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Research Article

Action research in science education: a systematic review

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Abstract

This study aims to systematically examine the importance and use of action research in science education. 30 articles in the Web of Science (WoS) database were analyzed according to the research, problem status, distribution by years, study groups and findings. It was determined that the most studied problem status was students' skills and emotions; there was a noticeable change between 2013 and 2023; most of the study groups of the articles were high school students, student candidates and teachers, and the findings were in the areas of "scientific thinking and skill development", "design of educational environments and use of technology", "understanding of concepts", "intercultural and inclusive education", "new student-centered educational approaches", "teacher education and professional development". According to this article, it was observed that action research has positive effects on science education, and it is expected that providing support to teachers and researchers will increase the conduct of action research and increase the quality of science education.

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Introduction

The main objective of science education, which has great importance in the development of countries, in the educational context is to ensure that students comprehend scientific concepts, promote their structuring of scientific knowledge, gain the skill of scientific thinking and adopt the scientific process skills. In order for individuals to have the desired qualities with a view to ensuring the sustainable scientific, technological and economic development of countries, the quality of science education needs to be improved (Ayas, 1995). Teachers, as education practitioners in raising individuals who will ensure sustainability, are a vital part of the educational process (Eilks et al., 2006; Loughran, 2007). In addition to their role of teaching in the classroom setting, teachers also have duties, like, to be investigative in assessing the practices and introducing new seekings to improve the quality of teaching and perform conscious educational practices. To achieve this, teachers need to use their reflective thinking skills in relation to educational process. The research method that can be employed by teachers for this purpose in the process of practicing and by which they can assume the responsibility of research is the “action research”. Action research was suggested as an approach that encourage teachers to control their own studies contributing their academic progress and will contribute to development to fill the gap between theoretical (Bolton, 2010; Burnaford, 2011; Burns, 2010; Farel, 2004; Jay & Johson, 2002) and

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practical teaching practices (Eilks & Ralle 2002; Scott & Driver 2003). The aim of action research is not to generate new knowledge but improve and change the process in the educational situation (Feldman, 1996). The aim of action research is to identify real-world problems and develop practical and applicable solutions (Coghlan & Shani, 2014). It is achieved through a systematic research by comparing different approaches, exchanging ideas, analyzing the problem, finding solutions for the problems it analyzes (Capone et al., 2016). The basic cycle of action research consists of identifying the problematic area, gathering and organization of data, interpretation of data, and databased action and reflection stages. Research cycle is as given in Figure 1.

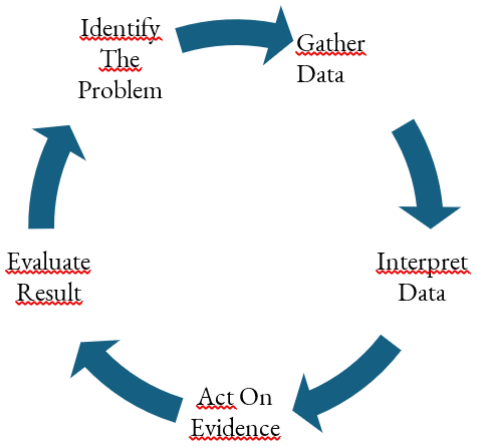

Figure 1. The cycle of action research (Ferrance, 2000)

In the step of identifying the problem, which is the first stage of action research, researcher asks meaningful and applicable questions. A careful planning of the first stage will ensure action research to proceed smoothly (Ferrance, 2000). After gathering the data, the data interpreted guides researcher in drawing out the needs of action. Whether or not improvement has occurred is demonstrated by examining the action research results planned based on the results from the data. This cycle should continue until the desired result is achieved (Carr & Kemmis, 1996).

Action research can be performed by the practitioner's himself/herself or an external researcher while it can be done by several practitioners together. There are various classifications in the literature by different qualities of action research depending on the point of view of the researcher.

Table 1. Classification of action research

Grundy (1988, as cited in Berg, 2001)	Technical Action Research Practical Action Research Emancipatory Action Research
Holter & Schwartz- Barcott (1993, as cited in Berg, 2001)	Technical-Collaborative Action Research Mutual-Collaborative Action Research Enhancing Action Research
McKernan (1991, as cited in Berg, 2001)	Scientific-Technical Action Research Based on Problem Solving Practical-deliberative action research Critical-emancipatory action research

Berg (2001) combined these approaches and classified action research under three types:

Technical/Scientific/Collaborative Action Research: According to this approach, the first aim is to evaluate a specific situation within a predetermined theoretical framework

Practical/Mutual Collaborative/Deliberative Action Research: In this approach the researcher and the practitioner come together to identify potential problems and look for ways to avoid their underlying causes and possible interventions

Emancipatory / Enhancing / Critical Action Research: Emancipatory / enhancing / critical action research is an approach that provides new knowledge and skills to researcher ensuring them to perform reflective thinking towards their own

practices. Thus, the researcher will be able to look critically their own practice, generate explanations for the problems in practice and question their role in the process.

Action research is one of the research methods employed in sciences education, as in many disciplines of education, to eliminate the emerging problems. A literature review revealed that there is no review study that addresses the studies on action research carried out in sciences education from different perspectives. This study is assumed to fill this gap in the literature, being guiding for researchers and educators who will use action research method.

Problem of Study

By this study, it is aimed to set forth the problem situation, working groups and subject area of action researches in science as a result of review of articles in the Web of Science (WoS) database. In this respect, the general purpose of the study was determined to "review the articles involving action research in sciences education published in WoS database". In line with this general purpose, answers were sought for the research questions given below:

- Which problem situations did the articles in the Web of Science (WoS) database involving action research in sciences address?
- What is the distribution of the articles in the Web of Science (WoS) database involving action research in sciences by years?
- What working groups do the articles in the Web of Science (WoS) database involving action research in sciences involve?
- What findings were obtained in the articles in the Web of Science (WoS) database involving action research in sciences?

Method

Research Model

This research is a type of qualitative research and was designed as a review study Maule and Goodman (2009) state that review studies are carried out in three different types (as cited in Karaçam, 2013). These are narrative review, systematic review and meta-analysis. This article is based on a systematic review of action research studies on science education. Systematic review aims to bring evidence together to answer a pre-defined research question. This involves the identification of all primary research relevant to the defined review question, the critical appraisal of this research, and the synthesis of the findings (Gough, Oliver & Thomas, 2012). Systematic reviews use objective and transparent methods to identify, evaluate and summarize all relevant research findings. When carried out well, systematic reviews provide the most reliable evidence about the effects of tests, treatments and other interventions (Centre for Reviews and Dissemination, 2024). Within this scope, the studies that were carried out using action research in science education were reviewed in this study taking certain criteria into consideration and presented to the attention of researchers with certain characteristics.

Inclusion and Exclusion Criteria

This study was carried out on the research articles in the Web of Science (WoS) database as it includes the reference indexes regarded as most prestigious by academic circles (Şeref and Karagöz, 2019). WoS provides a wide range of data repository as it contains numerous databases and journals. It, thus, provides great opportunities for researchers for literature review. In the study, many different criteria were applied in selecting the relevant researches. The assessment steps related to these criteria are presented in Table 2.

Table 2. Criteria for Selecting Articles

Inclusion Criteria	Exclusion Criteria
Studies including the key term "Action research"	Studies carried out before 2014 and after 2023
WoS database	
Last 10 years from 2013 to 2023	

Firstly, articles were restricted to the years 2014 to 2023. In this context, the studies the publication year of which is a year between 2023 and 2024 with "action research" as the research method were included in the study. This period was selected because it represents recent research in science education. In addition, the studies which are "Open access" and "article" were included in the review while "Education & educational research" was selected as WoS category. Narrowed-down citation topics was selected as "Science education" with inclusion of the research articles in English in the review study.

Search Procedures

To begin with, the phrase "action research" was typed in the search bar in WoS Core Collection database on 1 January 2013 and a search was performed selecting the following criteria: Language: English, Document Type: Article, Timespan: 2013-2023, Open Access: All Open Access. Besides, with the inclusion of the fields "Education & educational research" in the scope of the review study, 47 studies were included in the study and reviewed in line with the study objectives set. While the action research articles in science education were reviewed within the scope of the study, the studies that include the practices for the problematic cases experienced were made subject of review. The action research articles which were carried out in theoretical scope in science education were excluded. The reason why researchers have such an attitude is to provide a general point of view towards the problems that are experienced in science education and share, in general, the results achieved.

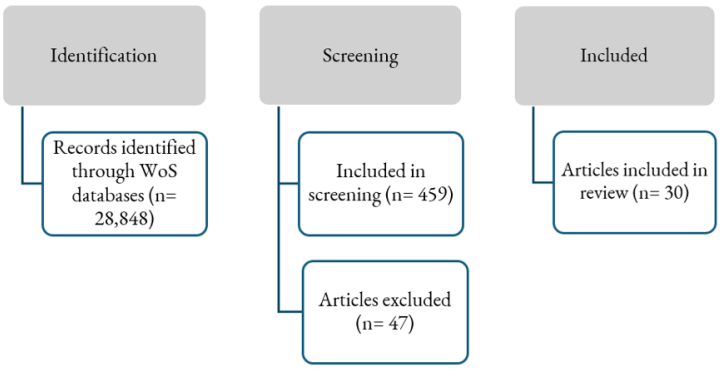

Figure 2. Numerical data used to evaluate stages based on specific criteria

Researcher Positionality

Researchers selected the articles at the time of screening in parallel to the criteria set. Apart from the researchers, expert opinion was obtained on whether the articles meet the criteria set, after screening. With this, it was aimed to strengthen the aspects of validity and confidence targeting "internal consistency" and "persuasiveness". Another point for which an expert support was needed is the phase where the data collected in line with the subgoals of the study was set forth. And after the content analysis performed, it was aimed to receive feedback on the unbiasedness of the data by sharing the findings with the same expert apart from researchers.

Data Analysis

First, the selection of articles is performed based on the inclusion criteria set. All articles selected were reviewed by the researchers and a consensus was sought on whether any given article meets the criteria set and achieve the subgoals of the study. All articles selected were sent to the expert, who gave feedback on whether they are in line with the subgoals.

As the second phase, articles were reviewed in line with the subgoals of the study set. At this phase, content analysis was employed. A coding scheme was created for this purpose. The articles were shared out by researches for content analysis and were reviewed on a shared database by importing the coding scheme into Excel. Among the articles, which were analyzed for content, three were selected for different researchers, each, to review for consistency across researchers. The consistency across encoders was found to be high as a consensus of 90 percent was observed as a result of the consistency study performed (Miles & Huberman, 1994). This result can be interpreted that the findings obtained from the content analysis by researchers are valid and reliable.

The data obtained in the third phase of the study were submitted for expert opinion. Content analysis was performed by the expert by randomly selecting three articles which were analyzed by different researchers. It was concluded that as a result of the analysis, the findings that were analyzed by the expert and the findings by the researchers were significantly compatible. In this context, the review study revealed the following findings.

Findings

The following sections present the results of the review. Findings for Research Question (RQ) 1 are presented in what problem situations are addressed in the articles containing action research in the field of science education found in the Web of Science database. Findings for RQ 2 illustrated what is the distribution of articles containing action research in the field of science education in the Web of Science database by year. Findings for RQ 3 are presented which study groups are included in the articles containing action research in the field of science education in the Web of Science database. Findings for RQ 4 are presented as findings obtained in the articles containing action research in the field of science education in the Web of Science database.

Research Question 1. The problem situations that articles containing action research in the field of science education address

This study reviewed 30 articles that employ action research in the field of science education. In reviewing the articles, the unique structures of the problem situations addressed were employed with no limitation on subject. The frequency of the problem situations addressed in the articles are summarized in Table 3.

Table 3. Problems addressed in action research

Theme	**f**	**%**
Teaching methods	5	16.67
Students' skills and emotions	13	43.33
Teacher Education and Development	7	23.33
Learning Environments and Technologies	3	10
Scientific Concepts and Content	2	6.67
Total	30	100

As shown in Table 3, the problem situations addressed in the action researches in science education were divided into 5 different categories. The most studied problem situation is the situations related to "students' skills and emotions" (43.33%) which is followed by the situations related to "teacher education and development" (23.33%) and to "teacher methods" (16.67%), respectively.

Year

This study also addressed the distribution of the studies on action research by years. The chart on the results is given below.

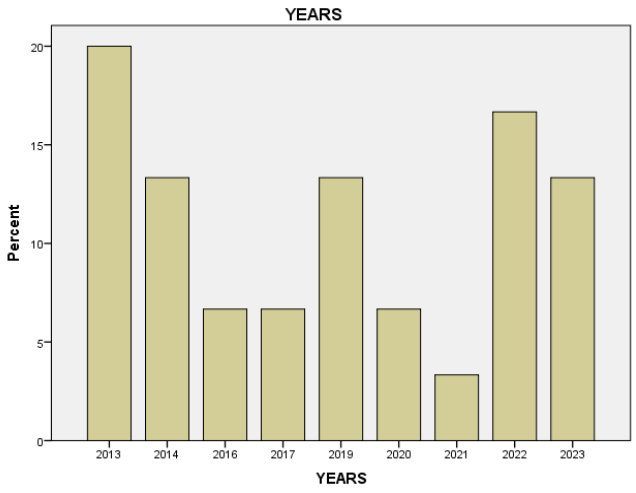

Figure 2. Number of action researches in science education between 2013- 2023

A remarkable fluctuation is observed between 2013 and 2022. Number of studies increased in some years while they decreased in some others. The reasons for this fluctuation may be research budgets, academic interests or external factors (e.g. pandemic) etc. And in recent years, particularly in 2023, 4 studies (13,3 per cent) were performed. This may indicate that recently, the interest in the subject has still been strong.

Study Group

It gives ideas for practical use to researchers in addition to the group in which action research was studied. Therefore, this study reviewed with which group or groups the action researches were performed. The results were presented in Table 4.

Table 4. The study groups in the articles

Participations	**f**	**%**
Pre-school students	1	3.33
Elementary school students	1	3.33
Middle school students	2	6.67
High school students	9	30.00
University students	3	10.00
Pre-service teachers	5	16.67
Teachers	4	13.33
Teacher + Middle school students	2	6.67
Teacher + High school students	3	10.00

It is seen that most of the researches included high school students, candidate teachers and teachers. It is remarkable that pre-school pupils and elementary school students were less included in the studies. This distribution may offer the opportunity to focus on the missing or less represented groups in future studies.

Findings

The findings of the majority of action research have been positive. The findings were established to be in the fields of "scientific thinking and skills development", "design of educational settings and use of technology", "understanding of terms", "intercultural and inclusive education", "new student-centered educational approaches", and "teacher education and Professional development". Table 5 presents the distribution of findings.

Table 5. Distribution of findings

Field	**f**	**%**
Innovative Educational Approaches	8	26.67
Teacher Education and Professional Development	8	26.67
Scientific Thinking and Skills Development	7	23.33
Intercultural and Inclusive Education	4	13.33
Understanding of Terms	2	6.67
Design of Educational Settings and Use of Technology	1	3.33
Total	30	100

As shown in Table 5, the fields in which most findings were obtained the "Innovative Educational Approaches" with 26,67% and "Teacher Education and Professional Development", respectively. These are followed by "Scientific Thinking and Skills Development" with 13.33%, "Understanding of Terms" with 6.67% and "Design of Educational Settings and Use of Technology" with 3.33%.

Discussion

Sciences education plays an important role in providing scientific knowledge and skills to learners. Efforts are made to improve the quality of science education. In this context, the articles on action researches in science education in WoS database were reviewed.

As per the findings of the study, the problem situation of "learners' skills and emotions" was addressed most in the studies on action research in science education that was carried out between 2013 and 2023. Emotions are factors that

affect one's way of life, working capacity and increase or decrease of their activities. Dzerviniks (2011) concluded that the active learning of learners may be remarkable depending on the learner-teacher relationship, emotional state of teacher and learner, and learner's cognitive skills. Poonputta (2021) concluded that the emotional attitude after the application of STEM education instructional plans is higher than the emotional attitude prior to the application. In other words, action research applications in STEM education has a favorable effect on the emotional attitude of students. Another subject which was studied most in the studies on action research in science education is "teacher education and development". Teachers can closely review the needs and change of the teaching environment by getting familiar to themselves in research and practice within their reflecting skills through their own research. Action research enables educators to review and improve the teaching and learning process. In this context, the challenges of teaching practice, professional skills and development caused the demand for the practice-based research. Varsat (2013) concluded that teachers develop both professionally and personally as they participate in action research and what they learn from teaching process has effects on what will happen in the education and training processes in future. It can be claimed that action research applications positively affect the aspects of learners' skills and emotions and teacher education and development.

When examined by years, action research in science education was performed most in 2013 and least in 2021 between 2013-2023. A fall might have occurred in the number of the studies due to the COVID-19 (Coronavirus disease 2019) pandemic experienced in 2020 and 2021 as active participation in action research is important. The reason why the number of studies carried out after COVID-19 can be construed with the sudden changes in the field of education caused by the pandemic. The impact to education, remote education, online environment and individualized teaching gained importance with the pandemic. It can be interpreted as the adaptation to the changing conditions in the field of education after COVID-19 pandemic and the preparedness for similar situations that may be faced in future. Most of the action research studies carried out in the field of sciences education after COVID-19 pandemic addressed the "Socio-scientific" subject while stress was laid on the creation of social product creation and development of reasoning skills in students.

It was found that most of the studies on action research in sciences education that was carried out from 2013 to 2023 included high school students, candidate teachers and teachers. The reason why most of the studies were carried out in high school students is that the students were in a critical phase, would pass to young adulthood and to contribute to the academic, social and emotional development of students. One of the study groups most studied were candidate teachers and teachers. It can be claimed that teachers and candidate teacher, who will raise the future generations, are one of the study groups most studied as they contribute to professional development, classroom management skills, ensuring the active participation of learners, use of learner-centered educational approaches that increase the permanence in learning, ensuring the cooperation between teachers, and improvement of educational activities. The group least studied was pre-school and elementary school students. It can be claimed that less number of studies were carried out in pre-school and elementary school students as the attention level of such students are low, scientific education involves abstract concepts, and STEM education, which is one of the innovative approaches, requires the provision of high level thinking skills such as critical thinking, problem solving skills. In order to be able to maintain the high quality of education, teachers should have learning characteristics involving continuity such as adaptation to changes, self-improvement etc., and be provided the opportunity to continuously improve. In Table 5, one of the findings obtained most is "Teacher Education and Professional Development". In her study where she investigated the influence of an in-service training program on English language teachers' professional development, Qındah (2019) demonstrated that it has a positive influence on their professional development in terms of learner's participation, teaching strategies and evaluation and that the skills of giving constructive feedback and classroom management were developed. Table 5 shows that one of the findings most commonly found is "Innovative Teaching Approaches". While inclusion of the ways of learning such as online environments, which is one of the innovative teaching approaches replacing conventional educational practices, individualized learning etc. in education, saves time and place, they offer learners the opportunity to watch the recorded courses over and over again in the cases such as COVID-19 pandemic in

2019 and to regulate their own learning experiences. The outbreak of COVID-19 pandemic in 2019 caused a decrease in the number of action researches in sciences education in 2020 and 2021 as shown in Table 2. Innovative teaching approaches are an approach that gives place to STEM applications and allow for individual learning, providing reasoning skills, and project-based learning, shifting learners from conventional learning environment and offers a social point of view. It provided the opportunity to employ online media, which is one of the innovative teaching approaches, in such extraordinary situations. It can be claimed that the number of action researches carried out in this field increased with the online media, individual learning etc. that has become important. Another innovative approach is STEM education. Landicho (2020) found in his study of 46 STEM teachers/researchers that teachers/researchers developed positive attitudes towards their own learning skills and students' learning experiences. In Escopete's study (2023), motivation of teachers to carry out action research is the provision of a quality environment and support and fosterage by school administrators. Teachers should be encouraged and supported to do action research.

Conclusion

Action researches are an important research method for the enhancement of the quality of sciences education and for improvement. It is clear that the studies on action research in sciences education contributes the learners' development cognitively, emotionally and socially. Action research is a frequently employed method in science education to address and improve issues, as in many other disciplines of education. A review of the literature revealed no systematic review studies examining different aspects of action research in science education. This study aims to analyze articles indexed in the Web of Science (WoS) database to identify the problem statements, study groups, and subject areas addressed. The research is based on a qualitative research method, specifically a systematic review. As a result of the keywords determined, 30 articles published between 2013 and 2023 were included in the study.

According to the findings, the most frequently studied problem statements were related to "students' skills and emotions," while the least addressed problem statements were associated with "scientific concept and content." In terms of distribution over the years, the highest number of studies were conducted in 2013 and 2022, while the lowest number was observed in 2021. Regarding the study groups in action research conducted in science education, it was found that most studies focused on high school students, preservice teachers, and in-service teachers. The majority of the findings pertained to "innovative educational approaches," while the least focus was on "designing educational environments and the use of technology."

This research highlights the need to encourage and support teachers in conducting action research. In line with this study, it is seen that action research in sciences education helps the professional development of teachers in the changing and improving matters and the enhancement of the quality of education in classroom management. This study hopes to emphasize the importance of action researches in science education and promote the action research studies in science education. Providing support to teachers and researchers is expected to increase the conduct of action researches and improve the quality of science education.

Recommendations

In future studies, the scope can be expanded by incorporating different keywords not only in science education but also in interdisciplinary topics. By comparing the results of action research from various fields, issues in science education can be identified more clearly. Challenges in science education can be supported with data obtained through interviews with individuals working in this field. Additionally, this research can be revisited in the future to regularly track changes in trends related to the subject.

Limitations of Study

This study included articles indexed in the Web of Science (WoS) database that contained the keyword "action research" and were published between 2013 and 2023. For WoS categories, "Open access," "article," and "Education & educational research" were selected. The narrowed citation topic was determined as "Science education," and only research articles in English were included in the review.

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