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Research Article

Science Curricula and Science Teachers Training in Turkey: Past, Present and Future

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Abstract – The article highlights the challenges to science curricula and science teaching programs in Turkey and analyzes both these challenges and the opportunities that exist for teachers, teacher educators, policymakers. The aim of this literature review is to identify the historical development of the science curricula and the policies for science teacher training in Turkey. This research encompasses an analysis of the science curricula from before 2005, and those of 2005, 2013, and 2018, focusing on their alignment with educational needs, expectations, and curriculum outcomes. The evolution of science teacher training programs in Turkey for the years 1998, 2007, and 2018 has been assessed, and potential future modifications to these programs have been deliberated. The findings reveal that although curricula have been progressively updated to meet contemporary standards, teacher training curricula have not kept pace, resulting in numerous issues including compromised education quality and performance in international exams. The review offers recommendations for educational practices, emphasizing the need for coordinated efforts between the Ministry of National Education in curriculum development and the Turkish Council of Higher Education in shaping teacher training policies.

Key words: Science curriculum, Teacher training, Science education, Turkey.

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Introduction

Different science curricula have had different balances between the needs of science and scientists, of students, and of society (Childs, 2015). The development of new curricula is a common occurrence in countries around the world (Rogan & Grayson, 2003). Although the first changes in science curricula originated from the establishment of countries, political, social and scientific developments also had an effect on the changes that occurred until the following years (Bakaç, 2019). The increasing number of students and teachers, innovations in educational philosophy, the addition of new learning areas (Ünsal et al., 2008), changes in the number of subjects and curriculum outcomes (Kurtuluş & Çavdar, 2011), changes in national placement exams (Koç et al., 2008), changes in the compulsory school year (Karatay et al., 2013; Ministry of National Education [MoNE], 2013), innovations in measurement and evaluation techniques (Özyurt et al., 2014), low-performance results in exams such as PISA and TIMSS (Çakır & Yaman, 2018; Yaz & Kurnaz, 2020), engineering and technology innovations, and the country's socio-economic development plans (Güneş et al., 2018) effects curriculum reforms. Turkey, with a population of eighty-three million people, is the second most crowded country in Europe. While 1.629.720 of the students in formal education are preschoolers, 5.279.945 students are at a primary school level, 5.701.564 students are at a middle school level and 5.630.652 students are at a secondary school level (MoNE, 2019a). The number of students in Turkey is higher than that of those in most of the European countries. More than one million teachers have been employed in educational institutions (MoNE, 2019a). Understanding how and why the education system has developed and changed over time will enable readers to appreciate the present-day challenges faced by science teacher educators, researchers, teachers, and students and offers some context for considering what issues are significant to address in the future (Faisal & Martin, 2019). This literature review highlights the challenges to science curriculum and science teaching programs in Turkey and analyzes both these challenges and the opportunities that exist for teachers, teacher educators, policymakers.

Aim of the Literature Review

The objective of this literature review is to examine the historical and current states of the science curriculum and science teacher training programs in Turkey, with the aim of understanding the interrelationship between them. The review also seeks to explore the implications of these programs by forecasting potential future developments. By considering the trends in science teacher training and science curriculum development within Turkey's social, political, and educational contexts, the review addresses the following questions:

- What are the historical changes in the development of the science curriculum in Turkey, and how might these influence its future trajectory?

- What have been the defining features of science teacher education in Turkey historically and in contemporary times, and what are the potential future implications of these characteristics?

The Importance of Literature Review

As part of this literature review with national and cultivating change science education and science teachers in Turkey in the international arena in the past and is intended to provide information and publicity about today's developments. It also provides predictions about possible future changes. Different studies have examined the changes in the education programs of different countries. Tuan and Lu (2019) examined science teacher education in Taiwan by dividing it into three parts according to years. In the first part, between 1949-1994 (being a sufficient science teacher and a good role model), in the second part, between 1994-2017 (being a professional science teacher and a good role model), and in the third part, between 2018 and later (science teachers that questions and can integrate different disciplines) were considered. In addition, in the last section, the society's view on the science teacher certificate is mentioned. Similarly, Wei (2019) explains that regarding the science teacher in Macau, the autonomous state did not have an educational innovation until 1999, and after this date, after being connected to China, the personnel rights of science teachers were improved. It has also been stated that science teachers have difficulty in subjects that require the integration of interdisciplinary education, such as STEM. Again, in Park's (2019) study, he focused on the history of the appointment of science teachers in Korea according to their graduation level, their graduation from universities or colleges today, and the skills that science teachers should acquire in the future. In these studies, the past and present of science teacher education in the subject countries are discussed in order to determine or predict the future. Particular emphasis is placed on interdisciplinary integration, which is a trending education approach. Similarly, with the spread of STEM education in our country, curriculum updates and engineering applications subjects have been added in parallel. In addition to these studies, Faisal and Martin, (2019) focus on science education with the history of pre-service and in-service training of science teachers in Indonesia. It appears that the researchers also addressed innovations in science curricula in Indonesia, student learning, and teachers' challenges. In addition, the study includes suggestions for increasing the rate of schooling and doing science and the quality of teachers. Apart from these, Kang (2019) focused on the past, present and future of science education for gifted students in Korea. Gilbert et al. (2003) summarize the past, present and future of research in the field of science education worldwide. Rennie and Stocklmayer (2010) conducted research on the past, present and future of the development of science and technology, focusing on the role of it in social learning. In their study, Zohar and Barzilai (2013) analyzed the articles in the ERIC database and made predictions about the current status and future of metacognitive development of publications in science education. Based on all these publications, it becomes clear that a similar study should be conducted in Turkey. It is important to analyze the historical development, current situation and future of science teacher training in Turkey and similar developments in science curricula. In these studies, the development of science education and the historical change in the training of science teachers are discussed. The main purpose of these studies is to introduce the situation in their country at national and international levels. Similar goals are used in research on the historical development of science education or science teachers (Rudolph, 2008). Especially in terms of science education examining up to change and development since Turkey's establishment is of great importance. In the literature, it is possible to find studies comparing student and teacher training between countries (Geesa et al., 2019). This study of science education related to Turkey, is thought to be the source for this type of work. It is thought that by giving the development process of science education in detail and in-depth, it will set an example for future studies or updates. Similarly, it is believed that changes in teacher training can be followed. In addition, research in different countries, is the source for the data belonging to Turkey for researchers.

The role of science teachers in delivering science education, as guided by the science curriculum, holds significant importance at both national and international levels (Peker & Dolan, 2014). It is inevitable to update science curricula due to reasons such as the development of technology, the structuring of knowledge, the social effects of science, the impact of knowledge on solving daily life problems, the acquisition of twenty-first century skills, global innovation studies and the economic-industrial development goals of countries. As a matter of fact, there are updates in science curricula. Similarly, science teacher training also needs to be updated. By updating science curricula according to interdisciplinary integration, science teacher training programs also need to be updated. The increase and importance of science communication requires the integration of scientific innovations for the benefit of society into the curriculum and teacher training programs. The need for new generations of qualified questioners requires the development of science curricula and therefore the updating of science teacher training programs. Because it is the teachers who will implement the science curriculum. Having the two updates in parallel will make science education healthier. For these reasons, the historical development, current situation and future of both science curricula and teacher training programs should be analyzed. In this way, it is important to obtain a situation report for Turkey and shed light on future studies and policies.

Method

This research was conducted with the document analysis method, which is evaluated within the scope of the literature review. The research presented in the content of this method is the detailed investigation of the subject determined among the available resources and the systematic collection of the subject (Fraenkel & Wallen, 2006). Data regarding the science teacher training program and science curriculum in Turkey were identified, interpreted, estimated and evaluated. Within the scope of the literature review, a document analysis was conducted, involving the examination of written and visual documents containing comprehensive information and insights relevant to the research topic. This process involved scrutinizing related publications in the literature. Document analysis entails the thorough evaluation of documents to extract relevant data and understandings pertinent to the research subject. (Creswell & Plano Clark, 2011; Glesne, 2013).

Table 1 Analyzed Contents

Categories	**Analyzed Documents**	**Title and content**
MoNE Science Curriculum	Elementary science curriculum (1924) Elementary science curriculum (1926) Elementary science curriculum (1938) Elementary science curriculum (1949) Elementary science curriculum (1969) Elementary science curriculum (1974) Elementary science curriculum (1992) Primary science curriculum (2000)	Science Curriculum Before 2005
	Science and technology curriculum (2005)	2005 Science Curriculum
	Science curriculum (2013)	2013 Science Curriculum
	Science curriculum (2018)	2018 Science Curriculum
Turkish Council of Higher Education (CoHE) Science Education Teacher Training Programs	Teacher training curriculum (1998) Content of undergraduate science education (2007)	Teacher Training in the Past
	Content of science undergraduate education (2018)	Teacher Training in the Present

Table 1 shows the analyzed contents of science curriculum and science teacher training programs. We tried to reach all the science curriculum since the foundation of the republic. In this context MoNE (1974, 1992, 2005, 2013, 2018) science curriculum examined. In addition, five updates of MoNE before 1974 were also examined (MoNE was established in 1920). The CoHE teacher-training program (1998, 2007, and 2018) analyzed. In this review, the curriculum outcomes, contents, education process and evaluation dimensions of the programs were discussed. All of these dimensions are mentioned below under the headings of the relevant years. The publications in this context were analyzed descriptively. It covers presenting existing data with numerical values and classifications to the reader in a more fluent and descriptive manner (Yıldırım & Şimşek, 2013). This analysis in the context of educating science teachers and science curriculum changes occurring in Turkey, starting from the 1920s to the present day has been reported. Based on these data, the estimates for the future of science education and science curriculum have been established in Turkey.

Results

In order to interpret the historical evaluation of Turkey's science curriculum and its impact on future development, the curricula need to be examined in detail. We used before 2005, 2005, 2008, 2013 and 2018 definitions to examine the changes in science curriculum. Because 2005 is accepted as a period when reform movements started.

Science Curriculum Before 2005

It has been found out that nine different regulations had been made in science programs between 1923, when the Republic of Turkey was founded, and 2005. Those regulations were mainly aimed at promoting the Republic regime and making it widespread. At the same time, the prominent scientists worldwide, like John Dewey (Erdoğan, 2007), were consulted on the issue. In the following years, the updates continued to be made depending on the scientific and sociological developments in Turkey and around the world. In the 1940s, the emphasis in the curricula being updated overtime was on the curriculum outcomes such as having curiosity, displaying a positive attitude, and understanding the importance of science. It was also suggested that education should be student-centered. In the 1970s, it was pointed out that the use of science in everyday life problems as necessary. As of 1992, the curriculum outcomes came to the forefront, such as being able to do experiments and observations, using one’s own mind, and also being able to relate science and technology with each other. With a radical decision being taken in 1996, elementary schools (five years) and middle schools (three years) were integrated with each other, and compulsory primary education was enacted for the first time in the history of the republic. Elementary schools and middle schools were all renamed as primary schools. For such reasons, there became a change again in 2000. In the 2000s, the skills and the curriculum outcomes, such as collecting, analyzing, and presenting data, gained importance. In general, the courses were teacher-centered and based on the students' doing homework (Ayas et al., 1993; Bakaç, 2019; Yurdatapan, 2011). Table 2 shows the updates in science curricula between 1924 and the 2000s.

Table 2 Updates in Science Curricula before 2005

Year	Course name	Subjects	Course Hour	Source
1924	Nature and Objects Sciences	These courses were given separately: Animals, Plants, Hygiene, Physiology, Physics, Chemistry and Science Applications.	8 hours	Bakaç (2019), Yurdatapan (2011)
1926	Nature and Objects Sciences	These courses were given separately: Animals, Plants, Physiology, Physics, Chemistry and Science Applications.	4 hours	Bakaç (2019), Erdoğan (2007)
1938	Natural Sciences	Zoology, Botany (also Physics)	3 hours	Budak & Budak (2014)
1949	Natural Sciences	Living creatures, Human body, Systems, Animals, Plants (also Physics)	3 hours	Yurdatapan (2011)
1969	Science and Natural Sciences	Scientists, Substance, Living creatures, Animals, Weight, Heat, Body, Plants, Weather, The Earth, The Sun, Light, Chemistry	3 hours	Erdoğan (2007), Yurdatapan (2011)
1974	Science	It covers the subjects of Physics, Chemistry and Biology.	3 hours	MoNE(1974), Yurdatapan (2011)
1977	Science		4 hours	Yurdatapan (2011)
1992	Science		3 hours	MoNE (1992)
2000	Science		3 hours	Erdoğan (2007), Yurdatapan (2011)

According to Table 2, the updates in the science curricula in 1924 and 1926 mostly included the courses consisting of the science subjects, which were given separately. In addition, the name of the course was "Nature and Objects Sciences". It is understood that the Physics subjects were still being taught both in 1938 and 1949 although the course was called "Natural Sciences". The course which was named "Science and Natural Sciences" in 1969 was later renamed "Science" in 1974. It is understood that Physics, Chemistry, and Biology were now in the same curriculum. The course hours above have been given on a weekly basis. In addition, it is known that in some years there was an increase or a decrease of one hour in accordance with the class level. It is understood that Physics, Chemistry or Biology subjects were all included in science courses, or they were given separately although the science courses generally had different names in all years.

2005 Science Curriculum

MoNE updated the science curriculum with the purpose of making a contribution to individual skills, such as science literacy, researching and questioning, problem-solving, critical thinking, and decision-making in 2005. What is remarkable in this curriculum is that the principle that an individual can learn for a lifetime was added into it (Tekbıyık, 2018; Tüysüz & Aydın, 2009). In addition, it was decided that the science curricula should be prepared from that day on by taking the opinions of the academicians, field specialists, parents, students, and teachers (Erdogan, 2007). The subjects of Technology, Society and Environment were also added into the curriculum besides Physics, Chemistry, and Biology, and the course name was changed to "Science and Technology" (MoNE, 2005).

The teacher-centered structure of the curriculum was changed, and the curriculum was developed with student-centered approaches and constructivist philosophy. The curriculum for science and technology courses adopted such principles as constructivist learning, science and technology literacy, new and alternative evaluation techniques, physical and mental development of the students, spiral principle, integrating all disciplines, meaningful learning, and the view that less knowledge is more (Özdemir, 2007). The subject areas in this curriculum were presented in four different categories. The main subjects were determined to be ‘Living Creatures and Life’, ‘Matter and Change’, ‘Physical Events’, and ‘the Earth and the Universe’(Ünsal et al., 2008). Although there were four different subjects determined, three new subject areas were also added into the curriculum, which are Science-Technology-Society-Environment, Scientific Process Skills, and Attitudes and Values (MoNE, 2005).

It has been found out that there were some negative thoughts about the 2005 science curriculum besides the positive ones although the curriculum was thought to be great by the teachers when it was first enacted. When compared to the previous curricula, this curriculum and the changes in it were positive in general (Bukova et al., 2005; Coşkun, 2005; Erdoğan, 2007). It is possible to say that the new curriculum had a positive effect on students’ learning (Delen & Kesercioğlu, 2012). It has been determined that the students who were educated under the 2005 science curriculum enjoyed the courses (Çeken, 2010). Moreover, it has been found out that the participation of students in the courses increased positively with the new curriculum (Aydın & Çakıroğlu, 2010; Küçüköner, 2011).

The science curriculum had some aspects which were thought to be negative as well as positive ones (Dindar & Yaygın, 2007). First of all, the fact that it was an unusual curriculum gave rise to a bias. The application of the curriculum was negatively affected by some reasons. For example, the curriculum was found to be overly extensive, encompassing numerous subjects and skills, coupled with an excessive number of student activities. This complexity made it challenging for students to complete their homework. Additionally, there was a notable scarcity of materials and equipment, further compounded by the issue of overcrowded classrooms. The most negative thing was that the courses were still teacher-centered (Doğan, 2010; Kurtuluş & Çavdar, 2011; Özdemir, 2007). It has been determined that the teachers had difficulty in telling the subjects in a timely manner and doing laboratory activities (Şengül et al., 2008). It has been observed that the negative aspects of the curriculum consisted of the problems arising from the fact that professional development seminars were introduced inadequately, the teachers were not informed about the alternative measurement and evaluation techniques in the curriculum, and science subjects requiring mathematical skills were told before the math's subjects (Bütüner & Uzun, 2011). In addition to these, there was another problem arising from the fact that the eighth graders at the middle school level took private lessons outside of the school. In the examination the students entered for passing to an upper class, there were some questions, which were out of the subjects and outcomes in the curriculum (Koç et al., 2008). It has also been found out that some teachers had difficulty in the application of Science-Technology-Society-Environment, Skills, and sensorial curriculum outcomes (Buluş-Kırıkkaya, 2009). For all these reasons, it was inevitable for the curriculum to be changed again.

2013 Science Curriculum

The science curriculum was updated when eight-year compulsory primary education changed into 12-year compulsory education, which involved an education period with four years of elementary school, four years of middle school and four years of high school with the regulation made in 2012. 2013 curriculum started to be gradually implemented in third grades at the elementary school level, fifth grades at the middle school level, and nineth grades at the high school level. With this curriculum, the "Science and Technology" course was renamed "Science". The 2013 curriculum was based on "research and inquiry" instead of constructivism although the vision of this curriculum was not different from that of the 2005 curriculum (Benli Özdemir & Arık, 2017; Karatay et al., 2013; Keskinkılıç Yumuşak, 2017; MoNE, 2013).

The curriculum mentioned here had four main subjects with four learning areas, which are 'Living Creatures and Life', 'Matter and Change', 'Physical Events' and 'The World and The Universe' for called "Knowledge", Scientific Process Skills for called "Skill", Attitudes and Values for called "Sensorial" and "Science-Technology-Society-Environment". Subjects and learning areas were integrated with each other. The aim in the integration of the subjects with the learning areas was to make the individuals science-literate, who have developed general and sensorial skills in Science-Technology-Society-Environment, besides having the basic knowledge (Karatay et al., 2013; MoNE, 2013).

Although the 2013 curriculum had more positive aspects than the 2005 curriculum in general, it is also understood that it had also some negative or incomplete aspects. Some of the innovations with this curriculum, which are thought to be generally positive, were that the students' readiness levels were taken into account in the preparation of the curriculum, there were fewer curriculum outcomes, the process was being evaluated, and the curriculum outcomes that could support the development of students' cognitive, sensorial and psycho-motor characteristics were integrated with the curriculum outcomes of the subjects (Özcan & Küçükoğlu, 2014; Tekbıyık, 2018; Toraman & Alcı, 2013). Furthermore, the order of the subjects was changed, and what is most important is that the changes were made in accordance with the other courses. The subjects were told in the same order as the Mathematics subjects or other disciplines. It is stated that especially the decrease in the number of curriculum outcomes was positively welcomed by the teachers (Keskinkılıç Yumuşak, 2017).

It has been found out that one of the negative aspects of the 2013 science curriculum was that there were no exemplary practices in teaching and evaluation processes. Another one was that alternative evaluation techniques were not introduced, and they were not supported with any example (Özata-Yücel & Özkan, 2013; Özyurt et al., 2014). It has been observed that the curriculum outcomes in the 2013 curriculum mostly remained at the level of knowledge, and the number of curriculum outcomes at the conceptual level was higher especially in the upper classes. It is known that this curriculum, which aimed to prepare the students for higher education, had a limited number of curriculum outcomes to stimulate the ability of high cognitive thinking (MoNE, 2013; Yaz & Kurnaz, 2017). As a result, the 2013 science curriculum went through a change in 2018. Although this change was caused by the above-mentioned negative aspects, it is thought that the political-educational problems that arose after the coup attempt in Turkey in 2016 could also be one of the reasons for the change in the curriculum.

2018 Science Curriculum

The science curriculum was issued as a draft in 2017 and organized with the consultation of the academicians, teachers, and parents, and it was implemented in 2018. It has been observed that the learning areas in the 2018 curriculum, which are knowledge, skills, sensory skills, and Science-Technology-Society-Environment, remained the same when compared to the ones in the 2013 science curriculum. Only some of them had minor changes in it (Candaş et al., 2019). On the other hand, the number of subjects (‘Living Creatures and Life’, ‘Physical Events’, ‘Matter and Nature’, ‘The Earth and The Universe’) was increased from four to five. With the newly added subject areas of “Science and Engineering Applications”, the students were expected to understand the importance of science and scientific processes. In addition, the aim is the integration of engineering with technology was to raise the students’ awareness of the scientific developments that would be beneficial for the socio-economic development of the country (Güneş Koç & Kayacan, 2018). Moreover, the targeted products in the fields of science and engineering were decided to be presented through such events as a project exhibition and a science fair. Science festivals, where the products made in the school environment will be exhibited, were aimed to be arranged. Furthermore, it is thought that increasing STEM education approaches were effective in the addition of these subject areas (Bakırcı & Kutlu, 2018).

The number of outcomes in the curriculum was slightly reduced. The aim here was to have unity in the implementations by clarifying the limitations and explanation parts of the curriculum outcomes. The attention was particularly paid to the association of the curriculum outcomes with daily life. The aim of avoiding the curriculum outcomes that could create an information overload was to make it more interesting. In this context, the evaluation part of the curriculum was prepared in accordance with the international standards. Especially the evaluation systems such as TIMSS and PISA, which have been held worldwide, were taken into account. Moreover, the measurement and evaluation methods and techniques were exemplified (Cengiz, 2019).

Providing teacher guidance was emphasized in the curriculum to be important as well as having a student-centered structure. Furthermore, the values education of teachers, which existed in the curriculum in an implicit manner, was given importance. Such skills as having universal, moral, and cultural values and decision-making were also mentioned in the curriculum (Deveci, 2018). The curriculum centered upon research and inquiry although there was no change in its philosophical and theoretical structure. Apart from these, scientific processes, life skills, and innovative and entrepreneurial thinking skills were highlighted in the context of 21st-century skills (Deveci et al., 2018; MoNE, 2018). Interdisciplinary relations were made in an implicit structure in the curriculum. There were no direct curriculum outcomes from the other disciplines, and the repetitions were avoided accordingly. The attention was paid to the harmonious time frames of the curriculum outcomes associated with the other disciplines. The subjects told at some different class levels were replaced with each other (Bahar et al., 2018).

The 2018 science curriculum is generally regarded as positive in all respects (Özcan et al., 2018; Saraç & Yıldırım, 2019). It is known that some of the teachers stated that they might need a separate draft or booklet for measurement and evaluation apart from the curriculum. It is thought that the curriculum outcomes were still too many although the number of them was reduced (Cengiz, 2019). Apart from these, there is a concern that there might be a problem due to the teachers' inadequate knowledge in the practices of science and engineering (Özcan et al., 2018; Saraç & Yıldırım, 2019).

Potential Directions for Future Science Curricula

It is possible to say that it was after the 2000s that there were different and permanent changes in the science curricula (Benli Özdemir & Arık, 2017). It is also possible to state that these changes were positive and innovative in general (Karatay et al., 2013). Today's curriculum has been shaped by many types of research and interviews. The changes in the curricula are the result of the political, economic, and social developments in the country. Turkey has gone through a continual revision process, considering the national and international variables. Regulations and continuity, in this sense, are good in a general term. According to Table 3, which shows the three important changes after the 2000s, it is possible to say that the numbers indicate how significant the changes in the curricula are.

Table 3 Comparison of the Science Curricula Subjects in 2005, 2013 and 2018 in Terms of the Curriculum Outcomes and Course Hours

	Number of Curriculum Outcomes			Course Hour		
Science Curriculum Subjects	2005	2013	2018	2005	2013	2018
Living Creatures and Life	221	78	73	180	174	150
Physical Events	299	84	75	178	202	198
Matter and Change	194	65	52	166	126	108
The Earth and The Universe	93	39	27	52	74	72
Science and Engineering Applications	-	-	15	-	-	48
Total	807	266	242	576	576	576

Table 3 has been prepared according to the science curriculum (for fifth, sixth, seventh and eighth grades). As it is seen in Table 2, while the 2005 and 2013 curricula cover four subjects, the 2018 curriculum also include the fifth subject, which is "Science and Engineering Applications". As a matter of fact, this field shows hope for science education

(Thiry et al., 2017). The number of curriculum outcomes was reduced from 807 in 2005 to 266 in 2013. Then, with the change in 2018, the number of curriculum outcomes was reduced to 242. In all curricula, the course hours are the same, which are 576 for each. However, it is clear that the number of course and hours depending on the subjects differs from one another. There is probably going to be a decrease in the number of curriculum outcomes and the course hours in the future. But rather, it seems to be a matter of debate how the curriculum outcomes will be achieved.

The process of the coronavirus, which has affected the world like a pandemic, shows that the question of where and how the curriculum outcomes will be achieved is more important than the number of the course hours or the curriculum outcomes. The technological infrastructure of all the schools in Turkey has been strengthened with "Fırsatları Arttırma ve Teknolojiyi İyileştirme Hareketi (FATİH)" (The Project of Increasing Opportunities and Improving Technology). In general terms, the interactive boards and the internet can be used easily in the courses. In addition to the technological infrastructure of the schools, the courses were continued through "the Education Information Network" during the epidemic period. Moreover, the education process at all class levels has continued with EBA television channels. Apart from all these, the schools have prepared online courses for the students with their own means. This platform provides such opportunities as maintaining the education process and making evaluations in traditional ways. During the pandemic process, this platform has begun to be used more effectively. It is clear that EBA is an instrument that can be used efficiently in the pandemic process. It is thought that the measurement and evaluation parts of the platform should be improved (Sarı, 2020). According to the data released by the "Turkish Statistical Institute" in 2019, 75.3 % of the people in Turkey use the internet. However, it is thought that participation and motivation are not at an expected level although the online courses are supported by television (Sarı & Nayır, 2020). It is thought that the following education curricula will focus on the efficiency of online education. Online education will be used in the technology part of the curriculum, and it will be activated in any case of a disruption in education. It is thought that the studies will be especially carried out on the development and dissemination of the measurement and evaluation techniques in online education.

Although there is an overall and a rapid improvement in the number and type of the curriculum outcomes, it is thought-provoking that most of the outcomes in the current curriculum are at a basic level. There should be curriculum outcomes that appeal to the high cognitive levels of the students (Yaz & Kurnaz, 2017). The curriculum outcomes should include scientific and social information, enable the individuals to think and allow them to produce alternatives, thus making them find creative solutions with an investigative spirit. In other words, the curriculum should also enable the individuals to learn the information, methods, and techniques which they can use to solve daily or social problems, rather than only getting information and passing it to an upper class (Doyle et al., 2020). In addition to the science curriculum, the basic characteristics of historical and contemporary science teacher education in Turkey and its effects on the future are presented below.

Historical Overview of Teacher Training

As the Republic period was underway, teacher training was one of the issues that require urgent solutions as a very important problem. With “The Law of Education System” in 1926, the teacher training schools were classified as “The First Teacher Training Schools” and “Village Teacher Training Schools”. In the 1927-1928 academic years, a teacher training curriculum was prepared for the schools in the rural areas, and two "Village Teacher Training Schools" were opened in Denizli and Kayseri provinces to train teachers for the village schools. However, this curriculum, which was used for four years, failed to meet the expectations (MoNE, 1992). Until 1948, 21 village institutes were opened in various parts of the country, and additionally, a high village institute that provided three years of higher education to train temporary head teachers and supervisors in primary schools was established in the Hasanoğlan Village Institute. The teachers in the village institutes were trained to work in the villages and to support the regional development because, in those years, 80% of the population is known to have been living in the villages (Şeren, 2008). Until 1953, there were two types of teacher training policy for primary schools; the institutions which were training teachers were united under the name of "The First Teacher Training Schools” after 1953. These schools gave education for 6 years after elementary school and for three years after middle school. From the foundation of the Turkish Republic to the early 1990s, there was a constant change in general terms, and the graduates of Physics, Chemistry, and Biology, who were trained as high school teachers, began to teach at middle schools as science teachers. As of 1992, the fact that the universities started to train science teachers has been an opportunity to improve education and to increase the quality in this field. Until 1998, only Gazi Faculty of Education and Buca Faculty of Education trained teachers in the field of Science, and these faculties implemented the curricula in a way that they determined themselves (Meriç & Tezcan, 2005).

Current State of Teacher Training

Within the framework of the reconstruction since the 1998-1999 academic years, the science teaching curriculum has been published by CoHE and sent to the faculties for implementation. Of the 97 faculties of education, 66 have a science teaching department and they have been training teachers in the field of science.

Table 4 A Comparison of the Course Hours in Theory and Practice of the Professional Knowledge Courses in Science Teaching Department

	Theoretical course hours (T)	Practical course hours (U)	Course credit (K)
1998	130	50	157
2007	132	42	153
2018	130	36	148

Table 4 shows that the least course hours in the practical courses belong to the year 2018 when the updates in 1998, 2007 and 2018 are compared depending on the theoretical and practical hours of the professional knowledge courses in the science teaching department (CoHE, 2007, 2018). When the contents of the courses are examined, it is understood that the theoretical course hours remain constant over the years.

Courses in science teaching department are divided into three sections: field education courses (F), professional teaching knowledge courses (PT), general culture courses (GC). Among the field courses, there are also Physics, Chemistry, Biology and Mathematics included, which are the major science courses. In 2018, CoHE, which is responsible for teacher training, updated the teacher training curricula. The percentage of the professional teaching knowledge courses in the curricula is 30-35%; general culture courses15-20%; and field education courses 45-50% (Turkish Education Association [TEDMEM], 2019). Professional knowledge courses consist of educational sciences, science teaching, interdisciplinary science teaching and science laboratory courses. General culture courses are the courses thanks to which the teacher candidates can keep up with the new conditions of the changing world. Four years of teacher training process has been divided into 8 semesters. Table 5 shows the courses given in these 8 semesters.

Table 5 Course Contents in Science Teacher Training

First Year	Second Year	Third Year	Fourth Year
First Semester Courses	Third Semester Courses	Fifth Semester Courses	Seventh Semester Courses
History of Turkish Revolution and Ataturk's Principles-1 (GC)	Teaching Principles and Methods(PT)	Turkish Education System and School Management(PT)	Teaching Practice-1 (PT)
Turkish Language-1 (GC)	Research Methods in Education(PT)	Measurement and Evaluation in Education(PT)	Guidance at Schools(PT)
Foreign Language-1 (English German or French) (GC)	Approaches in Science Learning and Teaching (PT)	Science Teaching-1 (F)	Interdisciplinary Science Teaching (F)
Information Technologies	Biology-2 (F)	Science Teaching Laboratory Applications-1 (PT)	Environmental Education (F)
Introduction to Education (PT)	Physics-3 (F)	Astronomy (F)	Professional Knowledge.Elective-5 (PT)
Philosophy of Education (MB)	Chemistry-3 (F)	Professional Knowledge. (PT)	Elective-5 (Human Anatomy and Physiology) (F)
Physics-1 (F)	Vocational Elective-1 (F)	General Culture-Elective-3 (GC)	Elective-5 (Evaluation of In-Class Learning) (PT)
Chemistry-1 (F)	General Culture Elective-1 (GC)	Elective-3 (Renewable Energy Sources) (F)	
General Mathematics-1 (F)	A. Elective-1 (Biological Resources of Turkey) (GC)		
Second Semester Courses	Fourth Semester Courses	sixth Semester Courses	Eighth Semester Courses
History of Turkish Revolution and Ataturk's Principles -2 (GC)	Turkish History of Education(GC)	Morals and Ethics in Education(PT)	Teaching Practice-2 (PT)
Turkish Language-2 (GC)	Teaching Technologies(PT)	Classroom Management(PT)	
Foreign Language-2 (English, German, French) (GC)	Community Service Applications(GC)	Science Teaching-2 (F)	
Educational Psychology (PT)	Science Curricula(PT)	Science Teaching Laboratory Applications-2 (PT)	
Sociology of Education (PT)	Biology-3 (F)	Scientific Reasoning Skills (F)	
Physics-2 (F)	Geology(F)	Professional Knowledge. Elective-4 (MB)	
Chemistry-2 (F)	Professional Knowledge Elective-2 (PT)	General Culture. Elective-4 (GC)	
Biology-1 (F)	General Culture. Elective-2 (GC)	Elective-4 (Material Design in Science Teaching)(PT)	
General Mathematics-2 (F)	A. Elective-2 (Applications of Science in Technology)		

Table 5 shows the courses taken by the science teacher candidates in the faculty of education. All universities provide the same subjects for the teacher candidates although each of the subjects has a different name within the framework of the universities’ academic structure. During the academic period of the faculties, the educational courses are given by the academicians with general educational backgrounds while the science-related courses are given by academicians who are experts in their fields. In general, the subjects told by field experts are selected to be at a challenging level for teacher candidates.

It has been observed that the curriculum does not have applications that can provide socialization and motivation. It is also clear that there are no contents such as 21st-century skills, research and inquiry applications, or STEM education. In addition, the teacher candidates are settled in this department according to the superiority of the scores they have had. Their interests, needs, and vocational tendencies are not taken into account either before or after the academic period. Those teacher candidates, who complete the academic period, take the public personnel selection examination and the field examination. The average scores of the candidates taking the field proficiency tests are the lowest ever obtained especially from higher education transition exams in the field of science in recent years (TEDMEM, 2019). If they succeed in these examinations, the oral interview process on teacher proficiency begins with the establishment of central commissions. The teacher candidates, who become successful in the interview, are subjected to the central appointment according to their score superiority. After that, they are obliged to serve for at least three years under contract in the region where they have been appointed.

Future Prospects in Teacher Training

Educational reforms are directly linked to teacher training (Ültanır & Ültanır, 2018). While MoNE determines the needs for teacher training, CoHE is the institution that responds to these needs. Accordingly, MoNE policies should be participatory, data-based, holistic and long-term. The aim of the document “2023 Education Vision for a Strong Future” prepared and published by MoNE was to address the shortcomings in the implementation. In this document, it is notable that there are the subjects such as the formation of the institutions that train teachers, professional development, personal rights, the improvements in different types of employment and the teaching profession law. This can be interpreted as the evaluation of the teaching profession as a whole (MoNE, 2020). In most institutions in Turkey, there is a gap between education curricula and the contextual needs of the teachers (Balbay et al., 2018). “A school is just as good as the teachers in it” (Kavcar, 2002). Increased awareness that "quality in education is the key to success" has led to the innovations and therefore the progress. With the rapid development of digital technologies and their use in the education and training process, it is necessary to add programs for the recognition and use of these technologies in teacher training programs (Thiry et al., 2017; Thoma, 2019).

It has been determined that teachers have difficulties in using these technologies, especially in the distance education process, which has increased in importance with the epidemic period (Sarı & Nayır, 2020). Science teachers should have training to use digital technologies not only for the future, but also from now (Webb, 2019; Zhu & Liu, 2020). Finally, in the selection of future science teachers, teacher candidates' interests and abilities should be considered. A science teacher candidate to the exam center program in Turkey is taken. These candidates are placed on the basis of getting points by solving the right questions from any discipline in the exam they take (CoHE, 2020). It can be expected that the willing candidates will be selected and enjoy disciplines such as physics, chemistry, and biology, and solve some of the questions arising from these disciplines.

Discussion and Conclusion

In this literature review, which is about the past, present, and future of science curricula and science teacher training in Turkey, it has been found out that primary education should be in compliance with undergraduate curricula in terms of philosophy, purpose, and content in order for the teacher candidates to be able to implement this curriculum more successfully and to dominate this curriculum. Because the teachers are the practitioners of science training curricula at schools, it is important that they should be trained with contemporary knowledge, skills, and attitudes and be aware of the new learning and teaching approaches and theories used in science education (Demir et al., 2007). It has been observed that while the education system has a general philosophy, teacher training faculties and institutes do not have a philosophy of education specific to branches but only the general philosophy of the education system (Filiz & Kaya, 2013). It is thought that the final goal should be to find a solution to the concerns about qualification and the central administration should define the standards for the teacher training process and its outcomes. CoHE, rather than defining the standards for the updates in the curricula, sharply identifies all the undergraduate curricula to be applied in the faculties of education and do not give place to flexibility, authenticity, and the attempts to be made for the innovations beyond the minimum limits for qualifications (TEDMEM, 2019).

Although the changes in the science curriculum are not considered sufficient (Özcan et al., 2018; Saraç & Yıldırım, 2019), it is stated that updates are generally made in the science curriculum by considering current world conditions, scientific developments, and political policies (Bahar et al., 2018; Deveci et al., 2018). Until 1998, the training of science teachers in Turkey was conducted exclusively by only two universities, each of which had independently established their own science and teacher training programs (Meriç & Tezcan, 2005). Hence the consistent and systematic results of implementing a national-level program. Over the years, it is seen that theoretical knowledge has become more prominent in teacher training policy. However, teaching, which is a practical profession, should have practical training as well as theoretical knowledge (Çetinkaya et al., 2013).

It has been determined that the science curriculum aims to solve daily life problems with the latest update (MoNE, 2018; Özata Yücel & Kanyılmaz, 2018). However, it has been determined that teacher training programs also address problems away from daily life with intense theoretical knowledge (CoHE, 2018; Yadigaroğlu et al., 2017). The teacher training program should be updated on this issue. Students need to know where in their future lives they can use the knowledge and skills they acquire (Bahar et al., 2018; Muñoz-Campos, Franco-Mariscal, and Blanco-López, 2020). The science curriculum should be organized in a way that supports the professional life of the students and the careers them in this field. Excursions, on-site monitoring, internships and the information about how the tools used are obtained should be available in the science curriculum and become a country policy (Şimşek et al., 2013; Thiry et al., 2017). In addition, professional education at the middle school level (11-15 years) and the indispensable professional branches in the society should be integrated into the curriculum in a very proper way (Rolfsman, 2020; Turan & Kayıkçı, 2019). As a matter of fact, it has been determined that the vocational training students receive during school affects their after-school lives (Hsu et al., 2020).

Turkey has not achieved the expected success in international examinations (Özcan et al., 2018). The indication of it is that Turkey is at the 40th-45th place as a result of the TIMSS and PISA examinations covering science, mathematics, and reading skills. As a matter of fact, according to the 2019 PISA results, it can be said that there has been a slight recovery in science education, and we are above average (MoNE, 2019b). The curricula in Turkey has recently been integrated with daily life problems; however, the measurement and evaluation part of the science curriculum is not sufficient to measure these problems (Balbağ et al., 2018). In general, the theoretical and practical structure of the science teaching curriculum in Turkey does not match with the international examinations (Bayrak & Erden, 2007; Güngör & Bekmezci, 2023; Kuran & Kanatlı, 2009). Considering the ages of the current teachers working for the MoNE, 22.95 % of the teachers are at the age of 30 or below, 38.86 % are between 31-40, 26.29 % are between 41-50, 10.41 % are between 51-60, and 1.48 % is at the age of 61 or above. In general, it can be assumed that older age group teachers received training according to the old teacher training program, learned traditional methods and adopted these methods. Also, it is known that these teachers use traditional measurement and evaluation practices (MoNE, 2019a). For this reason, the science teachers should be allowed to use alternative measurement and evaluation methods, as in the PISA and TIMSS examinations. In addition, educational contents should be selected in accordance with the methods and techniques used in these examinations.

Especially in recent years, great efforts have been made to reveal the teachers' profile (Canado, 2018). In order to train qualified teachers, the education system should be continually evaluated in all aspects, and teachers should always participate in in-service training. The studies carried out in the universities aiming to train qualified teachers should be reshaped according to the changing time and needs, should be up-to-date and scientific, should be equipped with practical techniques and technological infrastructure in accordance with the needs of the new generation (Parlar & Halisdemir, 2020). The reason for it is that the courses in the faculties of education should include the contents such as the research and inquiry of the day, 21st-century skills, and STEM education. In the training of science teachers, the course contents should also be updated considering the expectations of the day and the expectations of the MoNE 2023 vision document.

MoNE points out that they need ninety thousand more teachers besides 1.160.293 working teachers, and they are planning to meet this need within four years (MoNE, 2019a). With the gradual decrease in the need for more teachers, it has been revealed that MoNE should focus on the problems of quality in education rather than the quantity (Anıl, 2009). MoNE has recently been involved in many theoretical-practical in-service training activities to have more qualified teachers. However, these in-service activities are not enough for one million teachers. MoNE, which has a central approach in administration, should organize joint studies with universities to focus on teacher training. Especially with the start of the pandemic process, MoNE has tried to increase the online education opportunities through Informatics Network (EBA). However, online education activities have been negatively affected with the fact that they only include theoretical knowledge, they have been planned to be teacher-centered, the teachers are not all digitally efficient, there is a lack of access for disadvantaged groups, and the internet infrastructure has some problems (Sarı, 2020; Sarı & Nayır, 2020). It is thought that practical applications are not adequate. In addition, the teachers and students who are in the Eastern and South-eastern (disadvantaged) regions of Turkey cannot reach those opportunities (Dönmez, 2020). As can be seen, MoNE and CoHE can solve the current problems by acting in coordination.

Technological developments are increasing rapidly in the world. In addition to groundbreaking inventions in the fields of communication and telecommunication, unmanned aerial vehicles, developments in software fields and increasing interest in robotic coding fields require changes. Interdisciplinary integration, the importance of which has been emphasized intensively since the 2000s, is seen as the fundamental pioneer of industrial and economic development. In addition, global epidemics or disasters emphasize the need to increase protection methods and preventive activities in the health sector. Along with all these, the need for qualified individuals equipped with 21st century skills is included in governments' plans to eliminate future concerns. As can be seen, humanity, which is in a rapid change, has to keep up with the continuity of science and technology. As a matter of fact, science is at the center of all these developments. The development of all of these fields is parallel to the progress in science. For these reasons, science curriculum needs to be updated. They are science teachers who implement the science curriculum. It is unthinkable that teacher training programs cannot be updated in the face of updated curricula. After all, science teachers are the practitioners and communicators of science. In the education of science teachers, they need to be trained with updated training programs on subjects such as technology, innovation, research and development, robotics-coding, interdisciplinary integration, global health problems-prevention and coping with daily life problems. For these reasons, both science teacher training and science curriculum need to be updated in parallel and integrated. In new updates, global problems or targets should be analyzed and reflected together with national expectations. Science teachers are practitioners, communicators and role models of science. A teacher equipped with the requirements of the age can shed light on new generations with a strong curriculum.

Suggestions

CoHE and MoNE should act together about the science curricula and in the training of science teachers. In this context, the faculties of education and public schools should be combined with each other. The reason for it is that education faculties function depending on the universities with legal entities. Although universities are linked to MoNE formally and indirectly, it is thought that the updates on the curriculum by the MoNE are not completely adopted by the faculties. Therefore, the faculties of education, the schools and the units that update the curriculum should be directed by the same institution particularly for the field of science.

The framework of formal education in science curricula, there should also be educational activities such as the ones including science museums, art events and excursions.

Teachers, students and parents should be encouraged in this regard. Similarly, the holidays in the academic period should be supplied with the activities that can allow students and teachers to both rest and learn.

In the current CoHE science teacher training program, there are only laboratory practices in two semesters. The development of science laboratories in schools should be increased by increasing laboratory practices and integrating them into the science curriculum (Especially due to the danger of chemicals, chemicals in all laboratories were confiscated).

The curriculum's especially international measurement and evaluation dimensions such as PISA and TIMSS should be kept alive, and brochures and educational activities should be developed according to it.

A sustainable curriculum integrated with the state policy should be developed in accordance with the views of teachers, students and parents. Activities should be planned in a way that students can discover their own interests and abilities.

Knowledge of field, professional knowledge and knowledge of general culture should be provided for the teachers in the schools, and they should be renewed within the framework of the updated curricula.

Compliance with Ethical Standards

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Türkiye'de Fen Bilimleri Dersi Öğretim Programları ve Fen Bilimleri Öğretmeni Yetiştirme: Dünü, Bugünü ve Geleceği

Özet:

Bu makale, Türkiye'deki fen bilimleri dersi öğretim programları ve fen bilimleri eğitimi programlarındaki zorlukların altını çizmektedir. Ayrıca hem bu zorluklar hem de mevcut fırsatlar öğretmenler, eğitimciler ve politika yapıcılar için analiz edilmektedir. Bu literatür taramasının amacı Türkiye'de fen bilimleri dersi öğretim programının tarihsel gelişimini ve fen bilimleri öğretmeni yetiştirmeye yönelik politikaları belirtmektir. Bu araştırma kapsamında 2005 öncesi, 2005, 2013 ve 2018 yılı fen bilimleri dersi öğretim programları ihtiyaçlar, beklentiler ve program çıktıları açısından analiz edilmiştir. Türkiye'deki fen bilimleri öğretmeni yetiştirme programlarının gelişim süreci (1998, 2007 ve 2018) değerlendirilerek gelecekte olası program değişiklikleri tartışılmıştır. Programların zaman içerisinde çağın standartlarına uygun olarak güncellendiği bulgulardan anlaşılmaktadır. Ancak öğretmen yetiştirme programlarının güncellemelere ayak uyduramadığı, bunun da eğitimin kalitesi, uluslararası sınavlar gibi farklı aşamalarda pek çok soruna yol açtığı gözlemlenmiştir. Bu literatür taramasında, eğitim uygulamalarından ve özellikle öğretim programlarının hazırlanmasından sorumlu Milli Eğitim Bakanlığı ile öğretmen yetiştirme politikalarından sorumlu Yükseköğretim Kurulu arasındaki koordinasyona yönelik öneriler sunulmuştur.

Anahtar kelimeler: Fen bilimleri dersi öğretim programı, Öğretmen eğitimi, Fen bilimleri eğitimi, Türkiye.

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