DEVELOPMENTS IN THE FIELD OF SCIENCE EDUCATION IN TURKEY THAT TOOK PLACE BETWEEN 1938-1980

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Introduction

What is Science?

For years, scientists have been grappling with the question; what is science? The most important reason for this is that science has a developing and evolving structure, and there are no limits to scientific topics and the methods employed. The idea embraced over recent years has been that science is an activity that attempts to explain the universe (Soslu, 2014). Science has been described differently by many researchers. According to Ronan (2005), science is an intellectual adventure. Francis Bacon defined the goal of science as improving the fate of man on Earth and argued that the way to achieve this goal was through theories obtained through fact-based observations (Köroğlu & Köroğlu, 2016).

Physical Sciences?

There are three basic disciplines in the creation and development of scientific knowledge. These are "formal sciences," "social sciences and humanities," and "physical sciences" (Sakız, 2018). The field of research of formal sciences is mathematics and logic, and its subjects of study are not perceptible and tangible with its study materials not physically found in nature, but only in thoughts on an abstract level. The field of research of social sciences and humanities is the historical, cultural, and social existence of man (Bilen, 2015). The research area of physical sciences is a natural phenomena, and laws that regulate such phenomena (Goblot, 1954).

The purpose of physical sciences, also called natural sciences, is to understand and explain natural phenomena (Karasar, 2015). Physical sciences include physics, chemistry, biology, geosciences, and environmental sciences. The common goal of all these sub-areas is to understand nature and the laws that regulate it (Sakız, 2018).

Physical sciences play a significant role in the social and economic development of a nation. To this end, countries should pay particular attention to science education to keep pace with scientific and technological developments, to make continuous progress and to create a qualified pool of human resources that can generate information and produce technology (Ünal, 2003). Science education has two main objectives: Its first objective is to raise individuals who can adapt to the changing and evolving age of science and use the latest technological innovations in all areas. Its second objective is to teach individuals that science is necessary for technological discovery and development

(Hançer, Şensoy & Yıldırım, 2003). Countries that want to build a strong future for their citizens emphasize that every citizen must have a good education and that special importance must be given to science education in the process (Eş & Sarıkaya, 2010).

Science Education

In many parts of the world, science education is an indispensable part of education. Students gain literacy in science through science courses in the curriculum (Holbrook & Rannikmae, 2007). Scientific literacy requires the ability to approach, explain, evaluate, and interpret a problem scientifically (OECD, 2017).

Inclusion of science courses in primary school curriculum dates back to the 19th century. As in other disciplines, the basic principle of scientific programs in that century was based on memorizing the knowledge. These teacher-centered programs were replaced by objective teaching in the 1850s. The basis of this approach was the observation of the natural environment by the learner. The aim was to improve learners' observation and communication skills. However, this approach could not go beyond learners defining and memorizing the object they observed instead of understanding and interpreting it (Gücüm & Kaptan, 1992).

In the 1950s (January 1, 1950 to December 31, 1959) the world had for the most part been liberated from the effects of the Second World War, but the cold war between the Soviet Union and the United States that began in the 1940s had escalated into a steep competition. The struggle between Soviet Russia and the USA to achieve superiority over one another continued intensively, and these two states, which were striving for superiority in the air, took their rivalries to space (Gülmez & Tahancı, 2014). Hence the greatest developments in science teaching began after the Second World War. Russia, in particular, launched a man-made satellite (Sputnik 1) into space for the first time in 1957 (Ayas, 1995). That same year, a dog named Laika went on a space trip. In 1961 the Russian cosmonaut Yuri Gagarin remained in the Earth's orbit for 108 minutes with a spaceship called Vostock I marking the beginning of space adventures for mankind. These developments spurred the United States, the United Kingdom and other developed western countries into action (Sakız, 2018).

The cold war between the two nations also influenced science and technology, putting more responsibility on schools. Countries that did not want to lag in the technological race decided to develop, renew or modernize their science curriculum to keep pace. For instance, there were scientific programs at all school levels designed to help with efforts to make discoveries and land on the Moon (Gücüm & Kaptan, 1992). This would raise an army of qualified scientists and accelerate the development of countries. This idea came to be embraced by all countries (Ingle & Ranaweera, 1984). Efforts to renew the science curriculum began in the United States spreading from there to Europe. Redesign

of the physical sciences curriculum began with the renewal of the content of physical sciences and math courses. For this purpose, Modern Physics (PSSC-Physical Science Study Committee), Modern Chemistry (CHEM-Chemical Education Material Study and CBA Chemical Bond Approach), Modern Mathematics (SMSG-School Mathematics Study Groups) and Modern Biology (BSCS-Biological Science Curriculum Study) curriculum were prepared. Laboratory booklets, teaching aids, and guiding materials for teachers were also included in these new programs (Ünal, Coştu & Karataş, 2004). So, how did all these developments in physical sciences affect our country? The innovation trend, which began in the field of physical sciences, undoubtedly influenced the Turkish national education system in the early 1960s. Some of the efforts to improve science education in our country were as follows: Founding of the Production and Repair Center for Teaching Materials in 1961, efforts to establish the Ankara Science High School in 1962, transformation of the Center for Instructive Movies into a Film, Radio, and Graphics Center in 1963 (Çilenti, 1985).

It turned out that the science programs developed between 1950 and 1970 appealed more to talented students. With the implementation of these programs, which did not appeal to all students, interest in elective science courses (especially physics and chemistry) gradually declined in developed western countries. New curricula have been developed to prevent students from falling out of love with science and renew their interest in science courses. Consequently, many new approaches emerged for designing science curriculum. The Learning Cycle and Generative or Constructivist Learning Model were the most important of these models (15). The Learning Cycle model is explained in detail under the heading "Science Curriculum Improvement Study (SCIS)." The Generative Learning Model, on the other hand, was developed by Wittrock (1974). The basis of this model was founded on the idea posited by Ausubel that students' foreknowledge is the crucial important factor in learning. According to Driver (1988), this learning model consists of four stages: In the first stage, students' foreknowledge is unveiled, whether correct or not. In the second or focusing stage, the students gain practical experiences with the desired concept. The teacher assumes the role of a guide in the process. In the third or challenge stage, students question their thoughts, compare them with others, and change them. The most important feature of the last stage, the implementation stage, is the reinforcement of the newly learned concepts. This is the phase where the learned knowledge is adapted to other situations, like writing an essay on a topic.

A look at the 1980s shows a world that has changed dramatically. As a consequence of that change, there was a need for individuals who could not only understand scientific principles but could also relate these principles to social changes, produce technology and apply it (Gücüm & Kaptan, 1992). By the end of the 20th century, science was considered both a product and a process (Harlen, 1991).

According to Yager and Penick (1988), science and technology are needed to adapt to rapidly changing and evolving technologies, to solve social problems related to science, to raise awareness of the importance of developing expertise, and to prepare individuals for academic life. In addition, science programs that can foster student interest in science are needed to keep pace with a continually changing world and to raise inquisitive individuals with a curious mind who can question, discuss, and think critically. Developing countries translated and adapted science education programs developed in the West. Because the program development process is expensive, time-consuming, demanding, and requires trained personnel (Ayas, Çepni & Akdeniz, 1993; Akman, 2016). However, it was realized that the adaptations of programs from other countries through translation were not as useful as expected. The main reason for this was that these programs had been designed in accordance with the cultural and socio-economic realities of the countries in which they were developed making them unsuitable for use in other countries (Özinönü, 1976).

Changes in Approaches to Science Education and Approach towards the Application of Science Programs

Since the mid-1950s, many scientists have done so much to improve the quality of the American education system. Studies to design innovative science programs conducted with funding from the National Science Foundation were as follows:

*_Physics Curriculum_, Physical Science Study Committee (PSSC),

*_Chemistry Curriculum_, Chemical Education Material Study (CHEM-Study),

*_Biology Curriculum_, Biological Science Curriculum Study (BSCS),

For primary education:

*Science A Process Approach (SAPA)

*Elementary Science Study (ESS)

*Science Curriculum Improvement Study (SCIS)

*Conceptually Oriented Program in Elementary Science (COPES)

(Demirbaş & Yağbasan, 2005)

Physics Curriculum

In the United States, physics was one of the most challenging courses for students to learn. For this purpose, the Physical Science Study Committee (PSSC) was founded in 1956. The committee rearranged subject matters such as quantum and wave theories which were still used but had lost their currency (Demirbaş, 2001). Critical and scientific thinking was the focus of the physics curriculum (Schaefer, 1988). In addition, laboratory

activities were prepared for students to acquire investigative skills. The main features that distinguished the modern physics curriculum from a traditional one were that it contained fewer subjects with more in-depth learning, barely included applications of physics in technology, and emphasized thorough learning of general principles (Haber-Schaim, 1971).

Biology Curriculum

In 1954, some committees (National Academy of Science, National Research Council) began their work by identifying problems in biology teaching before drawing up the curriculum. The Biological Sciences Curriculum Study Group (BSCS), founded in 1959 at the University of Colorado, contributed to the development of the biology curriculum. Biologists, teachers, writers, and administrators were also included in the study group. When selecting topics for the curriculum, special attention was paid to the selection of topics related to real-life. This increased the interest and motivation of the students in the courses. In the selection of topics, the systematics of living beings were relegated to a secondary position while evolution and the relationships between living beings were brought to the fore. In short, instead of describing living beings individually, the focus was placed on the relationship between nature and living beings, as well as the relationship of living beings to other living beings (Okay & Karamanoğlu, 1974).

Chemistry Curriculum

In 1957, the American Chemical Society initiated studies to give a new shape to chemistry courses, primarily at high schools and universities. They found that chemistry teachers were not satisfied with the subjects they were teaching and out-dated subjects were included in the curriculum (Turgut, 1970). The Chemical Bond Approach Group (CBA) was founded in 1959. This group aimed to make students gain scientific skills and review important theories and experiments. The name of the study group was later changed to Chemical Education Material Study (CHEM-Study) (Demirbaş & Yağbasan, 2005). The topics included in the chemistry curriculum were selected to deliver comprehensive teaching of the structure of matter, chemical energy and dynamic equilibrium. Very little weight was given to the industrial applications of chemistry. The experimental method was preferred as the dominant teaching method (Chemical Education Material Study, 1963).

According to Gücüm & Kaptan (1992), the following are some of the approaches towards the implementation of science programs for primary schools:

Science A Process Approach (SAPA)

The main purpose of this approach was to provide students with scientific skills through

experiments during the eight-year basic schooling period (5-12 years). Course books had no place in these programs. Children learnt by actively participating in activities. Teachers used a handbook that contains information on how to determine the teaching outcomes, how and in what order scientific skills are to be taught, what materials are used for the experiments, and how student success should be measured. The teacher was not at the center in this program, but rather fulfilled the role of an intellectual guide.

Elementary Science Study (ESS)

The main purpose of this approach is to help establish the concepts and relationships that form the basis of a child's education. In this approach, students take the center stage while teachers merely provide guidance. Students learn at their own pace, find answers to their questions through interaction with one another and diligent research, and so the learning takes place. The system does not allow the teacher to make an overall assessment.

Science Curriculum Improvement Study (SCIS)

The Learning Cycle model was developed after the mid-1970s with input from Piagetin, and Karplus was the main contributor in the development of this model. Using this model, Karplus and his colleagues developed a science curriculum known as the "Science Curriculum Improvement Study" (SCIS). The program is for 5-12-year-olds. This laboratory-based program which owes its existence to Piaget consists of three levels. Matter, living beings, change and concepts of conservation were taught at level I; the relativity theory was taught at level II; while level III covered subject matters such as energy, equilibrium, position, and reproduction. Karplus et al. proposed a cycle model consisting of three steps to seamlessly implement this program in a classroom environment. These are: "review or data collection," "introduction to the concepts," and "implementation of the concepts." Karplus (1960) briefly describes this model as follows:

During the review or data collection phase, students examine new equipment and other materials in the learning environment on their own without help. These experiences create confusion in the student's mind not being reconcilable with previously learnt concepts. By the end of this process, the student is ready to learn. In the introduction to the concepts stage, the student gets a new concept or a new book, a new film, etc. from the teacher. Then the student gets the definition of this new concept. In this way, the student can interpret his new experiences by utilizing the concept. This stage should be linked up with the review or data collection phase. Otherwise, students may have difficulties in learning. In the implementation of the concepts stage, students reinforce learning by adapting the concepts to different situations.

Conceptually Oriented Program in Elementary Science (COPES)

Science and technology have an increasing influence on people in modern societies. However, our society has little knowledge of science. The main reason for this is the wrong education system. So, what is the best way to help young children understand and like science in a way it can guide them in their future lives? For this purpose, the Conceptually Oriented Program in Elementary Science (COPES) was developed. This program aimed to help children focus on big ideas in science with comprehensive, integrative and conceptual schemes rather than fill their minds with unrelated facts and details. This program was a science curriculum that focused on some of the conceptual schemes in science. This basic idea was emphasized throughout the program: everything in the program refers to these conceptual schemes where possible (COPES, 1973).

Approaches to the Application of Science Programs in Turkey

Science programs developed in the USA were also applied in many European countries as well as Turkey. After the 1960s, science teaching projects were developed and put into practice in cooperation with the Ministry of National Education, the Scientific and Technological Research Council of Turkey and the universities and by also taking abroad cases into account. So, what was the state of program development studies in Turkey before the 1960s? Traditional program development studies in our country consisted of the following steps:

1. The Board of Education at the Ministry of National Education reviews the school curricula and defines the purpose of each course in general.
2. They make a list of the contents of the courses through an illustration of the topic titles.
3. The document gains official status when it is published as the resolution of the Board of Education.
4. Books written according to the established curriculum are accepted as textbooks.

After all these processes, the program development process comes to an end (Turgut, 1970). In these teaching programs inspired by a traditional understanding of education, the teachers had an active role and the students had a passive one. Since the students could not relate the science subjects in the curriculum to real-life situations, student success was rare (Çağlayan, 1961). Science books written according to a traditional understanding of education did not go beyond paltry definitions. Teaching aids and materials did not exist at all or were insufficient. During those years there was a shortage of teaching staff in almost all subjects. In addition, as in other subjects, graduates from departments other than science were appointed as science teachers. As a result, students' interest in science decreased (Alpaut, 1984). The decline of student interest in science courses led to a decline in qualified workforce employable in the fields of science and

technology. The shortage of skilled workers in the field of science and technology led to the revision of the science programs in Turkish schools. Starting from the mid-1950s, new projects have been introduced to improve science teaching. Some of these activities were: training of teachers in summer schools, domestic production of course materials, the establishment of mobile laboratories, preparation of educational films. In addition to these studies, the project period during which time modern scientific and mathematical programs were applied, played a key role in the improvement of science teaching (Turgut, 1970). The projects for science education developed in Turkey are as follows:

* Project for Science Education Units

*Science High School Project (1960-1967)

*BAYG-E-7 Project (1967-1968)

* BAYG-E-14 Project (1968-1970)

* BAYG-E-23 Project (1971-1976)

* BAYG-E-33 Project (1976-1980)

Project for Science Education Units

OECD experts held meetings with representatives of ministries and universities in Turkey and proposed the launching of the "Science Education Unit" projects under the supervision of Istanbul University's Faculty of Natural Sciences. Although within the project the most innovative ideas on mathematics and science courses were offered, the project was scuppered due to lack of funding (Acar, 1968).

Science High School Project

The most comprehensive modernization of scientific education in Turkey is embodied in science high schools. In 1963, an agreement was made between the Ministry of National Education and the Ford Foundation, and as a result, the Science High School project was initiated. This project was carried out jointly by the Ministry of National Education, Turkish universities and the University of Florida in the USA. With this project, a special high school called "Science High School" was founded and so modern education, which would be epitomized here, would spread around the entire country. This is how the modernization of secondary education in Turkey began. To participate in the project, a commission consisting of a total of 11 people, including 10 lecturers who were experts in the field of science and a teacher from the Ministry of National Education, was sent to the University of Florida in 1963 to carry out studies in book writing and translation. In the aftermath of the process, the Ankara Science High School began its educational activities in 1964 with about 300 students (Ayas, Özmen, Demircioğlu & Sağlam, 1999). With its first graduates in the year of 1967, the science high school achieved significant successes

in the university entrance examination (Şenvar, 1968). Modern programs developed in the USA (CHEM Study, PSSC, BSCS, etc.) were offered at this high school as a pilot project. These programs were more than a textbook. The program included a wide range of materials such as teacher's guide, resources for teachers and students, educational films, and laboratory equipment. In short, the program included not only the subjects to be taught but all teaching materials. These modern programs were then implemented in other high schools. However, since modern programs could not be applied to all high schools, the dichotomy of modern-traditional schools emerged. Moreover, since the desired levels of success could not be achieved, these modern programs were completely abolished in 1984 (Durusoy, 1984). But, what was meant by a modern program?

According to Turgut (1990), the most notable features of a modern program are:

1. The topics are mostly clustered around a central theme. The different branches of science in the program are associated with basic concepts.

2. For each branch, basic information is provided as well as the methods for accessing information.

3. Technological applications in each scientific branch are brought down to a level that gives the students an overview.

4. Each branch of science is introduced as a human endeavor, with references to the working methods of scientists.

5. The student stands at the center of all learning activities. The student doesn't just listen passively. He is also expected to have skills such as making hypotheses, drawing conclusions, and making generalizations. What is expected of the teacher is not only to impart knowledge to the student but also to guide him by directing him to learning activities.

The so-called modern programs were rather new in terms of both content and methodology. Teachers undoubtedly played an important role in ensuring the success of these programs. For this reason, teachers started to attend summer courses in small groups of science and mathematics teachers starting from the summer of 1965. The summer courses continued until the end of the science projects (Turgut, 1977).

BAYG-E-7 Project (1967-1968)

In the early months of 1967, the Scientific Commission for the Improvement of Science Education was set up to update and modernize science programs. This Commission, attached to the Board of Education, was a decision-making and executive body. Most of the members of the Commission were faculty members working in science and

mathematics departments at the universities in Ankara. Between 1967 and 1980, the Commission carried out activities such as the adoption and arrangement of science and math programs, the production and distribution of program materials, the training of teachers, etc. The Commission received financial support for the project from the Scientific and Technological Research Council of Turkey. When the institution could no longer provide funding for science education projects, the Commission was automatically dissolved (Turgut, 1990).

The BAYG-E-7 project was part of the effort to improve science education in line with the recommendations of the Scientific Commission for the Improvement of Science Education in collaboration with the Scientific and Technological Research Council of Turkey and with funding from the Ford Foundation. To this end, new programs were developed in parallel to modern programs and implemented in two classes of the science high school. Then these new programs were introduced to 9 schools in the academic year 1966-1967 (Ünal, Coştu & Karataş, 2004).

BAYG-E-14 Project (1968-1970)

The BAYG-E-14 project, carried out between 1968 and 1970, was developed by the Science High School. With this project, an overview of the basic principles and concepts of science and math were provided while the subject matters were covered using research methods to enable students to think scientifically. In this project, laboratory tools and equipment were developed by giving weight to lab studies. With the BAYG-E-14 project, nine high schools from different regions began a three-year trial education. This was followed by a comprehensive evaluation project. According to Turgut (1968), the main objectives of the assessment are:

1. Do modern programs fit into the lesson hours prescribed by the high school curriculum?
2. How successful are students?
3. What are the variables of learning in modern programs?
4. What are the views and attitudes of the teachers about the program?
5. What revisions are required for the programs?

Based on the monthly reports prepared for the evaluation of this project, teacher surveys and evaluations by inspectors, some amendments were made to the project. The amendments were made in accordance with the decisions of the 8th National Education Council. Based on the new arrangements, any incongruities between the curriculum of normal, technical and vocational high schools were minimized. The 1st grade in high school was considered a preparatory stage which students had to go through before choosing their specialties or vocations in the second grade. In addition, a general

science course program (Introduction to Physical Sciences) was introduced for first-grade students of high schools where modern science programs were to be implemented. Furthermore, intensified courses in physics, chemistry and biology were offered to certain classes spaced throughout a year (Ministry of National Education, 1995). The students' performance was measured through specially prepared tests. The results of the detailed evaluation were reported to the Commission for the Improvement of Science Education. Some important findings from the report:

1. None of the modern programs could be fitted into the lesson hours, so no teacher could cover the entire program in any of the classes.

2. The two main factors affecting student performance are the teacher's command of modern subjects and the extent to which teaching methods recommended in the teacher's guide are implemented.

3. It was understood that simplifications and scope restrictions were required to introduce modern programs to normal schools.

(ARYM Assessment Group, 1971)

Combined Science Programs

In the ninth grade, science lessons were delivered four hours per week as part of the "Introduction to Physical Sciences" program while tenth-grade Literature students received science courses within the scope of "Physical Sciences II". Both programs were imported from the USA and adapted to schools in Turkey (Haber-Schaim, 1971). According to Turgut (1975), a combined program means bringing together subjects from a variety of disciplines best suited to nourish behaviors desirable in students rather than delivering subject-based courses. With the adoption of the Physical Sciences programs, printed materials and teaching materials were produced and teachers began to be sent to summer courses for training. It was determined that Physical Sciences programs spread faster compared to earlier versions of modern programs. Two applications of Combined Science programs are "Science" and "Collective Science" programs. The Science program was formed by the combination of courses such as natural history, physics, and chemistry. Until 1969-1970, it was taught in secondary schools. The Collective Science program was the second tried modern science program developed for secondary schools. There are no textbooks in this program, but some books are still recommended. Moreover, in this program, students do not learn by reading or memorizing scientific concepts; and less weight is given to mathematical formulas (Gücüm & Kaptan, 1992).

BAYG-E-23 Project (1971-1976)

(Dissemination of Modern Programs)

The BAYG-E-23 project was prepared to implement the decisions of the 8th National Education Council and to greatly disseminate the program developed with the BAYG-E-14 project based on the feedback from pilot high schools. This project was implemented starting from the school year 1971-1972 at 100 high schools and 89 teacher's training schools (Demirbaş & Soylu, 2000). Furthermore, the "trial-correction-dissemination" strategy was embraced for this project. During the three-year teaching process, evaluation studies were carried out each year and a final evaluation report was produced at the end of the third year. Some of the most notable findings from the final evaluation report are:

1. Although it had been recommended to shorten the programs on the basis of the feedback from pilot high schools, the project was started with only a few amendments here and there, if at all. Consequently, most subject matters could not be covered at all, predominantly from the fields of Physics and Chemistry, and with less severity concerning Math and Biology.

2. Student performance was measured using assessment tests, but student performance varied greatly from school to school and from teacher to teacher.

3. High schools using modern programs were compared to those using traditional programs in terms of student success. High schools using modern programs proved to be more successful in university entrance examinations, graduation rates and in terms of the scientific reasoning skills of their students compared to high schools using traditional programs.

4. It was revealed that some changes should be made to the program materials, textbooks, and teacher's guides.(Turgut & Pekgöz, 1976).

BAYG-E-33 Project (1976-1980)

In September 1976, the BAYG-E-33 project was developed to introduce modern science and mathematics curricula to educational institutions training secondary and high school teachers. The project lasted three academic years (Ünal & Ünal, 2010). The objectives of this project were:

1. Trial and development of Collective Science and Modern Mathematics programs at certain schools.

2. Evaluation of the application of the prepared curriculum for Collective Science and Modern Mathematics.

3. Development of textbooks and supplementary books, teaching materials and assessment and evaluation tools for testing in pilot schools.

4. Training of teachers at pilot schools through in-service training courses.

5. Introduction of the program to other schools according to feedback from trial applications.

6. Revision of programs used by academies training teachers of natural sciences according to feedback from the application results.(Gücüm & Kaptan, 1992).

There was no significant difference between the performance scores of students in the experimental group studying collective sciences and those in the control group studying physical sciences concerning the Science High School First Stage Examination that took place in the academic year of 1979-80.

Introduction of Modern Programs to Secondary Schools and Academies Training Science Teachers

For secondary schools, a process-centered collective science program giving special weight to experiments was developed (Soylu, 1977). Laboratory equipment was prepared for this program and teachers were trained in summer schools. Starting from 1976-1977, the program was implemented as a pilot program for three years in around 30 schools. The program was then evaluated in terms of its various aspects. The evaluation foresaw the comparison of the achievements of schools teaching the Science program to schools teaching the Collective Science program taking into account the attitudes and opinions of teachers regarding the program. The most remarkable findings were as follows:

1. The objectives of the collective science program can be achieved using the means at hand.

2. The course hours in secondary schools are enough to cover the entire program.

3. Teaching is successful in schools with teachers having a good command of the teaching methods and where no more than 30-40 pupils occupy the classrooms.

4. Teachers' attitudes and opinions about the program are positive. (Akhun & Açıkalın, 1980).

It was concluded that the collective science programs would be beneficial for secondary schools if the teachers could be trained well and the necessary conditions were met. Despite these positive results, the project for the introduction of collective science programs to secondary schools was discontinued.

When efforts for the introduction of modern programs to academies training science teachers are examined, it becomes apparent that these programs were included in the

"Science Teaching and Application" courses at these schools. It was planned to carry out a two-year trial study at these academies training science teachers. However, due to the escalating wave of anarchy in these schools, especially between 1977 and 1980, this project could not be carried out (Turgut, 1990).

ABOLISHMENT OF MODERN PROGRAMS

A Commission set up by the Ministry of National Education in 1983 for the evaluation of science programs prepared a report called the Assessment of Science Programs. The main findings of this report can be summarized as follows:

- Students adapt better to new programs than older ones.
- Students find lab activities and personal studies more interesting.
- Parents are also more positive about lab practices in schools. That's why they want to send their children to these schools. But, due to high demand, the classroom population is usually higher than 40 and therefore laboratory activities cannot be carried out sufficiently.
- Due to the high number of subjects in mathematics and natural sciences programs, many subjects cannot be covered.
- As the tools and materials cannot be sufficiently reproduced or sent at all to some schools, these materials are either missing in some schools or not effectively used in others.
- Since project assessment takes place after the project has been completed, the results cannot be sufficiently incorporated into the program.
- Teachers and administrators working at schools covered by the project do not have sufficient knowledge of the implementation of modern scientific programs.
- The Mobile Guide teams, which were set up to continuously monitor the work done and solve problems on-site, lost their effectiveness after a while. (Demirbaş & Soylu, 2000)

The results of the Science Programs Assessment Report showed that the infrastructure necessary for the implementation of the program was lacking in many aspects. Besides, the Scientific Commission for the Improvement of Science and Mathematics Education was terminated because the protocols on science projects concluded between the Ministry of National Education and the Scientific and Technological Research Council of Turkey on May 31, 1980 were not renewed and the Ford Foundation had withdrawn its financial support. Consequently, modernization efforts for the teaching of natural

sciences at secondary schools that had been ongoing since 1960, was discontinued and completely abolished in 1984 (Çilenti, 1985).

Studies on Science Programs in Turkey

Since all processes related to the survival and development of society take place within the social structure, social structure studies are important. The period 1938-1980 is an important era for Turkish society when important social events took place. Some remarkable events after 1938 were Atatürk's death, attempts to switch to a multi-party system, and the social and economic impact of World War II even though the country was not involved in the war. The era after 1950 witnessed changes in the material culture which reflected upon the spiritual values of the society. The years 1960-1980 are known as the years characterized by big social ruptures and terror incidents, during which time two coups (the 1960 and the 1980 coups) took place and the 1971 memorandum emerged creating an impact on the Turkish society which continues to this day (Erkal, 2016). In those years, when the Cold War was escalating into a vigorous competition between nations, countries were putting a lot of effort into becoming a leading force in the fields of science and technology.

As in our country, countries that did not want to be left behind in this race started attaching more importance to education, especially science education. The science education in our country has principally been influenced by developments in the West, and the greatest influence has been over three different periods since the beginning of the republican era (Özinönü, 1976). Science programs in our country can be categorized under two titles: "Primary School Science Programs" and "Secondary School Science Programs". While it is possible to come across many programs that have been carried out at primary school level since the Republic, this section will be focusing on scientific programs for primary and secondary schools implemented between 1938 and 1980 (1948, 1968, 1974, 1977).

Developments In Primary School Science Programs

1948 Primary School Science Program

With the transition to a democratic multi-party system in 1946, the need for democratic education in schools increased. To meet this need, a new program was put to use in 1948 (Binbaşıoğlu, 1995). Concerning the natural science curriculum for primary schools developed in 1948, natural science subjects were subsumed under the "Life Sciences" course in the first term (1st, 2nd, and 3rd grade) while they were contained within the "Natural History," "Family Science" and "Agriculture-Work" courses in the second term (4th and 5th grade) (Gücüm & Kaptan, 1992). The Life Sciences course was an observation and experimentation course according to this program. For this purpose, suitable learning environments were created where students could come across objects

and phenomena which they could analyze and examine according to the grade they are in. The Life Sciences course is the basis of courses such as Natural History, History, Geography and Civic Education, but it differs from these in terms of its particular importance (Şahin, 2009). The objective of the Life Sciences course in this program was to help children from grades 1 to 3 to observe and study everyday events such as family and social life that are easy to comprehend, irrespective of their locale (home, school, village, town, city, etc.) while providing them with the tools to understand nature better, cultivate a love for nature, and helping them acquire good habits aimed at protecting nature. In addition, other objectives of the program included cultivating sentiments of love and respect among students in their interactions with others, laying the foundation for their loyalty to the nation and awakening in them an awareness of their national history (Ministry of National Education, 1948).

Some new topics were added to the Life Sciences curriculum of 1948. These were: The animals in our houses; games played in the garden, in the neighborhood and in the countryside; the marketplace and scenes from the marketplace; Atatürk and İnönü's life stories; preparation of winter food for the household; repairing old clothes; the ovens, barbecues or heaters at our homes; household laundry day; sewing old clothes; agricultural lessons on the schoolyard; the history of our family and our house; regulations for vehicles; the history of our town and our village; the meaning of the 19th of May; domestic goods week; laundry day; radio etc. (Magazine of the Ministry of Culture, 1937).

The 1948 curriculum was criticized in many ways, for example in terms of the excessive number of courses, subjects and chapters, misalignment of the subjects with the academic level of the students, lack of connection between courses, its inflexibility and disregard for personal differences. Due to such criticisms, the American professor Kate Wofford was invited to Turkey in 1952. After examining the system, Wofford prepared a report. In her report, Wofford stated that more efforts should be made to prepare more democratic programs (Kalaycı, 2004). The 1948 program, which had been in force for 20 years, was replaced by a new program in 1968. Besides, social benefits (for human beings and the environment) were placed at the forefront of this program where science played a subordinate role. A closer look at the sections of this program reveals too many aspects which do not sit well with a modern program (Gücüm & Kaptan, 1992). These were:

1. inability to express learning goals in terms of student behavior;
2. the principle of social benefit and not activities that require scientific processes were placed at the forefront;
3. the lack of a specific system for arranging the units and the themes of the units;

4. many course chapters on agriculture were integrated into the natural history course although there was a separate lesson on agriculture.

1968 Primary School Science Program

The primary school curriculum of 1968 is a long-term curriculum that has been implemented for about 30 years. One of the most important innovations brought by this curriculum was the application of the concept of consolidation for 4th and 5th-grade primary school students, previously introduced for life sciences courses. All the objectives set out in the curriculum were aligned with student requirements. Furthermore, with the introduction of this curriculum, social sciences and physical sciences were acknowledged as central courses alongside the Life Sciences course (Bektaş, 2001; Binbaşıoğlu, 2003).

In the explanations section of the Life Sciences program, it was stated that the Life Sciences course was a lesson based on observation, active work and experiment assigning to it the character of a true science course (Gücüm & Kaptan, 1992). The program was flexible and there was no obligation to follow a certain order when the teacher works through the chapters. While the subjects that could not be covered at school could be excluded from the units to be studied, the subjects that were not included in the program but needed to be covered could be added to the program. In the 1968 curriculum, the principle of proximodistal learning was adopted when the subjects were being taught. Life Sciences is one of the most important courses of the first three years of primary school. The Life Sciences course should be studied in relation to other courses (Turkish, Mathematics, Painting, etc.), and the topics of the Life Sciences course should be made more concrete for students through various methods. This curriculum also emphasized that excursion and observation activities should be given sufficient weight for the Life Sciences course. While the goals of the Life Sciences course were laid out under different main headings, the same goals were set for all three grades. This caused some difficulties in setting out learning objectives at a class level (Ministry of National Education, 1968).

A comparison of the 1948 Life Sciences curriculum with its 1968 version reveals some differences. For instance, the number of chapters in the Life Sciences curriculum of 1968 is fewer than that in the Life Sciences curriculum of 1948. In the 1968 curriculum for life sciences, however, sub-topics of the units were enunciated in detail. Topics added to the Life Sciences curriculum of 1968 were: Vehicles and Protective Measures against Accidents, New Year's Celebrations, How Did You Spend New Year's Day, Differentiation of Holiday Habits, the Sea, the Beach, Swimming, Mail, Letters, Postman, How Can We Protect Our Health, Military Service, etc. The "Physical Sciences and Natural History" course in the primary school curriculum of 1968 is a combination of natural history, agriculture-work, and family science courses included in the 1948 program. In addition,

the 1968 program recommended the kind of education that would ensure the active participation of students (Ministry of National Education, 1948; Ministry of National Education, 1968).

The "Physical Sciences and Natural History" curriculum of 1968 was amended in 1974 and 1977 (Gücüm & Kaptan, 1992).

The Science Curriculum of 1974

In the 1974 program, the name of the course was changed to Physical Sciences and a number of changes were also made to the content of the units. The most striking aspect of this program was that it adopted the concept of social benefit and attached more importance to technology. The program introduced no independent natural science course for the first three grades of primary school with some topics of the natural science course interspersed with the subjects of the Life Sciences course. It would be impossible to prepare students for science courses based on scientific processes in the 4th- and 5th-grades due to a primary focus on social benefit rather than on scientific methods.

The Science Curriculum of 1977

The 1977 program is almost identical to that of 1974 in terms of their content. However, some units were re-arranged.

Developments In Secondary School Science Programs (1938-1980)

The sixth, seventh and eighth grade in primary education was referred to in some earlier programs as the first level of secondary education. This stage, commonly referred to as the secondary school, forms the basis of the second stage of primary education. In view of developments in science programs for secondary schools between 1938 and 1980, the program implemented between 1937 and 1938 remained in practice for only one year. The total number of lessons per week was reduced to 31 hours and the names and the length of science courses were changed. Offered as a three-hour course, the physical sciences course was combined with the chemistry course and the biology course was combined with the hygiene course. The program remained in effect for one year, and afterwards, in 1938, a new program was drawn up which was to remain in force for eleven years. In addition, biology, hygiene, and natural sciences courses were removed from the new program to be replaced by a single course called Natural History (Karataş, 2002). An examination of the content of the natural history course reveals that it is divided into two sections, namely "Botanic" and "Zoology". In short, the program, which was put to use in 1937, had a content progressing from easy toward difficult topics with two main sections, "Botanic" and "Zoology."

With the introduction of the program that was designed in 1948 and remained in force

between 1949 and 1970, the number of weekly course hours was increased again to 32. The content and features of the 1948 Science Program were not changed until 1970. The content of this program is similar to the content of the previous one but contains detailed information about the human body. The topics of photosynthesis and respiration included in the 1938 program were excluded from the 1948 program, while health-related topics were added to the 1948 program. Starting from 1969, science courses were grouped together under the "Physical Sciences" course. While there were no program changes from 1948 to 1969, a general program change in 1969 brought fundamental changes to the entire curriculum. According to the science program, which was put into practice after 1974, the Physical Sciences course was offered as a three-hour course. In addition, some topics were removed to make the program less cumbersome. Very few changes were introduced with the 1977 program. One of these changes was to increase the length of the Physical Sciences course to four hours for all three grades. Moreover, new titles were added to some units (Yurdatapan, 2011).

Conclusion

In the first years of the Republic, the need for qualified human resources had become more pronounced. Because during the wars, there had been an immense loss of lives, including scientists. These losses stalled the onset of social, economic, cultural, and educational reforms. The period from 1938 to 1980, on the other hand, saw important social events and incidents (the death of Atatürk, attempts for the transition to a multi-party system, the lingering effects of the Second World War, coups d'état of 1960 and 1980, memorandum of 1971, etc.). This period was also marked by nations squaring off against each other in a bid to get the upper hand in science and technology. Turkey did not remain indifferent to the wave of scientific and technological innovations sweeping the globe and so started to attach more importance to science education at its schools. To this end, the existing science curriculum was improved, renewed and made more modern. In addition, during these years (1938-1980) many projects were set into motion to reshape science education. In particular, science programs developed in the western world were translated and adapted. However, these programs fell short of meeting the expectations, especially since they had been drawn up without taking into account the socio-economic and cultural peculiarities of Turkey. The Science Programs Assessment Report prepared after the program development efforts showed that the country lacked the necessary infrastructure for the implementation of such programs. Furthermore, the efforts for modernizing the science curriculum in secondary education was halted due to the non-renewal of the protocols for science projects made between the Ministry of National Education and the Scientific and Technological Research Council of Turkey on May 31, 1980 and the withdrawal of financial support from the Ford Foundation, and came to a definitive end in 1984.

References

Acar, H. (1968). Son Yıllarda Matematik Öğretimindeki Değişmeler ve Ülkemizdeki Bugünkü Durum. *Ortaöğretimde Fen* Öğretimi *Sempozyumu*. Ankara: TÜBİTAK Bilim Adamı Yetiştirme Grubu Yayınları.

Akhun, İ. & Açıkalın, A. (1980). *Ortaokullarda ve Eğitim Enstitülerinde Matematik ve Fen Programlarının Denenmesi ve Teşmili Araştırmalar Projesi (BAYG-E-33) Değerlendirme Raporu*. MEB. Fen Öğretimini Geliştirme Bilimsel Komisyonu.

Akman, Ö. (2016). The Importance of Using Archive in Social Studies Education, *Research Highlights in Education and Science*, Eğiten Publishing, Editör:Wenxia Wu, Selahattin Alan, Mustafa Tevfik Hebebci, Basım sayısı:1, Sayfa Sayısı 173, ISBN:978-605-66950-0-1.

Alpaut, O. (1984). Fen Öğretimi Nasıl Verimli ve İşlevsel Duruma Getirilebilir? *Fen* Öğretimi *ve Sorunları Sempozyumu*, Ankara.

ARYM Değerlendirme Grubu. (1971). Pilot Liselerde Denenen Modern Matematik ve Fen Programlarını Değerlendirme Raporu. Ankara: MEB, Fen Öğretimini Geliştirme Bilimsel Komisyonu.

Ayas, A. (1995). Fen Bilimlerinde Program Geliştirme ve Uygulama Teknikleri Üzerine Bir Çalışma: İki Çağdaş Yaklaşımın Değerlendirilmesi. *Hacettepe* Üniversitesi *Eğitim Fakültesi Dergisi*, 11, 149-155.

Ayas, A., Çepni, S. & Akdeniz, A.R. (1993). The development of Turkish secondary science curriculum. *Science Education*, 77(4), 433-440.

Ayas, A., Özmen, H., Demircioğlu, G. & Sağlam, M. (1999). Türkiye'de ve Dünyada Yapılan Program Geliştirme Çalışmaları: Kimya Açısından Bir Derleme. *D.E.Ü. Buca Eğitim Fakültesi Dergisi* Özel Sayı, 11, 211-219.

Bektaş, M. (2001). *Hayat Bilgisi Programlarının Değerlendirilmesi*. Yüksek Lisans Tezi, Sakarya Üniversitesi Sosyal Bilimler Enstitüsü, Sakarya.

Bilen, K. (2015). Bilim Nedir? Ne Değildir? N. Yenice (Ed.), *Bilimin Doğası, Gelişimi ve* Öğretimi. Ankara: Anı Yayıncılık.

Binbaşıoğlu, C. (1995). *Türkiye'de Eğitim Bilimleri Tarihi*. İstanbul: MEB Yayınları.

Binbaşıoğlu, C. (2003). *Hayat Bilgisi* Öğretimi. Ankara: Nobel Yayın Dağıtım.

Çağlayan, H. (1961). *Okullarda Modern Fizik* Öğretimi. Ankara: Arı Matbaası.

Chemical Educatian Material Study. (1963). *Chemistry: An Experimental Science*. San

Francisco: W.H. Freeman and Co.

Çilenti, K. (1985). *Fen Eğitimi Teknolojisi*. Ankara: Kadıoğlu Matbaası.

COPES. (1973). Conceptually Oriented Program in Elementary Science. *Teacher's Guide for Grade Six* (Preliminary Ed.). New York University.

Demirbaş, M. & Soylu, H. (2000). Türkiye'de Etkili Fen Öğretimi İçin 1960-1980 Yılları Arasında Geliştirilen Programlar. *IV. Fen Bilimleri Eğitimi Sempozyumu*, Hacettepe Üniversitesi, Ankara.

Demirbaş, M. & Yağbasan, R. (2005). Türkiye'deki Ortaöğretim Kurumlarında Uygulanan Fen Öğretim Programlarının Analizi. *Gazi* Üniversitesi *Kırşehir Eğitim Fakültesi*, 6(2), 33-51.

Demirbaş, M. (2001). *Türkiye'de Etkili Fen* Öğretimi İçin *1960-1980 Yılları Arasında Geliştirilen Fen* Öğretim *Programlarının* İncelenmesi. Yüksek Lisans Tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Driver, R (1988). A constructivist approach to curriculum development. In P. Fensham (Ed.), *Developments and Dilemmas in Science Education*. London: The Falmer Press.

Durusoy, M. (1984). Fen Öğretiminde Karşılaşılan Başlıca Sorunlar ve Nedenleri. *Fen* Öğretimi *ve Sorunları Sempozyumu*, Ankara.

Erkal, M. E. (2016). 1938-1980 Dönemi Türkiye'de Sosyal Yapı ve Dinamikleri. *Sosyoloji Konferansları*, 53, 157-185.

Eş, H. and Sarıkaya, M. (2010). İlköğretim 6.sınıf Fen ve Teknoloji Dersi "Yaşamımızdaki Elektrik" Ünitesi Kazanımları İle İlgili Öğretmen Görüşlerinin Değerlendirilmesi. *E Journal of New World Sciences Academy Education Sciences,* 6(1), 32-45.

Goblot, E. (1954). İlimler *Sistemi* (Çev: F. Yücel). İstanbul: Maarif Basımevi.

Gücüm, B. & Kaptan, F. (1992). Dünden Bugüne İlköğretim Fen Bilgisi Programları ve Öğretim. *Hacettepe* Üniversitesi *Eğitim Fakültesi Dergisi,* 8(8), 249-258.

Gülmez, N. & Tahancı, B. (2014). Soğuk Savaş Çekişmelerinden Bir Örnek: U-2 Uçak Krizi. Çağdaş *Türkiye Tarihi Araştırmaları Dergisi,* 14(28), 225-252.

Haber-Schaim, U. (1971). *Introductory Physcial Science, Teacher's Guide. (Fiziksel Bilimlere Giriş:* Öğretmen *Kılavuzu)*. N. Armağan ve diğerleri (çev.). Ankara: MEB Fen Öğretimini Geliştirme Bilimsel Komisyonu.

Hançer, A. H., Şensoy, Ö. & Yıldırım, H. İ. (2003). İlköğretimde Çağdaş Fen Bilgisi Öğretiminin Önemi ve Nasıl Olması Gerektiği Üzerine Bir Değerlendirme. *Pamukkale* Üniversitesi *Eğitim Fakültesi Dergisi*, 13(13), 80-88.

Harlen, W. (1991). *Primary Science: Taking the Plunge*. Heinemann Educational Books, Oxford.

Holbrook, J. and Rannikmae, M. (2007). The Nature of Science Education for Enhancing Scientific Literacy. *International Journal of Science Education*, 29(11), 1347-1362.

Ingle, R.B. & Ranaweera, A.M. (1984). Curriculum innovation in school chemistry. D.J. (Ed.), *Teaching School Chemistry.* Waddington.

Kalaycı, N. (2004). *Cumhuriyet Döneminde* İlköğretim *Hükümet Programları ve Uygulamalar*. İstanbul: Milli Eğitim Bakanlığı Yayınları.

Karasar, N. (2015). *Bilimsel Araştırma Yöntemleri*. Ankara: Nobel Yayınları.

Karataş, S. (2002). *Batılılaşma Döneminde Ders Programı Değişimi*. Yüksek Lisans Tezi, Afyon Kocatepe Üniversitesi, Afyon.

Karplus, R. (1960). Science Teaching and Development of Reasoning. *Journal of Research in Science Teaching*, 14(2), 169-75.

Köroğlu, C. Z. & Köroğlu, M. A. (2016). Bilim Kavramının Gelişimi ve Günümüz Sosyal Bilimleri Üzerine. *Pamukkale* Üniversitesi *Sosyal Bilimler Enstitüsü Dergisi*, (25), 1-15.

Kültür Bakanlığı Dergisi. (1937). Yeni İlkokul Müfredat Programı. Sayı. 20-1 (Sonkanun), ss.161-197.

Milli Eğitim Bakanlığı (MEB). (1948). İlkokul *Programı*, İstanbul: Milli Eğitim Basımevi.

Milli Eğitim Bakanlığı (MEB). (1968). İlkokul *Programı*, İstanbul: Milli Eğitim Basımevi.

Milli Eğitim Bakanlığı (MEB). (1995). *1923-1983 Yıllarında Talim ve Terbiye Kurulu* Çalışmaları. İstanbul: Milli Eğitim Basımevi.

OECD (2017). *PISA 2015 assessment and analytical framework. Science, reading, mathematics, financial literacy and collaborative problem solving, revised edition.* Paris, PISA, OECD Publishing. Retrieved from doi: https://doi.org/10.1787/9789264281820-en.

Okay, S. & Karamanoğlu, K. (1974). *Modern Biyoloji Cilt I-II.* İstanbul: Devlet Kitapları.

Özinönü, A.K. (1976). *Innovation and Changes in Secondary Science Education* .Faculty of Arts and Sciences, METU, Ankara.

Ronan, C. A. (2005). *Bilim Tarihi: Dünya Kültürlerinde Bilimin Tarihi ve Gelişmesi.* (Çev: E. İhsanoğlu ve F. Günergun, 4. Basım). Ankara: Tübitak Yayınları.

Şahin, M. (2009). Cumhuriyetin Kuruluşundan Günümüze Türkiye'de Hayat Bilgisi Dersi Programlarının Gelişimi. *Uluslararası Sosyal Araştırmalar Dergisi,* 2(8), 402-410.

Sakız, G. (2018). Fen Bilimlerinin Diğer Bilimler Arasındaki Yeri ve Tarihi Gelişimi. H.Ş. Ayvacı (Ed.), İlkokulda *Temel Fen Bilimleri.* Ankara: Pegem Akademi.

Schaefer, D.A. (1988). Plaudits for PSSC Physics. *Physics Today*, 131-132.

Şenvar, C. (1968). Fen Lisesi Projesindeki Temel Amaçlar ve İlk Uygulama. *Ortaöğretimde Fen* Öğretimi *Sempozyumu*. Ankara: TÜBİTAK Bilim Adamı Yetiştirme Grubu Yayınları.

Soslu, Ö. (2014). Fen Eğitiminde Bilimin Doğasını Anlama Üzerine Bir Değerlendirme. *Bayburt* Üniversitesi *Eğitim Fakültesi Dergisi,* 9(1), (90-100).

Soylu, H. (1977). Ortaokullarda Modern Toplu Fen Programının Denenmesi ve Yaygınlaştırılması Üzerine Araştırmalar. *TÜBİTAK VI. Bilim Kongresi Bilim Adamı Yetiştirme Grubu Tebliğleri*, Ankara: Türkiye Bilimsel ve Teknik Araştırma Kurumu.

Turgut, M. F. (1968). *Pilot Liselerde Uygulanan Modern Fen Müfredatını Değerlendirme Projesi*, MEB Fen Öğretimini Geliştirme Bilimsel Komisyonu Başkanlığına sunulan teklif.

Turgut, M. F. (1970). *Kimya* Öğretiminde *Yeni Düşünüş*. İstanbul: Milli Eğitim Basımevi.

Turgut, M. F. (1977). Program Yenileme ve Yaymada Ögretmen Yetiştirne Sorunu. *TÜBİTAK VI. Bilim Kongresi Bilim Adamı Yetiştirme Grubu Tebliğleri.* Ankara: Türkiye Bilimsel ve Teknik Araştırma Kurumu.

Turgut, M. F. (1990). Türkiye'de Fen ve Matematik Programlarını Yenileme Çalışmaları. *Hacettepe* Üniversitesi *Eğitim Fakültesi Dergisi*, 5, 1-14.

Turgut. M. F. & Pekgöz, M. (1976). *Yeni Ortaöğretim Sisteminde Modern Matematik ve Fen Programlarının Denenmesi ve Teşmili* Üzerine *Araştırmalar Projesi Kesin Değerlendirme Raporu.* Ankara: Fen Öğretimini Geliştirme Bilimsel Komisyonu.

Turgut. M. F. (1975). Bilim Adamı Yetiştirmede Birleştirilmiş Fen Programlarının Rolü. *TÜBİTAK V. Bilim Kongresi Bilim Adamı Yetiştirme Grubu Tebliğleri*. Ankara: Türkiye Bilimsel ve Teknik Araştırma Kurumu.

Ünal, F. & Ünal, M. (2010). Türkiye'de Ortaöğretim Programlarının Gelişimi. *Sosyal Bilimler Araştırmaları Dergisi*, 1, 110-125.

Ünal, S. (2003). *Lise 1 ve 3* Öğrencilerinin *Kimyasal Bağlar Konusundaki Kavramları Anlama Seviyelerinin Karşılaştırılması*. Yüksek Lisans Tezi, Karadeniz Teknik

Üniversitesi, Trabzon.

Ünal, S., Coştu, B. & Karataş, F. Ö. (2004). Türkiye' de Fen Bilimleri Eğitimi Alanındaki Program Geliştirme Çalışmalarına Genel Bir Bakış. *Gazi Eğitim Fakültesi Dergisi*, 24(2), 183-202.

Wittrock, M.C. (1974). Learning as a generative process. *Educational Psychologist*, 11, 87-95.

Yager,R. & Penic, J. (1988). Changes in Perceived Attitudes toward the Goals for Science Instruction in Schools. *Journal of Research in Science Teaching*, 25, 176-184.

Yurdatapan, M. (2011). İlköğretim 6, 7 ve 8. Sınıf Fen Öğretim Programlarının Biyoloji Alanı Açısından Tarihsel Değerlendirmesi. Ç.Ü. *Sosyal Bilimler Enstitüsü Dergisi*, 20(1), 41-60.