis, followed by regression (*n*=24) and factor analysis (*n*=21), respectively. Similarly, in the ERIC database, it can be seen from Figure 9 that cappa analysis (*n*=58), frequency/percentage/chart (*n*=32) and *t*-test (*n*=30) methods were the most preferred data analysis methods.

https://doi.org/10.33225/jbse/22.21.1101

Journal of Baltic Science Education, Vol. 21, No. 6, 2022
ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Discussion

Science is in almost all areas of human life, and it is both a process and a product. Since it is a process, it consists of process skills that help develop scientific searches for products. SPS has a profound impact on students' learning and optimal use of science in their academic careers and personal lives as so-called basic skills to master science (Prayitno et al., 2017). The literature review is an important part of the scientific approach. Such studies also form the basis of most research in the humanities. Literature review in educational research provides ways to stand out in a particular field of knowledge in one's field. Thus, the literature in any field provides the foundation on which all future work should be built (Rao, 2008). Students' SPS can be developed in science-based learning so as to students can use these basic skills to master science (Saidawati et al., 2022). The 5E educational model provides teachers with a structure to meet the demands of today's science standards. It gets students thinking, then allows explorative discovery and fact-based learning to deepen students' understanding of the content topic. Students can become critical thinkers and continue to learn about topics of interest as time goes on. The 5E model is a science teaching method for raising science-literate students. As it is a pedagogical approach to teaching science, it provides a framework for teachers to develop students' understanding of scientific ideas and concepts. However, the 5E teaching model is flexible and can be used with many different types of teaching resources, programs, and materials that teachers may already have (Chitman-Booker & Kopp, 2017). The 5E teaching model, which encourages conceptual learning, is widely used in science teaching (Bahtaji, 2021). Data from a study by Budprom et al., (2010) also showed that the 5E educational model increased students' SPS levels. In the present study, it was aimed to review the articles in the field of education about SPS and 5E educational model according to the categories of the research area, sampling methods, sampling type, sample size, research type, research discipline, research methods, data collection tools, and data analysis.

In this study, when the articles browsed in WOS, ERIC, and ULAKBİM on SPS and the 5E educational model between 2010-2021 were examined, it was found that the number of articles published on SPS was higher when compared to the 5E educational model in the last 12 years. In addition, it was determined that the greatest number of articles related to these research areas were published in journals browsed in the ULAKBİM database and the least number of articles were published in the journals browsed in the WOS database. In the publication of articles in various journals, reasons such as the subject of the article, readership, and impact factor are usually important. In addition to these factors, the article acceptance rate is also among the important reasons for the difference in the number of articles published in these databases. In addition, it was determined that the number of articles published in both fields in the journals browsed in WOS was almost the same. It was also noticed that the number of articles on SPS browsed in the ERIC database was considerably higher than those related to the 5E educational model. In addition, the 5E educational model is the most used method in terms of gaining SPS (Colburn & Clough, 1997). It has been suggested in many studies that the stages of the SPS and 5E educational models support each other in many ways (Bıyıklı & Yağcı, 2014). In the studies on the SPS, the sample was generally chosen by random sampling method, the sampling type was usually pre-service teachers possibly related to easy accessibility, the number of samples varies between 11-50, and the effectiveness of a method was mostly examined, lower-secondary school science was concentrated as the research discipline, and the quasi-experimental method was prominent as a research method. Moreover, it has been determined that ability tests were used as data collection tools and cappa analysis was used in data analysis in the studies on the SPS. Yıldırım et al. (2016) thematically assessed Turkish studies in SPS from 2000 to 2015. They used a thematic matrix (needs, aims, methodologies, data collection tools, general knowledge claims, implications for teaching and learning) to evaluate the data. They identified the developing students' SPS as the needs, developing students' or teachers' SPS as the aims, experimental research as the methodology of SPS studies, questionnaires especially including multiple-choice questions as data collection tools for SPS studies, and lower-secondary school students and student teachers as the sample types. Çevik and Kaya (2021) examined postgraduate theses about SPS conducted in the field of science in Turkey between the years 2015 and 2021. It was determined that the majority of these related to SPS between the years 2015-2021 were master's theses and problem-based learning was generally preferred as the subject area in the theses. In addition, the quantitative research method and quasi-experimental design were particularly preferred in the thesis examined, with seventh-grade students as the study group, 40-60 people as the sample size, SPS and achievement tests as data collection tools, t-tests, and content analysis were generally preferred as data analysis methods. In the meta-synthesis study of Sibic and Şeşen (2022), which includes the analysis of master's and doctoral thesis, they stated that SPS was generally measured with multiple-choice tests, and original tests were developed in very few of them.

https://doi.org/10.33225/jbse/22.21.1101

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

In the studies on the 5E educational model, the sample was generally chosen by convenience sampling as the sampling method, the sampling type was usually lower-secondary school students, the number of samples varies between 11-50, and the effectiveness of a method was tested as the research type, lower-secondary school science was concentrated as the research discipline, and the quasi-experimental method was prominent as a research method. Moreover, it has been determined that achievement tests were used as data collection tools and frequency/percentage/chart was used in data analysis in the studies on the 5E educational method. The meta-analytic review of Mukagihana et al. (2022) identified educational methods used for teaching pre-service science teachers between the years 2010 and 2020. The 5E educational model was one of the most effective teaching methods for pre-service science teachers learning. In another study by Turan (2021) using the meta-ethnographic method, which examines the systematic examination of qualitative studies addressing the difficulties faced by pre-service teachers while applying the 5E educational model, time, resources, beliefs, content, and class size were determined as the obstacles in the implementation of the 5E educational model by the pre-service teachers. Anil and Batdi (2015) reviewed the quantitative studies carried out in Turkey and published in the national and international literature over the period 2008 to 2014 about the effect of the 5E educational model on students' academic achievement, retention, and attitude scores. The results of the meta-analysis conducted on the 5E model showed that the 5E educational model was generally effective in terms of students' academic achievement, retention, and attitude scores. Çakir and Güven (2019) examined the studies conducted on the 5E educational model in the field of science teaching between 2006 and 2016. All these studies are thesis containing qualitative data, performed in science teaching in Turkey, have been published or unpublished in national or international journals, and have been combined with the meta-analysis method. They concluded that the 5E educational model had the strongest effect on academic achievement at the university level, while the weakest effect was at the elementary school level, and this model had the strongest effect on academic achievement in physics. In addition, it was seen that the 5E educational model had a moderate effect on the attitude towards the course and had the strongest effect on the attitude towards the biology course. Saraç (2018) conducted a meta-analysis study to determine the effect of using the 5E educational model in the education process between 2007 and 2016 on the permanence of the learned information. As a result of the research, it has been determined that the use of the 5E educational model in the education process had a positive effect on the permanence of the learned information. In the research, analyzes were made according to the learning cycle models, the thesis type of the research, the discipline area in which the research was conducted, and the education level of the students participating in the research. As a result of the analysis, it was determined that the highest effect size value was in the 4E Model, in doctoral studies, in the field of biology, and in upper-secondary school students. In another study examining the doctoral dissertations written in the field of science education between 2001-2016, it was determined that the mixed method as a research method, secondary school students and pre-service teachers as sampling type, experimental studies, and case studies as research designs, inferential analysis, and content analysis as data analysis were the most widely used (Küçüközer, 2016).

Descriptive content analysis studies summarize the studies in the field of study and identify trends, facilitate the access of stakeholders to research data on the subject studied, provide holistic data about the studies, and offer new researchers the opportunity to see new and different studies on the relevant subject holistically and contribute to the researchers to develop different perspectives on the field to be studied (Çalık & Sözbilir, 2014; Dinçer, 2018). In related literature, there were some content analysis and meta-analysis studies examining science process skills (Çevik & Kaya, 2021; Sibic & Şeşen, 2022; Yıldırım et al. 2016) and the 5E educational model (Anil & Batdi, 2015; Çakir & Güven, 2019; Küçüközer, 2016; Mukagihana et al., 2022; Saraç, 2018; Turan, 2021), but there was no such comprehensive study reported like the current study.

Conclusions and Implications

In this study, a total of 522 articles were examined in the field of education related to the 5E educational model and SPS according to some criteria. The research criteria were the research area, sampling methods, sampling type, sample size, research type, research discipline, research methods, data collection tools, and data analysis. It had been sometimes difficult in determining the research criteria and especially the sub-criteria. Therefore, the determining criteria had to be updated from time to time during the article review process. One of the difficulties encountered during the examination process was that there was no clear statement about the research criteria in the abstract or throughout the article. In cases where the research criteria of the articles could not be reached from the abstracts or certain parts of the articles, the entire article had to be examined in detail. Through the discussions, the researchers

https://doi.org/10.33225/jbse/22.21.1101

tried to reach a consensus about the research criteria and tried to code the criteria by making inferences from the overall article. Of course, there were cases where consensus could not be reached, for which it was not specified, and other options were added to the criteria table. In addition, sometimes the same terms were named differently in different articles, and in such cases, the criteria were gathered under a single heading by reaching a consensus among the researchers. Accessing, downloading, and storing paid articles were also some of the other problems encountered in the current work process.

The current study is very important in terms of presenting the current situation for researchers who plan to conduct research in the field of SPS and the 5E educational model. It sheds light on the scientists who would work in the related fields and provides an opportunity to complete the shortcomings in the relevant literature. In addition, the majority of the related studies were limited to the studies conducted in Turkey, especially meta-analysis of thesis studies. Therefore, the available literature lacks enough comprehensive and adequate content or meta-analytical review showing the effect of the 5E educational method and SPS on learning outcomes.

The results of the research indicated that randomized sampling came to the fore as the preferred sampling method, lower-secondary school students as the sample type, 11-50 as the sample size, and studies in which the effectiveness of a method was tested as the research type, lower-secondary school science as the research discipline, as a research design quasi-experimental, achievement tests as data collection tools, and frequency/percentage/charts were frequently used in data analysis.

The following recommendations are based on the findings of this content analysis.

- A similar study can be conducted using different databases.
- Since the articles about SPS in all researched databases outnumber the articles about the 5E educational model, researchers should be encouraged to conduct studies on the 5E educational model.
- A convenient sampling method has often been preferred in studies about the 5E educational model, and researchers can be encouraged to conduct studies using different sampling techniques.
- In studies on the 5E educational model, lower-secondary school students have often been chosen as the sampling type, and studies can be conducted with different sampling types.
- In studies on the SPS, pre-service teachers have often been chosen as the sampling type, and studies can be conducted with different sampling types.
- The quasi-experimental design has been used frequently used as a research design in both the 5E educational model and SPS, and researchers can conduct studies with different research designs in related fields.
- Studies have been carried out in small samples (11-50) in both the 5E educational model and SPS, and studies involving larger samples can be conducted on these subjects.
- Generally, the effectiveness of an approach/situation has been preferred as a research type in both the 5E educational model and SPS, and studies can be conducted on other types of research in related fields.

Acknowledgments

This study was funded by the Scientific and Technological Research Council of Turkey by Grant No. 220K101.

Declaration of Interest

The authors declare no competing interest.

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https://doi.org/10.33225/jbse/22.21.1101

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Appendix
The Coding Form

		1. Research Area		2. Sampling Methods							3. Sampling Type											4. Sample Size											5. Research Type					6. Research Discipline						
		5E	SPS	Randomized Sampling	Convenience Sampling	Purposeful Sampling	Clustured Sampling	Stratified Sampling	Unspecified	Other	Pre-school Students	Primary School Students	Lower-secondary School Students	Upper-secondary School Students	Pre-service Teachers	Graduate Students	Academics	Teachers	Parents	Unspecified	Other	0-10	11-50	51-100	101-150	151-300	301-500	501-750	751-1000	More than 1000	Unspecified	Other	Effectiveness of approach/situation	Determination of the Situation	Test Development	Document Analysis	Other	Chemistry	Physics	Biology	Astronomy	Lower-secondary School Science	Unspecified	Other
5E	ULAKBİM																																											
5E	WOS																																											
5E	ERIC																																											
SPS	ULAKBİM																																											
SPS	WOS																																											
SPS	ERIC																																											
Total																																												

7. Research Methoods																		8. Data Collection Tools																			9. Data Analysis																								Total
a. Qualitative						b. Quantitative											c. Mixed																																												
Case Study	Phenomenology	Action Research	Document Analysis	Content Analysis	Unspecified	Survey	Single Subject Design	Pre-experimental Research	Quasi-experimental Research	True Experimental Research	Correlational	Causational	Metaanalysis	Test Development	Unspecified	Other	Mixed	Achievement Tests	Forms	Open Ended Questions	Alternative Assessment Tools	Predict-Observe-Explain (POE)	Attitude Tests	Personality Tests	Interest Tests	Alternative Tests	Ability Tests	Perception Tests	Interviews	Observation Forms	Documents	Tests	Scales	Surveys	Unspecified	Other	Frequency/Percentage/Chart	Mean/Standard Deviation	Graph	Correlation	Spearmen Test	Gain Score	Normality Tests	Eta-Squared effect size	Effect Size (Cohen's d)	Cappa Analysis	Tukey Test	t-test	Anova	Manova	Faktor Analysis	Regression	Non-Parametric Test	Structural Equation Modeling	Metaanalysis	KR20	Mancova	Descriptive Analysis	Unspecified	Other	

https://doi.org/10.33225/jbse/22.21.1101

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Received: *July 04, 2022* Revised: *September 15, 2022* Accepted: *November 22, 2022*

Cite as: Zorluoğlu, S. L., Yalçinkaya Önder, E., Timur, B., Timur, S., Güvenç., E., Özergun, I., & Özdemir, M. (2022). The scope of science process skills and the 5E educational model in science education. *Journal of Baltic Science Education*, *21*(6), 1101-1118. https://doi.org/10.33225/jbse/22.21.1101

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