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COMMENTARY

The Flipped Classroom: An Effective Model of Active Learning

Alan C.K. Cheung

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"Tell me and I forget. Teach me and I remember. Involve me and I learn."
–Benjamin Franklin

As a result of the development of humanistic psychology in the 1960s, there has been a growing recognition that affective factors can significantly impact the outcomes of education (Lu, 2001). Affective factors in language learning, particularly in second language acquisition, have been reckoned as non-cognitive factors and along with cognitive factors, have sparked substantial attention among academics. Affective variables that may influence foreign language acquisition include a variety of emotions and feelings arising in foreign language classroom such as anxiety, fear, embarrassment, or sense of inferiority. Among them, second language anxiety has long been a popular topic in foreign language instruction research.

Against the backdrop of the popularization of the Internet and new media, constantly emerging educational technologies are catalyzing changes in traditional pedagogical methods. Blended learning, an approach that combines the strengths of online and offline instruction, has garnered increasing attention of educators at all levels. This learning model is not only a mixture of two or more teaching modalities, but more importantly, represents in-depth integration of multiple teaching strategies. It advocates a restructured relationship between teaching and learning, promoting a teacher-guided and student-centered instruction paradigm with particular emphasis on students' agency in learning (Wang et al., 2018).

In 2009, the US Department of Education conducted a meta-analysis of data from experimental research in higher education from 1996 to 2008, drawing the conclusion that blended learning is a more effective instructional approach as opposed to pure face-to-face classroom teaching or online distance learning (Wang et al., 2018). He (2005), a professor with Beijing Normal University, argued in his study that the blended learning model had the advantage of utilizing the benefits of both traditional in-person teaching and online educational materials and interaction opportunities, thus giving full play to teachers' directive role in guiding and inspiring students and monitoring their learning process, and in the meantime, allowing students to take initiative as the major actors in learning.

The flipped classroom, also known as the inverted classroom, is an exemplary practice of blended learning. The idea underlying it is that lecture or direct instruction is not the best use of class time. With a flipped classroom, students are often initially introduced to new topics outside of school through a variety of forms including video lessons prepared by the teacher or third parties, online collaborative discussions, digital research, and text readings, freeing up classroom time for the exploration of topics in greater depth (Bishop & Verleger, 2013). In 2007, U.S. Woodland Park High School chemistry teachers Bergmann and Sams began practicing flipped teaching at the senior secondary school level. Students watched recorded lectures for homework and completed their assignments, labs, and tests in class with their teachers. What Bergmann and Sams found was that their students demonstrated a deeper understanding of the material than ever before (Bergmann & Sams, 2007). The flipped classroom model makes a shift in teaching procedure from in-class information transmission followed by after-class assimilation to pre-class information transmission preceding in-class problem-solving. It leverages information technology to build a digital teaching environment, thus reconstructing student learning activity before, in, and after class. Most importantly, it allows students to learn at their own pace, furthering opportunities for personalized education and helping foster self-directed learning in them (Bretzmann, 2013).

Explorations to Overcome Socio-Economic Barriers in Learning and Thinking: A Flipped Classroom Study in this issue of the journal is an examination of the effects of the flipped classroom model on the academic achievement and critical-analytic thinking skills of the 5th grade students from differential socio-economic backgrounds. Through experimental research, it concluded that the model had a significantly positive effect on the academic success of students from families of both high and low socio-economic status; and that it positively affected critical-analytic thinking development of students regardless of their family origins, despite the effect being not statistically significant (Oz & Kala, 2023). The article provides valuable insights into the efficacy of flipped classroom teaching from the perspective of socio-economic disparities.

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COMMENTARY

Educational Justice: The Cornerstone of Modern Society

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"Justice is the constant and perpetual will to allot to every man his due."
–Domitus Ulpian

EDUCATIONAL equity, a key feature of modernized society, is the application of fundamental values of modern culture in education, such as freedom, equality, justice, and human rights (Cole, 2022). It is also a product of education modernization, as well as an essential element of the new era's education.

Education modernization represents higher-order educational development, requiring the modernization of educational concepts, systems, institution, contents, methodology, governance, among other aspects. The primary purpose of modern education is to develop in citizens' modern ideas, competencies, and capabilities to participate in social activity (Gu, 2012). Given this, it is imperative that the educational equity be regarded as the core of education modernization, due to its close associations with human existence and development (Rather, 2004).

Educational equity has become a universal pursuit and shared vision in the present world. In 2015, to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" was established as one of the goals in the United Nation's transforming our world: the 2030 Agenda for Sustainable Development (United Nation, 2015). In response to this Agenda, the UNESCO announced The Education 2030 Framework for Action in November of the same year, with its overarching goal and specific targets pointing to the equity of educational opportunity, process, and quality (UNESCO, 2015).

For individuals, educational equity serves as a protection of their rights as humans. It assures them of basic rights to development by safeguarding their right to education. Through equal access to education opportunities and public educational resources, everyone has the chances to improve themselves regardless of their origins (Cao, 2017). From the societal standpoint, educational equity is the most crucial and fundamental component of social justice. It is critical to the society as a whole for its harmonious development (Yuan, 2001). In the meantime, it is a significant driver of social advancement by optimiz-

ing the structure of social organization, supporting social mobility, and ultimately advancing the positive development of social environment. In contrast, educational inequity has the potential for sparking social inequity in other domains or amplifying existing social inequalities, as a result, damaging the interests of the community, the nation, and humanity (He, 2010).

The two articles entitled *A Policy Analysis of the Development of Balanced Compulsory Education in Chinese Counties* (Guo, 2023) and *Developing Equitable and Balanced Compulsory Education in Chinese County Regions: Achievements and Challenges* (Yang, 2023) in this issue are discourses focusing on the educational equity issue with Chinese compulsory education within county regions. According to Easton (1965), public policies are tools for the authoritative distribution of social resources. Educational equity is an ongoing, dynamic commitment, requiring the creation of a high-quality policy network by the government and relying on the enforcement of educational policies via the state's power (Guo & Zhu, 2022). *A Policy Analysis of the Development of Balanced Compulsory Education in Chinese Counties* is a study of educational policies issued by the Chinese government to support the development of balanced compulsory education at the county level. It gave an overview of the evolution of relevant policies on educational financing, teacher staffing, supervision and evaluation, and education quality. The significance of national policies for the advancement of educational equity was underlined (Guo, 2023). *Developing Equitable and Balanced Compulsory Education in Chinese County Regions: Achievements and Challenges* presented the accomplishments China made in developing equitable compulsory education in the county regions from the standpoints of educational investments, teacher staffing, and educational quality, and revealed the issues and complications the country confronts in this sphere, using facts and data of a number of counties as evidence (Yang, 2023). It is hoped that these studies can ignite more debate about educational justice in China.

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ORIGINAL ARTICLE

Explorations to Overcome Socio-Economic Barriers in Learning and Thinking: A Flipped Classroom Study

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***Abstract**: The present study aims to examine the effect of the flipped classroom model on the academic achievement and critical-analytic thinking skills of students from different socio-economic backgrounds. For this purpose, two schools in the same province, attended by children from families with varying socio-economic levels, were included in the study. The study sample consisted of a total of 82 students: 30 from a secondary school with students from a low socio-economic background and 52 from another secondary school with students from a high socio-economic background in the 2021-2022 academic year. The study was designed based on the quasi-experimental design with pretest-posttest control groups. Experimental and control groups consisting of one class each, and four classes in total, were selected from the schools using the random assignment method. The total application period was 9 weeks while the duration of the experimental applications was 7 weeks (28 class hours). In the present study utilizing Edpuzzle, an online platform, interactive videos were developed in accordance with the learning outcomes of the course. Data were collected using the 25-item "Sun, Earth and Moon Achievement Test" applied to determine the learning levels of the students and the 72-item "Cornell Conditional Reasoning Test" applied to measure critical-analytic thinking skills. In conclusion, it was revealed that although there was no significant change in critical-analytic thinking skills, the flipped classroom model provided a significant increase in the academic achievement and critical-analytic thinking skills of students from both socio-economic backgrounds.*

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Conflict of Interests*: None*

Introduction

THE rapid developments and changes in technology have had an impact on numerous fields including social, cultural, medical, and financial sectors, and have made major innovations and changes inevitable. Accordingly, the use of technology in education has expanded and emerging communication technology tools have become a new subject of study (Kahramanoğlu & Şenel, 2018). It has been observed that the use of these new technologies in education facilitates learning, increases the learning levels of students and can help them better understand and retain concepts by transforming education from a passive and reactive state to an interactive and more enjoyable one (Raja & Nagasubramani, 2018). Previous studies in this context have also demonstrated that the use of new technologies in education can make a positive contribution to the academic achievement of students (Aktaş, 2013; Oktay & Çakır, 2013). However, when educators insist on traditional education, it becomes highly difficult for students to acquire higher-order skills (Kara, 2008).

In traditional classrooms, students mainly follow the lecture and occasionally engage in brief discussions (Bergmann & Sams, 2012). In such classrooms, the teacher is usually at the center of an educational process that focuses on providing students with information through memorization (Alharthi, 2018). However, it is important not only to convey information but also to be able to distinguish what information is reliable, and it is necessary for children to possess critical thinking skills in order to do so (Lone, 2017). For this reason, critical-analytical thinking has become a necessity for children to access accurate information, particularly in today's world where the transfer of information is quite intense (Yaralı, 2020). This is because, in this century, it is a necessity to train individuals who can adapt to the various occupations of the present age and possess higher-order thinking skills (Ichsan et al., 2021). However, it is very difficult, particularly within the traditional education model, for a single teacher to adopt an individualized education approach in crowded student groups and to progress in line with the learning pace of students (Bergmann & Sams, 2012). For this reason, technology-integrated learning models should be included in the design of new education processes, considering the changing living conditions and the importance of the use of technology in education (Aydın, 2016). One of the models that are compatible with current technologies is the Flipped Classroom Model (FCM).

The FCM is a contemporary educational innovation that is viewed by many as a means to transform teaching and learning in the 21st century and beyond (Keengwe et al., 2014). This model establishes a framework that also enables students to receive a personalized form of education tailored to their individual needs (Bergmann & Sams, 2012). Although it is quite difficult to

address the learning style of each student, the FCM adopts an instructional strategy that is relevant for a wide range of students (Lage et al., 2000). The starting point of the present study was the fact that despite the wide range of the FCM, no experimental study was found in the literature on the potential outcomes of this model in schools with different socio-economic levels. In this direction, the present study aims to examine the effect of the FCM on academic achievement, permanence, and critical-analytical thinking skills of students from different socio-economic backgrounds in the 5th-grade Science course unit "Sun, Earth and Moon". In the study, answers will be sought to the following sub-problems:

Among the experimental and control group students in schools with low and high socio-economic levels.

(i) Is there a significant difference in terms of the post-test scores of the Sun, Earth and Moon Achievement Test?

(ii) Is there a significant difference in terms of the permanence scores of the Sun, Earth and Moon Achievement Test?

(iii) Is there a significant difference in terms of the post-test scores of Critical-Analytic thinking?

Theoretical background

The Flipped Classroom Model

The FCM was first implemented by Lage et al. (2000) in the Department of Economics at the University of Miami. Various concepts are used to refer to the FCM. These include inverted classrooms (Lage et al., 2000; Strayer, 2012), flipped classrooms (Bergmann & Sams, 2012; Bishop & Verleger, 2013; Enfield, 2013), inverted learning (Ramírez-Montoya & Hernandez, 2016), flipped learning (Seery, 2015), and "class at home, homework at school" (Demiralay & Karataş, 2014).

In essence, unlike the traditional model, the FCM refers to the implementation of classroom activities at home and home activities in the classroom (Bergmann & Sams, 2012). That is, in contrast to the widespread teaching approach, lectures and homework are swapped (Talbert, 2012) and time is completely restructured (Bergmann & Sams, 2012). While most of the class time in the traditional teaching model is allocated to activities such as lecture presentations or homework review, in classrooms where the FCM is employed, a short Q&A session is held prior to the lecture to check the information acquired by the students, and a significant portion of class time is devoted to critical-analytical thinking, problem-solving and application (Hayırsever & Orhan, 2018). In this model, lessons are carried out outside

the classroom with pre-recorded videos, while active studies are carried out during class hours (Talbert, 2012).

The FCM establishes a student-centered teaching environment by ensuring active student participation (Özbay & Sarıca, 2019). Students are responsible for watching the videos, completing the exercises assigned in the videos, and asking appropriate questions. The teacher's role in the classroom is to manage and guide the process rather than conveying information to the students (Bergmann & Sams, 2012). In this sense, the model has replaced teacher-centered classes over time (Pierce & Fox, 2012).

Critical-Analytic Thinking and the FCM

Critical thinking is a process of analysis and evaluation to improve thinking (Paul & Elder, 2005). Analytical thinking is the process of breaking down a problem into parts and drawing meaning from these parts, explaining the functioning of a system, identifying the underlying reasons behind an event or the steps to solve a problem, comparing two or more situations, and evaluating and criticizing the properties of phenomena (Sternberg, 2002). Thus, this skill is referred to as critical, analytical, or critical-analytical thinking in the literature and is vital in understanding both daily life and science. This is because critical-analytical thinking is a type of logical and reflective thinking focused on making decisions regarding what to believe or what to do (Ennis, 1985). Acquiring this skill is the most favorable way to prepare the younger generation for a changing world (Marin, 2011).

Individuals with high levels of critical-analytical thinking can develop skills, abilities, and core values to help them succeed in life (Huong et al., 2018). Although the world has changed dramatically since the year 2000, students who practice critical-analytic thinking have been able to adapt to the changing landscape and have achieved exponentially greater success in higher education and the workplace compared to other students (Marin, 2011). Therefore, it is of great importance to design programs that can help students acquire critical-analytic thinking. Styers et al. (2018) stated that the implementation of active learning strategies in the flipped classroom can facilitate the acquisition of critical-analytic thinking skills. This is because when the learning environment is organized based on the traditional classroom model; students solve certain problems only when they "encounter" them. However, when the FCM is employed, students take turns answering questions, complete assignments, and maximize the knowledge they acquire by applying class outcomes to practical situations, and only in doing so can students' critical-analytic thinking skills gradually develop and reach higher levels (Huong et al., 2018).

There are previous studies examining the impact of the FCM on students' reading (Fulgueras & Bautıista, 2020) and listening comprehension

skills (Etemadfar et al., 2020). Since there is a limited number of studies examining the effect of the FCM on critical-analytic thinking skills (DeRuisseau, 2016; Fulgueras & Bautısta 2020; Etemadfar et al., 2020; Putri et al., 2021), it is anticipated that the present study will make a significant contribution to the literature. However, it is also important to investigate what results this model will yield in schools with different socio-economic contexts.

Socio-Economic Level and the FCM

Income inequality in learning is one of the most significant issues today (OECD/UNICEF, 2021). Bradley & Crowny (2002) state that the socio-economic level of students' families is associated with cognitive and socio-emotional outcomes, and that its effects begin in utero and persist through adulthood, affecting the well-being of children on numerous levels. Previous studies also show that socio-economic status significantly affects children's success (Aslanargun et al., 2016; OECD, 2021).

In the study conducted by Tansel (2002) in Turkey, it was stated that the socio-economic level of families is effective in the academic achievement and participation processes of students. Kozikoğlu & Camuşcu (2019) stated that the socio-economic level of families affects the development of children's attitudes and skills as well as their readiness levels. Additionally, Çiftçi & Çağlar (2014) stated that higher socio-economic levels facilitate the learning process of students whereas the environmental and contextual characteristics of lower socio-economic levels do not sufficiently support the development of students. According to the OECD (2021), children from socio-economically disadvantaged families not only experience this disadvantage themselves, but also affect their peers. In other words, the more students from low socio-economic backgrounds in the classroom, the more the performance of students from high socio-economic backgrounds is affected, thus reducing class success. These studies reveal the importance and impact of socio-economic status on students' learning processes. Therefore, the importance of instructional designs that can alleviate the inequalities arising from socio-economic status increases even further.

It has been argued that only students from high socio-economic backgrounds can benefit from the FCM whereas students with low socio-economic status cannot do so without access to computers and reliable Internet (Horn, 2013). Based on the related literature, it can be stated that students with high socio-economic backgrounds are more prepared to learn with the FCM and that the opportunities provided by families (internet and technological tools) are effective in the development of positive attitudes (Kozikoğlu & Camuşcu, 2019). Turkey is among the OECD countries with the strongest correlation between academic achievement and socio-economic status (OECD, 2021). Turkey is also one of the countries with the highest

Gini Index, which is recognized as an indicator of income inequality among OECD countries (World Bank, 2019). This shows that Turkey is a suitable country for the examination and comparison of the success of students from low and high socio-economic backgrounds in FCM applications.

It is observed that there is a very limited number of studies examining the effect of the FCM on critical-analytic thinking skills, mostly at the level of secondary (Fulgueras & Bautısta, 2020; Sulisworo et al., 2019) and undergraduate (Andrini et al., 2019) education, with a particular deficiency in the field of science education. However, it is crucial to start teaching higher-order skills such as critical-analytic thinking as early as possible. Moreover, the majority of the studies on this model utilized Blackboard, while the Edpuzzle platform was employed in a very limited number of studies (Demirer & Aydın 2016; Özbay & Sarıca 2019). The present study will make an important contribution to the literature in terms of its unique aspects related to these deficiencies. Beyond these, the most significant feature that distinguishes the present study from others is its focus on students from families with different socio-economic levels. While the literature mostly focuses on students from families with middle and high socio-economic backgrounds, a limited number of studies examining the effect of the model on students from families with low socio-economic status (Yeoman, 2018) were also found. There are no studies in the literature on how the FCM yields results for students from families with different socio-economic levels within the same cultural structure. The present study is significant in terms of revealing the effects of the FCM in different contexts. Moreover, if the experimental application is successful, the study can serve as an important alternative in overcoming the disadvantages of students from families with lower socio-economic backgrounds.

Method

Design

In the present study, a quantitative quasi-experimental design with pretest-posttest control groups was employed. Johnson & Christensen (2012) stated that the quasi-experimental is suitable for cases where random assignment to groups cannot be made. While FCM was applied to the experimental groups in the study, the routine practice of the Ministry of National Education (MoNE) was not significantly intervened with in the control groups. Since the students in the experimental group were tasked with an additional project outside of class time, the students in the control group were given a project assignment that could be completed at approximately the same time.

Table 1. School Features.

Features of the Schools	LSELS	HSELS
General Features	The school building was demolished as it was an old structure and not resistant to earthquakes, and the school was moved to another school building in the same neighborhood. The building is used jointly by both schools. The school building has limited facilities. There is no space for social and cultural activities in particular.	The school building is a new structure and in a more central location. There are areas for social and cultural activities in the school building.
Environmental Features	The school is located in a suburb of the city center. There are small and very old buildings in the vicinity of the school. Consequently, people with very low income and education levels live in the area. The school is located in a neighborhood with a high crime rate.	The school is located in a central area of the province. It is situated in an environment where students with more advantageous residential and transportation opportunities reside. The school is located in a neighborhood with mostly civil servant families.
Parental Features	The parents have very low levels of income and education. Therefore, they are incapable of meeting the needs of their children. The number of parents convicted of one or more crimes is substantial.	Both the income and education levels of the parents are considerably higher compared to the other school. The majority of the students take private courses or lessons outside of school time.
Physical Equipment of Classrooms	All classrooms have internet access and interactive whiteboards. However, there is no science laboratory available. The classrooms are adequate in size for the number of students and receive sufficient light.	All classrooms have internet access and interactive whiteboards. There is a science laboratory present. The classrooms are adequate in size for the number of students and receive sufficient light.
Features of Application Teachers	The applications in both classes were conducted by the teacher of the course in this school. The teacher is a male Science teacher with 13 years of seniority.	The applications in both classes were conducted by the teacher of the course in this school. The teacher is a male Science teacher with 12 years of seniority.

Sample

The study was carried out in the 2021-2022 academic year in two different schools located in a city in Turkey, attended by students from low and high socio-economic backgrounds. A total of 82 5th-grade students, 30 from a low socio-economic level secondary school (LSELS) and 52 from a high socio-economic level secondary school (HSELS), constituted the sample of the study. The mean age of the students was 10 years. Since there were two classes in the HSELS taught by the volunteer teacher and only two classes in the LSELS, all of the 5th-grade students participated in the study. The experimental and control groups were determined through a draw of lots among the classes in the schools. **Table 1** shows the features of the schools.

Instruments

Two data collection tools were used in the present study. These are the "Sun, Earth and Moon Achievement Test" and the "Cornell Conditional Reasoning Test" of the "Cornell Critical Thinking Skills Test Series".

Sun, Earth and Moon Achievement Test

The Sun, Earth and Moon Achievement Test (SEMAT) was developed by Sontay & Karamustafaoğlu (2020) in accordance with the learning outcomes of this unit. When the item difficulty of the 25-item SEMAT was analyzed, six items were classified as easy while four items were difficult, and 15 items were moderate. The researchers calculated the mean item difficulty index of the test as 0.53 and the mean item distinctiveness index as 0.54. The KR-20 internal consistency coefficient of this achievement test was calculated as 0.83.

The Cornell Conditional Reasoning Test, Form X (CCRT-FX)

The Cornell Conditional Reasoning Test, Form X (CCT-FX) of the Cornell Critical Thinking Skills Test Series was used in the present study. This test was developed by Ennis & Millman (1985) to measure the critical thinking skills of 4th-14th grade students. The test was translated into Turkish by Mecit (2006).

CCT-FX was chosen as it objectively measures critical-analytical thinking and its content overlaps with aspects of inquiry-based learning. The test yields the sum of scores obtained from items measuring skills related to deduction, evaluation, observation, and examination of the reliability of statements by others, identification of assumptions, and discernment of meaning. The CCT-FX is a 72-item multiple-choice, general content-based test. Each question has three choices and one correct answer. Reliability coefficients obtained from various studies vary between 0.87 and 0.91 (Mecit, 2006).

Procedure

The application lasted for a total of 9 weeks in all classes, with an experimental application of 7 weeks (28 class hours) and the application of the pre-post tests. **Table 2** shows the application process in both groups. The applications in the experimental and control groups are presented under separate headings below.

Application Process in the Experimental Groups

Table 2. Application Process of the Study.

Week	Subject	Learning Outcome Numbers	Applications in the Experimental Group	Applications in the Control Group
1.	Introduction of the study, pretests		Briefings, preparations, and pre-test studies related to the study were conducted.	
2.	Structure and Characteristics of the Sun	F.5.1.1.1.	We Have No Gaps, True or False? Find the Right Path, Activity-1, Activity-11, Activity-30	Making a Sun Model, Home Activity
3.		F.5.1.1.2.	The Choice is Yours, Activity-3, Activity-8, Activity-14, Activity-17	Let's Watch, Learn, Evaluate Ourselves 1.1
4.	Structure and Characteristics of the Moon	F.5.1.2.1. F.5.1.2.2.	We Have No Gaps, Reach the Right Exit, Explaining with What I Have Learned, Activity-13, Activity-15, Activity-16, Activity-26, Activity-33	Is Life on the Moon Possible? Let's Evaluate Ourselves 1.2
5.	Movements and Phases of the Moon	F.5.1.3.1.	We Have No Gaps, True or False? Activity-4, Activity-5, Activity-10, Activity-12	The Moon's Rotation and Orbit, Did You Know?
6.		F.5.1.3.2.	The Choice is Yours, Draw the Moons, Exit the Space Map. Activity-7, Activity-20, Activity-27, Activity-29	Phases of the Moon, Classroom Activity, Let's Evaluate Ourselves 1.3
7.	Movements of the Sun, Earth and Moon relative to each other	F.5.1.4.1.	We Have No Gaps, Reach the Right Exit, The Route of the Sun, My Light and Dark Side. Activity 24, Activity-28, Activity-41, Activity-44	The Sun, Earth and Moon Moving Together, Home Activity, Let's Watch and Learn, Assessment and Evaluation Activities
8.				
9.	Completion of the study and post-tests		Evaluation and post-test studies were conducted.	

The FCM application in both schools was carried out by the teachers of the course within the framework of the plan developed in the present study. The activities were selected from the textbooks prepared by the MoNE in accordance with the learning outcomes in the Science Curriculum (SC) (2018) and from the activities published on the MoNE Education Information Network (EIN) platform. All the necessary tools and materials for the activities were provided to both classes.

First, the teachers and students were informed about how the study would be conducted and how to use the Edpuzzle platform. In order to prevent any potential technical problems during the process, a class was created for each school on the Edpuzzle platform, and the teachers and students were assigned to these classes. One-on-one meetings were held with the parents of the students to inform them about the content and duration of the videos so that the students would not abuse the use of phones and tablets. Thus, the teachers were able to identify the students who did not watch the videos and to conduct one-on-one interviews with the students and their parents to en-

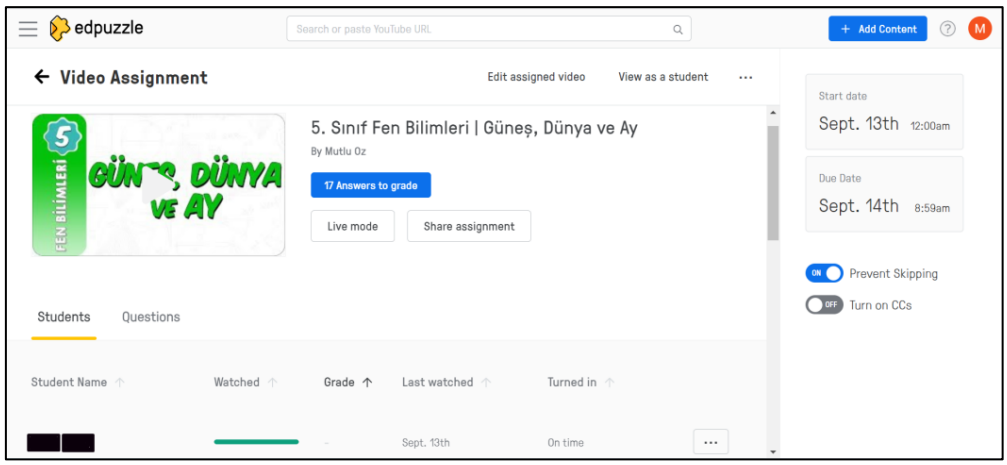

Figure 1. Video Content and Student Tracking Page.

sure that a more effective process. Moreover, one of the researchers registered as an administrator on Edpuzzle and closely monitored the application process and identified students who did not participate in the entirety of the application and excluded them from the sample.

In the study, the videos were prepared by one of the researchers. The aim here was to minimize uncontrollable variables that could affect the experimental implementation by using the same material in the experimental groups in both schools and ensuring that the process was carried out in the same way. The researcher worked in coordination with the teachers and uploaded the videos to the system in accordance with the learning outcomes.

The videos shared with the students were carefully picked from YouTube in accordance with the learning outcomes of the subjects and the developmental characteristics of the students. The videos were structured to be short (not exceeding 10 minutes), simple and comprehensible. Active student participation was censured by placing short pieces of information and various questions in the videos. Furthermore, by placing fast-forward and skip restrictions on the videos, it was aimed to ensure that the students watched the entire video without skipping the relevant questions and brief information. These structured videos were uploaded to Edpuzzle one day before each lesson with 2 videos per week. **Figure 1** shows a sample video content and student tracking page.

The students in the experimental group who came to school after watching the video related to the learning outcomes at home asked their teachers questions about the parts they did not understand nor had difficulties with in the first 10 minutes of the lesson. Then, the students performed

the selected activities related to the learning outcomes in small groups. In this way, it was aimed to establish peer learning, which is another aspect of the FCM. At the end of the activity, the parts that the students had difficulties with were addressed through Q&A and debate methods, and the deficiencies in learning were tried to be eliminated by the teachers.

Application Process in the Control Groups

In order to ensure unity between the schools, the lessons in the control group were conducted in accordance with a course plan prepared jointly by the two teachers within the framework of the same plan based on SC (2018). The teachers developed this course plan using the textbooks published by the MoNE and the EIN platform, as was the case in the experimental group. Thanks to the course plan developed, the same application could be carried out in both schools in a controlled and planned manner. The activities and applications recommended in the textbook were carried out within the framework of this course outline in both schools. Tools, materials, and various documents required by the students during the application phase were provided to both schools. All activities were carried out by separating the students into small groups as in the experimental group. With group work, it was aimed to promote peer learning among the students, as was the case in the experimental group. Unlike the experimental group, this group was assigned project homework, which was followed up by the teachers.

Data Analysis

Preliminary Analyses of CCRT-FX and SEMAT

In both tests, the students' answers were checked against the answer key. Accordingly, the students' answers were coded as "1" if correct, and "0" if incorrect or blank, and the students' total scores were calculated. Since there are 25 questions in the SEMAT, the maximum total score possible for the students is 25. Since there are 72 questions in the Cornell Conditional Reasoning Test, the maximum total score is 72.

Statistical Analysis

FCM and socio-economic level are the independent variables of the study as the focus is on the impact of FCM on the learning and critical-analytic thinking of students from different socio-economic backgrounds. As seen in **Table 1**, since the socio-economic variable is a multidimensional variable in itself, it was decided that it would be more accurate to compare two different schools descriptively rather than statistically. In this direction, first, the ef-

fect of the FCM on the dependent variables (SEMAT and CCT-FX) in each school was determined. Then, the effects of the FCM in the two schools were compared in terms of dependent variables.

The independent samples t-test was used to determine whether there was a significant difference between the SEMAT and CCT-FX pre-test mean scores of the experimental and control groups. Since there was a significant difference between the groups, it was decided to use covariance analysis to determine the effect of the FCM on the dependent variables (Kline, 2009). ANCOVA was utilized since it provides the necessary prerequisites for parametric tests. The normality of data distribution for ANCOVA was determined based on skewness and kurtosis values. The homogeneity of variances was tested with the Levene's F test. The equality of the slopes of the intragroup regression lines was examined for each measurement. The Pearson correlation was used to test whether there was a significant relationship between the controlled covariates and the dependent variables for all measurements in which ANCOVA was applied. The power of the independent variable to explain the total variance in the dependent variables was determined by eta-squared (η^2). η^2 values at levels of 0.01, 0.06 and 0.14 were interpreted to indicate a small, medium, and large effect size (Cohen, 1988), respectively. The interpretation of the significance of the findings was based on a significance level of 0.05.

Findings

Findings on SEMAT

Before starting the FCM applications in both schools, it was examined whether there was a significant difference between the groups based on the achievement test. In the LSELS, the pre-test mean scores of the students in the experimental group ($X = 4.643$) were lower than the mean scores of the students in the control group ($X=7.000$). There is a statistically significant difference ($t(28) = 3.022$, $p < 0.05$) between the experimental and control groups based on the pre-test of SEMAT. Similarly, the score difference between the experimental group ($X = 7.542$) and the control group ($X = 10.321$) based on the pre-test of SEMAT in the HSELS is also statistically significant ($t(50) = 3.024$, $p < 0.05$). Since there was a significant difference between the groups in the pre-test in both schools, ANCOVA was performed by assigning the SEMAT pre-test as the covariate.

As shown in **Table 3**, although the pre-test mean score of the students in the LSELS was 2.357 points higher in favor of the control group, the adjusted mean after the FCM application was 3.529 points higher in favor of the experimental group. However, according to the ANCOVA results, there

Table 3. SEMAT Pre-test, Post-test, Adjusted Mean and ANCOVA Results of the Experimental and Control Groups in the LSELS and HSELS.

				Mean Achievement Score					
School	**Group**	**N**	**Tests**	**X**	**SD**	**Adj. X**	**F**	**p**	**η_p^2**
LSELS	*Exp.*	14	*Pre-test*	4.643	0.589	-	2.650	0.115	0.089
			Post-test	15,000	5.818	16.749			
	Cont.	16	*Pre-test*	7.000	0.516	-			
			Post-test	14,750	5.894	13.220			
HSELS	*Exp.*	24	*Pre-test*	7.542	2.963	-	8.421	0.006	0.147
			Post-test	18.625	3.449	19.490			
	Cont.	28	*Pre-test*	10.321	3.570	-			
			Post-test	16.571	5.3085	15.830			

Table 4. The SEMAT Pre-test, Permanence Test, Adjusted Mean and ANCOVA Results of the Experimental and Control Groups in the LSELS and HSELS.

				Mean Achievement Score					
School	**Group**	**N**	**Tests**	**X**	**SD**	**Adj. X**	**F**	**p**	**η_p^2**
LSELS	*Exp.*	14	Pre-test	4.643	0.589	-	2.822	0.105	0.095
			Perm.-test	13.143	6.262	15.028			
	Cont.	16	Pre-test	7.000	0.516	-			
			Perm.-test	13.125	5.512	11.476			
HSELS	*Exp.*	24	Pre-test	7.542	2.963	-	6.238	0.016	0.113
			Perm.-test	16.125	3.627	17.075			
	Cont.	28	Pre-test	10.321	3.570	-			
			Perm.-test	14.750	5.317	13.936			

is no statistically significant difference between the adjusted post-test mean scores of the students in the experimental and control groups based on their SEMAT pre-test scores ($F(1, 27) = 2.650$, $\eta_p^2 = 0.089$, $p = 0.115$, $p > 0.05$). Based on the partial eta-squared value, the FCM has a moderate effect on the SEMAT post-test scores in the LSELS and explains 8.9% of the variance. Although the SEMAT pre-test mean score of the students in the HSELS was 2.779 points higher in favor of the control group, there was a difference of 3.660 points in favor of the experimental group between the adjusted post-test mean scores after the application. Based on the ANCOVA results, there is a statistically significant difference between the post-test mean scores adjusted according to the SEMAT pre-test scores among the groups in the

HSELS ($F(1, 49) = 8.421$, $\eta_p^2 = 0.147$, $p = 0.006$, $p < 0.05$). According to the partial eta-squared value, the use of different applications between the groups has a high-level impact on the SEMAT post-test scores and explains 14.7% of the variance.

As shown in **Table 4**, there is a difference of 3.552 points between the permanence test scores of the experimental and control groups in the LSELS as adjusted for the SEMAT pre-test scores. On the other hand, according to the ANCOVA results, the difference between the scores of the students in the experimental and control groups is not statistically significant, $F(1, 27) = 2.822$, $\eta_p^2 = 0.095$, $p = 0.105$, $p > 0.05$. According to the partial eta-squared, the use of different applications between the groups has a moderate effect on SEMAT permanence scores and explains 9.5% of the variance.

Similarly, there is a difference of 3.139 points between the permanence test scores of the experimental and control groups in the HSELS adjusted for the SEMAT pre-test scores. As seen in **Table 4**, according to the ANCOVA results, there is a statistically significant difference between the adjusted SEMAT permanence test mean scores of the students in the experimental and control groups ($F(1, 49) = 6.238$, $\eta_p^2 = 0.113$, $p = 0.016$, $p < 0.05$). The use of different applications between the groups has a moderate effect on the SEMAT permanence test scores and explains 11.3% of the variance.

Findings on CCRT-FX

According to CCRT-FX, the pre-test mean score of the experimental group students in the LSELS ($X = 25.857$) was lower than that of the control group students ($X = 30.563$). In the LSELS, there was a statistically significant difference between the experimental and control groups according to the pre-test of CCRT-FX, $t(28) = 2.302$, $p = 0.029$, $p < 0.05$. In the HSELS, unlike the LSELS, the pre-test mean scores of the students in the experimental ($X = 33.292$) and control groups ($X = 33.679$) were close to each other. Additionally, there was no statistically significant difference between the groups according to the pretest application of CCRT-FX, $t(50) = 0.136$, $p = 0.892$, $p > 0.05$. In the LSELS, it was decided to analyze covariance due to the presence of a significant difference between the CCRT-FX pretest scores of the experimental and control groups in the LSELS and the idea that some prior knowledge may affect critical-analytic thinking. Therefore, both the CCRT-FX pre-test and SEMAT pre-test were assigned as covariates in both schools. Below are some statistical data and ANCOVA results for CCRT-FX.

As shown in **Table 5**, the pre-test mean score of the LSELS experimental group students was 4.706 points lower than the control group. However, there was a difference of 3.336 points in favor of the experimental

Table 5. The SEMAT Pre-test, CCRT-FX Pre-test, Post-test, Adjusted Mean and ANCOVA Results of the Experimental and Control Groups in the LSELS and HSELS.

				Mean Achievement Score					
School	**Group**	**N**	**Tests**	**X**	**SD**	**Adj. X**	**F**	**p**	**η_p^2**
LSELS	*Exp.*	14	SEMAT Pre-test	4.643	0.589	-	1.812	0.190	0.065
			Pre-test	25.857	4.881	-			
			Post-test	29.714	6.753	33.762			
	Cont.	16	SEMAT Pre-test	7.000	0.516	-			
			Pre-test	30.563	6.132	-			
			Post-test	33.625	8.196	30.426			
HSELS	*Exp.*	24	SEMAT Pre-test	7.542	2.963	-	0.622	0.434	0.013
			Pre-test	33.292	7.827	-			
			Post-test	38.583	4.442	38.620			
	Cont.	28	SEMAT Pre-test	10.321	3.570	-			
			Pre-test	33.679	11.882	-			
			Post-test	37.536	6.071	37.505			

group between the post-test mean scores adjusted after the application. According to the ANCOVA results, there was no statistically significant difference between the mean CCRT-FX post-test scores of the students in the LSELS experimental and control groups adjusted according to the SEMAT pre-test and CCRT-FX pre-test scores, $F(1, 26) = 1.812$, $\eta_p^2 = 0.065$, $p = 0.190$, $p > 0.05$. The use of different applications between the groups explains 6.5% of the variance in CCRT-FX post-test scores, which shows a moderate effect.

There is a difference of 0.39 points between the CCRT-FX Pre-test Scores of the HSELS experimental and control group students in favor of the control group. In the CCRT-FX post-test, according to the adjusted mean scores, there was a difference of 1.11 points between the groups in favor of the experimental group. This difference is not statistically significant, $F(1, 48) = 0.622$, $\eta_p^2 = 0.013$, $p = 0.434$, $p > 0.05$. **Table 5** shows that the use of different applications between the groups had a low-level impact on the CCRT-FX post-test scores and explained 1.3% of the variance.

Discussion

In the study, one of the variables focused on in the FCM applications in schools with low and high socio-economic status was academic achievement. Coincidentally, the group with low levels of academic achievement was the experimental group in both schools. The SEMAT pre-test score difference between the groups before the application was significant in favor of the control group in both schools. After the application, there was a significant difference between the experimental and control groups according to the SEMAT post-test and permanence tests in the HSELS (Tables 3 and 4). This finding is in line with numerous studies (Alamri, 2019; Ali et al. 2021; Bergmann & Sams, 2012; Çakır & Yaman, 2018; Davies et al. 2013; Ghanaat & Habibzadeh, 2021; Kansızoğlu & Cömert, 2021; MacKinnon, 2015; Ok, 2019; Pierce & Fox, 2012; Yıldız et al. 2016; Zhao et al. 2021).

In the LSELS, the experimental group scored higher in SEMAT, but this difference was not statistically significant (**Tables 3 and 4**). While there is a limited number of studies (Yeoman, 2018) reporting that FCM applications are unsuccessful compared to traditional teaching methods, there are also studies in the literature stating that the effect of the FCM on academic achievement is not significant (Al-Abdullatif, 2020; Cabı, 2018; Smallhorn, 2017; Yavuz & Karaman, 2021). According to the findings of the experimental group in the LSELS, there was an increase of 223.27% in the SEMAT post-test compared to the pre-test and an increase of 10.36 points in the mean score. According to the adjusted post-test mean scores, the difference between the experimental and control groups was 3.53. In the HSELS, there was a difference of 11.09 points and an increase of 147.08% between the pre-test and post-test mean scores of the students in the experimental group (**Table 3**). The difference between the post-test scores of the experimental and control groups according to the adjusted mean in the HSELS was 3.66 points. Similarly, the difference between the adjusted SEMAT permanence test scores of the experimental and control groups in the HSELS was 3.14, while this difference was 3.55 in the LSELS (**Table 4**). Although the score differences in both schools were very similar, there was a significant difference at a level of $p = 0.006$ in the HSELS and no difference in the LSELS according to the post-tests (**Table 3**). This can be explained by the sample size. Since the sample of the LSELS is approximately half the size of the sample of the HSELS, a significant difference could not be found here due to Type 1 error (Cohen, 1988). Based on this, it can be said that conducting lessons based on the FCM in both schools greatly impacts students' SEMAT post-test and permanence test scores and that this practice is highly effective in learning.

When the variable of socio-economic level was examined from the perspective of learning, many studies revealing the presence of a significant relationship between socio-economic level and academic achievement outside of the context of the FCM were found (Ahmar & Anwar, 2013;

Aslanargun et al. 2016; Azhar et al. 2014; Çömlekcioğulları, 2020; Lacour & Tissington, 2011; Sarıer, 2016; Yelgün & Karaman, 2015). However, no studies were found in the literature that investigated the impact of the FCM on schools with different socio-economic levels. With the exception of the study conducted by Yeoman (2018), most of the studies were conducted in schools with middle and upper socio-economic levels. Yeoman (2018) stated that although there was no statistically significant difference between the groups, the data favored the traditional classroom group rather than the FCM group. This study completely differs from the SEMAT findings in the LSELS. In the present study, one of the reasons why the FCM was successful among the LSELS students as much as the HSELS students despite many disadvantages may be the interest of the students. In fact, Arastaman (2009) found that children from families with high socio-economic status had a lower sense of commitment to school compared to children from families with low socio-economic status. In addition, the author stated that schools cannot be an interesting environment for these children who have much greater opportunities in their own homes. This study is supportive of our view.

According to Çiftçi & Çağlar (2014), the socio-economic level of the family affects the child's access to resources, tools, and equipment. In the present study, it was found that while the families in the HSELS are able to provide their children with a wide range of opportunities outside of school through private tutoring and special courses as well as hardware support such as Internet access, computers and resource books, the families in the LSELS may be unable to do so. However, Bergmann & Sams (2012) stated that teachers can overcome this situation by using their creativity when educational materials are not accessible to poor families. In this direction, the present study was able to minimize economic inequality by opting to use mobile phones, which are accessible to almost everyone, and students in low-income families were also able to access these educational materials. At the same time, due to the pandemic process, non-governmental organizations and the MoNE have carried out a significant amount of work on the acquisition of tablets and computers by disadvantaged children in remote education. It can be stated that this situation is also beneficial in FCM applications.

Another variable focused on in the applications of the FCM in schools with different socio-economic levels is critical-analytical thinking. Unlike the HSELS, there was a statistical difference between the CCRT-FX pre-test scores of the LSELS students in favor of the control group. The group with low academic success in the LSELS also had low CCRT-FX pre-test scores. However, there is no significant difference between the groups in the HSELS. This finding is in line with Bozkurt (2022) who found that students from families with low socio-economic status were had less success

analyzing case-based science scenarios based on analytical thinking compared to those with middle and high socio-economic status.

According to the CCRT-FX post-test, it can be stated that results in favor of the experimental group were obtained although no significant difference was found between the experimental and control groups regarding the critical-analytic thinking skills of the students in both secondary schools based on the FCM. There are numerous studies in the literature reporting that the FCM has positive effects on the critical-analytic thinking skills of students (Andrini et al., 2019; Asmara et al., 2018; Baranovic 2013; Etemadfar et al, 2020; Kong, 2014; Nugraheni, Surjono & Aji, 2022; DeRuisseau, 2016; Sulisworo et al., 2019; Styers et al., 2018; Putri et al., 2021). However, in line with the present study, certain studies revealed that the model did not have a statistically significant effect on critical-analytic thinking (Fulgueras & Bautısta, 2020; Hantla, 2014; Saunders, 2014). The lack of a significant difference in the findings of the study may be attributed to the fact that the duration of the study was limited to seven weeks and longer-term applications are needed to significantly develop higher-order thinking skills such as critical-analytic thinking.

In the literature, no studies were found examining the effect of the FCM on the critical-analytic thinking levels of students from different socio-economic levels. Based on both the effect value and the difference between the adjusted mean scores according to the CCRT-FX post-test in both schools, it can be said that the FCM was more effective in terms of critical-analytic thinking in the LSELS (**Table 5**). Çakır (2016) found that parents in families with high socio-economic status asked more open-ended questions and talked to their children much more frequently compared to parents in families with low socio-economic status, thereby, children from families with high socio-economic status are introduced to high-level thinking by their parents before school. Keskin & Sezgin (2009) found that children from families with high socio-economic status had higher self-esteem and self-confidence. Based on these studies, the difference between the two schools suggests that the additional opportunities and family education provided to the children of families with high socio-economic status reduce the effect of the FCM on higher-order thinking. On the other hand, children from families with low socio-economic status may have been more disadvantaged both economically and in terms of parental education, and the effect of the FCM may have been greater. The fact that the FCM provides a flexible learning environment may have encouraged the LSELS students to participate more in the lessons (Aslan, 2020; Mazur et al., 2015; Ök, 2019; Rudow & Sounny-Slitine, 2015).

Conclusion

In the present study examining the effect of FCM-based teaching on students' success, it was concluded that the model had a moderate or high effect on the achievement and permanence levels of students from families with different socio-economic backgrounds. It is known that Turkey ranks first among OECD countries in terms of the relationship between socio-economic background and success (OECD, 2021). In families with high socio-economic status, there are high levels of parental education as children receive more support from their parents with private lessons or private courses during extracurricular time thanks to their financial opportunities. According to the results obtained, it can be said that although the FCM cannot equalize these students in socio-economic terms, it helps to eliminate this disadvantage in learning environments.

It was found that the FCM had a positive effect on students' critical-analytic thinking skills in both schools, but this effect was not statistically significant in either school. Based on the adjusted mean scores and the effect size of the model established in the present study, it was concluded that the FCM was more effective in the critical-analytic thinking skills of the students in the LSELS. The fact that the students in the LSELS were more successful despite having limited access to books and other resources as well as limited parental support to improve their critical-analytic thinking levels throughout their entire academic life shows that the model can also be implemented in such schools.

Statement of Responsibility

The authors contributed equally to the design and implementation of the research, to the analysis of the results, and to the writing of the manuscript. Therefore, each author is equally responsible.

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ORIGINAL ARTICLE

Students' Models of Magnetic Interactions: A Comparative Analysis of Accurate and Inaccurate Models over a Ten-Year Interval

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***Abstract**: This research investigates the Models of eighth-grade students in Turkey pertaining to magnets and magnetic interactions, while also examining the consistency of these models within themselves. Additionally, a comparative assessment is conducted by comparing the current data with data collected from eighth-grade students a decade earlier. The study comprises 59 students in the first phase and 45 students in the second phase, all of whom briefly received formal instruction on magnetism during fourth grade. The focus of the analysis centers on identifying the students' Models and evaluating their coherence across diverse contexts in both phases. Surprisingly, despite the passage of ten years, the mental model patterns exhibited by the students in both studies remain remarkably similar. Three primary categories emerged from the students' Models of magnets, including attraction and repulsion, magnetic poles, and the composition and functionality of magnets. However, noticeable distinctions between the two studies are evident. In the earlier study, the students' responses to survey questions displayed a greater variety and detail in comparison to the responses from the later study. Moreover, the second study revealed fewer instances of inconsistent Models concerning the magnetic interaction between magnets and nails, but more instances of inaccurate Models compared to the first study. The findings of this investigation offer valuable insights to educators, guiding them in designing effective lessons and activities aimed at helping students overcome their inaccurate and inconsistent Models.*

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Introduction

PHYSICS concepts are perceived as difficult and inconceivable by many students since physics understanding requires comprehension of different representations such as experiments, equations, math, and graphs, as well as conceptual explanations. Recent research revealed that many physics concepts pose obstacles to students' comprehension as well as their development of accurate models of those concepts (Sederberg, 2012; Thurn et al., 2020). As a result of engagement with physical phenomena, students come to the classrooms with an idea or model of physical concepts which are mostly not complied with definition that scientifically accepted (di Sessa, 1983). Furthermore, those incomplete or incorrect models cause an even bigger barrier to meaningfully understanding current and future concepts. Current literature offers much research to understand the underlying reasons for which students have difficulty learning science concepts. Every researcher has defined terminology to explain these underlying reasons. Some of those terms are misconceptions (Gilbert, 1983; Şengören, 2010); preconceptions (Kucukozer & Kocakulah, 2007); alternative concepts (Şengören, 2010); children's science (Osborne & Freyberg, 1985); and non-normative ideas (di Sessa, 1983). Although some of these terms have been used to refer to the same phenomenon, most of them are slightly or quite different from each other. For example, the term "misconception" is thought to be a synonym for "preconception," but there are subtle differences between the two. Misconceptions could be considered a completely incorrect piece of knowledge. Preconceptions, on the other hand, could be both correct and incorrect ideas. All these terminologies about the reason of students' learning challenges compromise around one common ground: students' existing models which provide a foundation for individual learning process (National Academies of Sciences, Engineering, and Medicine, 2018). Researchers who used the term "model" in their studies came up with their own definitions. For example, Craik's definition of model describes model as a cycle: first, it translates all external data into symbols, pictures, and internal models. Combine and compare those with existing models, and then translate back to these models for external representations (Craik, 1943). Gentner (2001) used the term "mental model" to explain a domain or a case that helps to understand a phenomenon, reason about that phenomenon, or make a prediction. As a cognitive scientist, di Sessa claimed that individuals try to interpret everything around them by rearranging and adjusting their existing ideas to new pieces of information, and they start to understand the external phenomena. He used the term "p-prims" (phenomenological primitives) to describe these knowledge structures, and he used p-primes in a different context than the term "Models."

In this work, I used the term "model" to include early researchers' term "mental model" to refer to individuals' internal representation of everything that they encounter. These models could take the form of a symbol, a scent, a picture, a verb, a graph, a formula, etc. Students' understanding of science concepts is highly dependent on how they construct their knowledge based on their previous knowledge of and experiences with physics phenomena (Ravanis et al., 2010). Constructivist researchers argue that students construct knowledge instead of acquiring it (Von Glasersfeld, 2013). Departing from this theory, science educators have begun to focus on knowledge construction as a process of generating and refining models (Gentner, 2001; Johnson-Laird, 1983), a construct that encompasses students' challenges with science concepts.

Students' Model in Magnetism and Magnetic Interaction

Since models are used to make sense of information by everyone, researchers started to study students' model representations about different topics of science, particularly physics topics, which students mostly struggle to understand. The nature of magnetism is one of these concepts that causes difficulties in students' learning and some scientifically inaccurate models (Kähkönen et al., 2020; Maloney et al., 2001; Sederberg & Bryan, 2010; Thurn et al., 2020). There are studies that have examined students' model representations about magnetism in K–12 classrooms (e.g., Greca & Moreira, 1997; Kähkönen et al., 2020; Ravanis et al., 2010; Sederberg, 2012). These studies revealed that students have both accurate and inaccurate models of magnetism. They also shed light on the students' different model representations of magnetism.

Numerous studies have been conducted to explore the challenges students encounter in comprehending magnetic phenomena. Several models of magnetism, such as the charge model (Borges & Gilbert, 1998; Kähkönen et al., 2020), pulling magnet model (Kähkönen et al., 2020; Voutsina & Ravanis, 2012), emanating model (Erickson, 2013), action-at-a-distance model (Bar & Zinn, 1998), electric polarization, and field models (Borges & Gilbert, 1998; Kähkönen et al., 2020), have been identified as scientifically inaccurate representations of magnetic interactions. However, scant attention has been given to studies focusing on students' conceptualizations regarding the interactions between magnets and objects, with a notable decline in the number of investigations at the K-12 level in recent times.

For instance, Ravanis et al. (2010) examined ninth-grade students' conceptualizations of magnetic fields and observed that many students resorted to the Newtonian model to explain magnetic phenomena. Moreover,

Henderson et al. (2019) investigated potential gender disparities concerning electricity and magnetism topics using the Conceptual Survey of Electricity and Magnetism (CSEM), revealing a gender gap favoring male students in their grasp of E&M concepts.

Some other studies focused on improving students' understanding of magnetic phenomena. For example, Kalogiannakis et al. (2018) conducted an empirical study employing the story reading method to assess its impact on preschool students' understanding of magnetism. Utilizing an illustrated fairy-tale storytelling approach, they noted positive changes in both male and female students' perspectives on magnetism. Similarly, Cai et al. (2017) developed an augmented reality (AR) based motion-sensing software aimed at enhancing the comprehension of magnetic fields among 8th-grade students. Through experimental design, they ascertained those students who utilized the AR software exhibited improved learning attitudes and outcomes compared to those who did not.

Numerous scholars have delved into the exploration of students' conceptualizations concerning magnetism, magnets, and magnetic interactions. However, there remains a notable dearth of studies investigating the consistency and accuracy of students' models across diverse contexts pertaining to the same phenomenon. Lemmer et al. (2020) investigated the understanding of basic-level magnetism concepts among 12 secondary students. In this study, the researchers also examined whether students consistently applied their incorrect understandings to answer other questions, revealing that a significant portion of students exhibited inconsistency in their conceptualizations. Departing from the current research findings and considering the gap in the literature, this study aimed to examine 8th grade students' model representations about the nature of magnetic interactions. Within this study, the consistency of the students' models and the logic behind their construction were identified. In their research, Kähkönen et al. (2020) employed the identical survey utilized in the present study, titled as "Magnets and Magnetic Things," to investigate the Models of magnetism among Finnish secondary students. The participants consisted of 12 students who had not received any prior instruction on magnetism before their involvement in the study. The researchers categorized the students' Models of magnetism into six distinct categories, namely the charge model, field model, pole/domain model, field/domain model, magnetism as pulling, and pole/field model.

There are a couple studies conducted to examine Turkish secondary students' misconceptions conducted almost 13-20 years ago (Demirci & Çirkinoğlu, 2004; Kucukozer & Kocakulah, 2007), conceptualizations (Tanel & Erol, 2008; Yurumezoglu & Cokelez, 2010), and models (Saglam, 2010; Şengören, 2010) about electricity and magnetism, particularly about electricity (Başer & Geban, 2007; Turgut et al., 2011) and electromagnetism (Saglam & Millar, 2006). Recently most studies were conducted with college

students in Türkiye (Güler & Şahin, 2017; Taşoğlu & Bakaç, 2014; Tereci et al., 2018). Güler and Şahin (2017) used an open-ended questionnaire to examine 77 preservice science teachers (PST)' understanding about electricity and magnetism and they found that although the PSTs knew the concepts of magnetic effect and magnetic field but were insufficient in explaining the effects of these concepts. Tereci et al. (2018), on the other hand, developed an experiment activity based on the TGA (Predict-Observe-Explain) strategy on magnetism to be used in physics courses at upper secondary level and received the opinions of physics teachers and found it useful by the teachers.

Based on the synthesis of the aforementioned studies, it is evident that over time, there persists a prevalence of inaccurate Models regarding magnetic interaction and magnets, particularly among K-8 students. Gaining insight into the content and underlying nature of these entrenched inaccurate Models will provide valuable guidance in devising effective strategies or methodologies for their remediation and elimination.

Research Purpose and Question

In this study, we aimed to investigate the Models of 8th grade students in Türkiye in the subjects of magnets and magnetic interaction and the consistency of their Models within themselves and make a comparative assessment with data collected from 8th-grade students ten years earlier. The first data of the study was collected during the first author's thesis study and the subsequent data was collected for comparison purposes. Magnets and magnetic attraction are concepts that students may encounter in many aspects of their daily lives, and they began to develop ideas about magnets and magnetic behaviors based on these experiences, as well as their existing models of magnetism and similar concepts. Knowing the early development of students' models about the nature of magnets and the interaction between magnets and other objects could facilitate planning an instructional design to help students reconcile inconsistencies and/or strengthen connections between new and old models as they learn about magnetism. In the light of these ideas, the following research questions guided this study: 1) What are the similarities and distinctions between Turkish students' Models of magnets and magnetic interaction a decade ago compared to those developed over the course of the subsequent ten years? 2) What is the consistency of students' models when responding to questions that pertain to the same phenomenon but are presented in different contexts during both phases of data collection?

Method

In this research, we explored students' accurate and inaccurate Models concerning the nature of magnets and magnetic interaction and compare them

with data collected from 8th-grade students ten years earlier. Additionally, we seek to ascertain the coherence between students' normative and non-normative ideas within a given context when they explain their models of magnetic interaction for the same phenomenon under two related scenarios: 1) wherein the nail is held stable while the magnet is rotated, and 2) wherein the magnet is held stable while the nail is rotated. As a data source, we used students' written responses and drawings to a survey questionnaire. Concerning the research's objectives, constructivist learning theory and an interpretivist approach were the most appropriate methodological perspectives for this study. Students constructed Models and external representations of their interpretations of the everyday world (Shepardson et al., 2011). Through the application of an interpretive-constructivist methodology, we achieved a comprehensive understanding and clarification of students' models pertaining to magnets and magnetic interactions. The interpretive phase within this framework entailed an exploration of the domain of their experiences (Van der Walt, 2020).

Research Design

In this study, we used a questionnaire that allowed students to use words and drawings to express their understanding and models. Questions from a survey; Magnets and Magnetic Things, designed by Sederberg (2012), were used as the main instrument to examine students' Models of magnets and magnetic interactions. Slight modifications were made to ensure the survey questions that originally were written in English were culturally and semantically appropriate for Turkish students.

Participants and Context

The 2010-11 Sample

The initial phase of the study was conducted during the fall semester of the 2010–2011 academic year. The sample consisted of fifty-nine 8th grade students, aged between 13 and 14 years old, who were attending a private school in Turkey. These students were selected from three different 8th grade classes and represented diverse academic backgrounds. Among the participants, twenty-eight were female and thirty-one were male. The selection of participants was carried out from students enrolled in a public school situated in a small district within the northwest region of Turkey. This particular town is characterized by its abundance of resources and is primarily known for its dominant ironwork industry, which serves as the primary

source of income for the local community. The families residing in this area predominantly derive their livelihood from industries such as textiles, iron-work, and steel. Consequently, the participating students were primarily from low- and middle-class socioeconomic backgrounds.

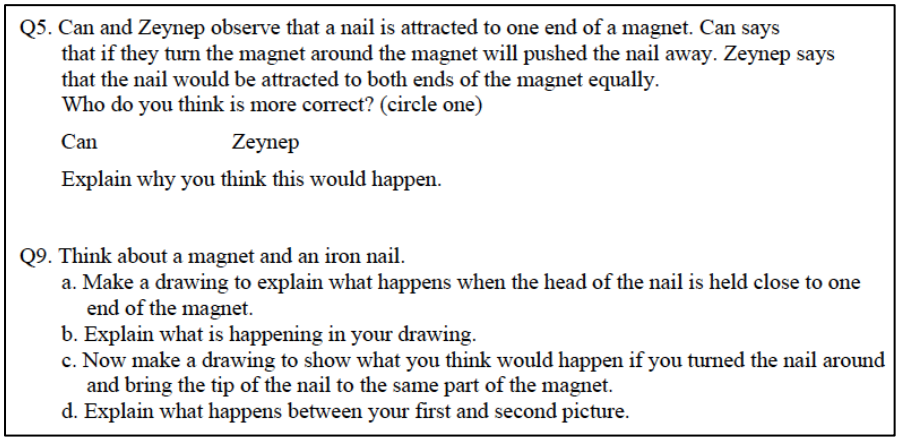
The 2022-23 Sample

The second phase of the study involved the participation of forty-five 8th grade students from a public school in Turkey. These students, aged between 13 and 14 years old, were selected from two distinct 8th grade classes and exhibited diverse academic backgrounds. Among the participants, twenty-four were female and twenty-one were male.

The participants were drawn from students enrolled in a public school located in a small district situated in the northeastern region of Turkey. Notably, one of the schools within this district, where data collection took place, is renowned as the premier middle school in the area. The other school primarily serves students from families with slightly lower literacy levels. Although there is variability in the socio-economic status of the families, tea production is a prevalent source of livelihood in this region.

Despite the revisions of the science curriculum in Turkey over time, it is worth noting that the topic of magnetism remains consistent, as it is included in the 4th grade science curriculum in both phases of the study. Therefore, the selection process aimed to identify students' initial models of magnetism and magnetic interaction, with a particular focus on those who had briefly received formal instruction in magnetism prior to the study. The selection of participants involved a meticulous process that included a thorough examination of the science curriculum across all grades, as well as active collaboration with science teachers. The valuable input provided by these experienced educators played a crucial role in identifying suitable candidates based on criteria such as their grade point average (GPA), voluntary participation, and willingness to submit consent forms. The participant group was intentionally diverse, encompassing individuals with varying levels of academic achievement and learning skills, thereby ensuring a representative sample.

Before commencing the data collection phase, detailed information regarding the study's procedures was conveyed to both the students and their parents or guardians. Informed consent was obtained from the participants' parents or legal guardians, underscoring the importance of ethical considerations, and ensuring that all individuals involved in the study were fully aware of its purpose and procedures. A two-tiered coding system, S1XX and S2XX, will be used to identify the students participating in this study. Students who were enrolled in the study during the 2010-2011 academic year will be assigned codes beginning with S1, while students who were enrolled in the


Q5. Can and Zeynep observe that a nail is attracted to one end of a magnet. Can says that if they turn the magnet around the magnet will pushed the nail away. Zeynep says that the nail would be attracted to both ends of the magnet equally. Who do you think is more correct? (circle one)

Can Zeynep

Explain why you think this would happen.

Q9. Think about a magnet and an iron nail.

a. Make a drawing to explain what happens when the head of the nail is held close to one end of the magnet.
b. Explain what is happening in your drawing.
c. Now make a drawing to show what you think would happen if you turned the nail around and bring the tip of the nail to the same part of the magnet.
d. Explain what happens between your first and second picture.

Figure 1. Question 5 & Question 9.

study during the 2022-2023 academic year will be assigned codes beginning with S2.

Data Collection

To identify students' models of magnetic interactions, we used questions from a survey called Magnets and Magnetic Things, which was designed for a larger research agenda (Sederberg, 2012). Sederberg (2012) developed the instrument for magnetism studies, which were conducted with 8th grade students in Finland and the USA before this study. This study was conducted in Turkey to find out more about students' Models of magnetism from different educational backgrounds and a decade apart.

The survey questions and consent forms (for the principal, parents, and students) were originally drafted in English. To ensure all translated documents were culturally appropriate as well as clearly composed, the survey questionnaire, consent forms, and a letter for parents were all approved by another native Turkish speaker before being submitted to the principal, parents, and students. Because individual interpretation is a key aspect of constructing models, the participants were asked to answer the questions as individuals, and not to discuss them with each other. Collectively, students' responses and behaviours during the data collection process showed they were comfortable.

This survey consisted of nine questions, including sub-questions. In this study, we focused on three survey questions. One of the questions posed to the students pertained to the "inside and outside features" of magnets. To examine the consistency in students' models about magnetic interactions, we

took a closer look at, in particular, two questions: Question 5 (Q5) and Question 9 (Q9) (see **Figure 1**).

These questions allowed us to analyze the students' understanding of the interactions between a magnet and an iron object as well as identify the consistency between their understandings of magnetic interaction toward one phenomenon given in two different ways. Q5 addressed whether a behavioral change happens when the magnet is turned around while the nail is not. On the other hand, Q9 was used to shed light on how students' Models are transferable and durable when asked to anticipate the interaction between a nail and a magnet when the magnet stays stable, and the nail is turned around.

To ensure comparability between the two data collection processes, we employ the same approach utilized in the previous study. The data collection process took place during a normal class period, and students were asked to complete the survey in those 45 minutes. However, the average time for completion of the survey was approximately 30 minutes in both studies.

Data Analysis

The data analysis in both studies followed a two-stage approach. In the first stage, we employed inductive analysis and creative synthesis strategies (Patton, 2014) to explore students' statements about magnets and magnetic interactions. Subsequently, content analysis was utilized as a framework in the second stage. Initially, responses were categorized based on accuracy, and then a content analysis strategy, as described by Strauss and Corbin (1998), was applied to re-categorize responses within each cell of the matrix. For creating the categories, we also drew insights from relevant literature.

Similarly, the same procedure was applied to students' responses concerning the behaviors of nails and magnets when held side by side. Subsequently, a matrix was constructed based on students' accurate and inaccurate Models. The primary objective of segregating students' responses using this matrix was to examine the consistency of models exhibited among students who provided either correct or incorrect answers for both questions, as well as those who provided correct answers for one question but incorrect answers for the other. After categorizing the data, we identified and analyzed the major themes present in students' responses.

Results

In the Turkish science curriculum, students learn the basic properties of magnets only in 4^{th} grade at the primary level for a decade. Other than that, they do not have any learning objectives about magnetism and magnets. Hence, participants in both phases of this study (2020-2011 and 2022-2023 academic years data collection phases) exhibited initial models formed

Table 1. The Most Frequently Possessed Models about the Nature of Magnets.

	2010-2011 Academic Year		2022-2023 Academic Year	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Attraction and Repulsion				
Attracts metal/iron Objects	39	66.1	23	51.1
Attracts magnetic objects	5	8.5	1	2.2
Same poles repel, opposite poles attract	38	64.4	18	40
Helps to find something (e.g., pin, needle, nail)	11	18.6	2	4.4
Magnetic Poles				
Magnets have "+" and "–" poles	17	28.8	15	33.3
Magnets have "N" and "S" poles	31	52.5	11	24.4
Magnets have "+,-" and "N, S"	7	11.9	4	8.9
No sign for the poles	4	6.8	15	33.3
Poles are separated from center	37	62.7	25	55.6
Composition and Functionality of Magnet				
Made of coal	3	5.1	0	0
There are matters/ elements inside a magnet	7	11.9	5	11.1
There are solid things inside a magnet	5	8.5	4	8.9
There is powders inside a magnet	5	8.5	2	4.4
There are atoms/ nanoparticles/ electromagnets inside a magnet	5	8.5	8	17.8
Works even when broken into pieces	52	94.5	36	80

through a combination of their 4th grade science course, personal observations, life experiences involving magnets, and information acquired from external sources (e.g., witnessing parents using tools with magnetic properties or incorporating magnets in their daily activities). Students' answers to the questionnaire were first identified as independent of any category and from each other. Later, the common themes were determined based on current literature as well as unique student ideas. These categories were presented in the first section. We also provide excerpts from the students' drawings and inscriptions to support our assertions.

Students' Models about the Nature of a Magnet

In response to a question about a detailed description of a magnet and its characteristics, students represented their models with their drawings and writings, which demonstrated students' normative and non-normative models. The comparison of students' Models of magnets from the 2010-2011 and 2022-2023 academic years is presented in **Table 1**. Overall, all students were aware of magnetic properties and the behavior of different polarities. However, they often did not articulate the terms and reasons behind those mag-

netic phenomena. In general, a comparison of the data collected from students during the academic years 2010-2011 and 2022-2023 reveals noteworthy differences in their understanding and articulation of concepts related to magnets. Specifically, the students surveyed in the earlier academic year exhibited a more profound grasp of magnetism, as evidenced by their ability to articulate a greater number of ideas concerning the properties of magnets compared to their counterparts in the later academic year.

In this section, the students' models are described as being very similar to other current research studies about magnetism. The three eighth grade Turkish students' models that emerged from both studies included: a) attraction and repulsion; b) magnetic poles; and c) the composition and functionality of magnets. **Table 1** shows three main concepts that were drawn from literature that focused on students' models of magnetism and from our participants' responses.

Attraction and Repulsion Model

During the initial study, a majority of students (66.1%) demonstrated an awareness of magnets' attractive properties, with a specific emphasis on their ability to attract metal and/or iron objects. In the second study, this proportion decreased, with only half of the students (51.1%) explicitly acknowledging the magnetic attraction towards metal and iron objects. Another prevailing normative model identified among the students was the concept that "like poles repel, while opposite poles attract." In the first study, 64.4% of the students explicitly mentioned this principle in their models, but in the second study, this percentage declined substantially to 40%.

Below are illustrative examples extracted from the students' models in both phases, showcasing their understanding and reasoning related to the attractive feature of magnets,

> *S128: A magnet is a metal structure that has the opposite poles on both edges. It generally attracts some materials, like iron and metals.*

> *S204: A magnet is a tool that attracts objects made of metal and iron. The magnet has two different directions: reverse, straight. Both sides of the magnet attract opposite poles.*

Above, we present instances of satisfactory responses provided by the students in both studies. The responses elicited from the participants regarding the question, "How would you elucidate the properties of magnets to an unfamiliar individual?" exhibited a tendency towards restraint and brevity. However, a discernible trend was observed, wherein students encountered

greater challenges in providing comprehensive explanations during the latter study. During the initial study, certain students substantiated their responses by drawing upon real-life examples of everyday materials. However, during the subsequent study, with the exception of one student, the majority of participants exhibited a notable decrease in their inclusion of practical applications of magnets in their explanations, thereby evincing a diminished emphasis on illustrating the relevance of magnets in daily life contexts in a decade:

> *S113: … magnets consist of iron, too. Hence, a magnet attracts iron. For example, it [the magnet] pulls pins, materials, iron, etc.*

> *S120: A magnet is a tool that has two poles and magnetic power. A magnet has two poles. One of them is N, and the other is S. Generally, it is used in electrical devices, and it helps us pull things easily.*

A careful analysis of the students' Models in both studies indicates that even though they know magnets attract certain types of objects (e.g., metal, iron, etc.), they did not use any supportive reasoning related to the interior structure of magnets to explain why some materials are attracted by a magnet while others (e.g., plastic, paper, glass, etc.) are not.

> *S224: A tool containing iron powder that attracts metals.*

On the other hand, S113 and S224 stated their reasoning for attraction by indicating magnets' structure ("magnets consist of iron, too"). Presumably, they associated the magnetic interaction between a magnet and a nail with the isomorphic nature of both objects.

An additional distinction between the two studies pertains to the portrayal of the force of attraction or repulsion between two magnets or between a magnet and a nail. The first study observed a prevailing trend where the representation closely resembled the conventional depiction of magnetic field lines found in textbooks. In contrast, the second study did not yield any instances where students utilized this specific representation.

Notably, a majority of students in the first study, similar to the example provided in S109's drawing, depicted the direction of attraction using arrows. In the second study, six students created drawings illustrating attractive or repulsive effects; however, these drawings exhibited considerable diversity, showing no resemblance to either each other or the representations observed in the first study. The drawings provided above serve as examples of this variation. Participant S243 represented the attraction between the magnet and nails by utilizing wavy-shaped lines in her drawing. In contrast,

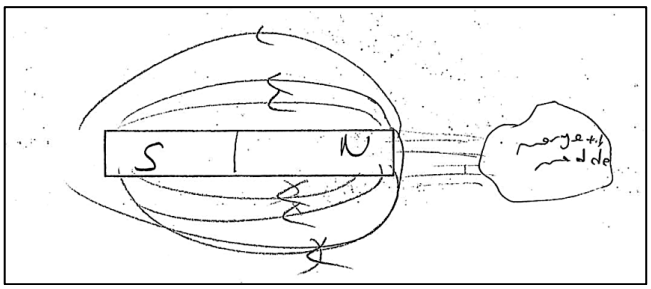


Figure 2. S109's Drawing of Magnetic Attraction/Repulsion Effect *[Magnetic matter]***.**

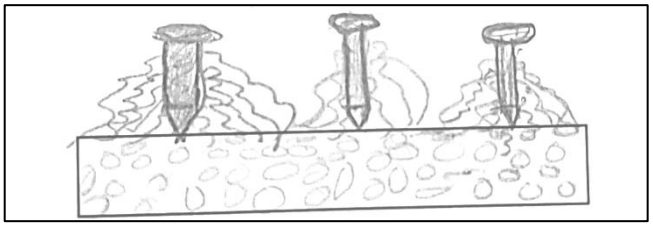


Figure 3. S243's Drawing of Magnetic Attraction/Repulsion Effect.

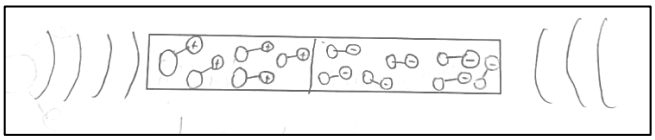


Figure 4. S245's Drawing of Magnetic Attraction/Repulsion Effect.

participant S245 depicted the magnet alone, incorporating half rings that resembled the wave representation at the ends.

Five students in the first study and one student in the second study specifically used the term "magnetic objects" to give examples of substances attracted by magnets. Presumably, iron, metals, nickel, etc. are grouped under that category.

> *S112: A magnet has "N" and "S" poles and attracts magnetic objects. There are different types of magnets, for example, a bar magnet, donut magnet, or horseshoe-shaped magnet. The objects that are attracted by magnets are nickel, cobalt, iron, etc.*

> *S201: A magnet is a tool shaped like an eraser or a horseshoe that attracts magnetic objects.*

S112 initially used the term "magnetic objects" and then listed these objects in his example. This kind of term is generally used by students to both shorten the long list of words and/or make it sound more scientific. S201 did not explain what he meant by a magnetic object.

The preeminence of students' observational experiences and pre-existing knowledge appears to play a pivotal role in the formulation of their conceptual ideas concerning natural phenomena. As children encounter diverse instances involving magnets in their environment, they naturally construct Models through the observational process. Notably, a pronounced distinction between the Models of students emerged between the initial and subsequent studies, particularly with respect to their perceptible association of magnets with toys or household objects, which was conspicuously present in the former but absent in the latter. In the first study, S107 provided additional elaboration on their use of magnets for retrieving specific objects, drawing parallels with the widespread practice of women in Turkish households using "tailor magnets."

> *S107: A magnet is a tool that makes our work at home easy and helps us find something that we are looking for. It holds things like small irons by pulling them toward it. For example, it holds needles and prevents them from spreading out and getting lost.*

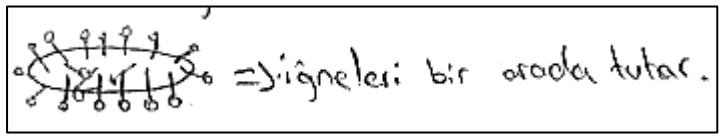


Figure 5. S107's Representation of Daily Use of Magnets *[Keeps Needles]***.**

In contrast, during the second study, the students refrained from making explicit references to their toys or household items while describing magnets. Merely two students mentioned that magnets attract needles, pins, and the like, without providing additional elaboration regarding the usage of these items at home. As an illustration, an excerpt from S243's response is provided below,

> *S243: A magnet attracts metal things and nails, pins, needles.*

Poles Model

Despite all students possessing knowledge about the existence of two distinct poles in magnets, their mental model representations concerning the expres-

sion of these poles exhibit significant variation (**Table 1**). In the initial phase of the study, a majority of students (52.5%) defined the poles as North and South (N,S), but this proportion notably decreased to 24.4% in the subsequent phase. An alternative prominent mental model employed by students for pole designation involves the use of + and - symbols, which was observed in 33.3% of students during the second phase, as opposed to 28.8% during the first phase.

Two students' responses were given as examples,

S104: A magnet has poles. A magnet's (+,-), (-,+) directions attract each other. Moreover, (+,+), and (-, -) directions repel each other.

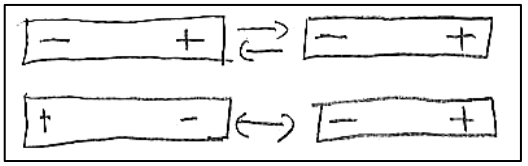


Figure 6. S104's Model Representation of Magnetic Attraction and Repulsion.

S124: A magnet is a matter which pulls metal and itself. A magnet has two poles; one side of it is negative (-), and the other side is positive (+). If the same poles come across each other, they repel each other. When opposing poles meet, they pull each other.

Figure 7. S124's Model Representation of Magnetic Attraction and Repulsion.

S244: I think there are + and - atoms inside the magnet. I remember that the + and - sides attract each other, but +,+ and -,- would not attract each other. Opposite poles attract and the same poles repel.

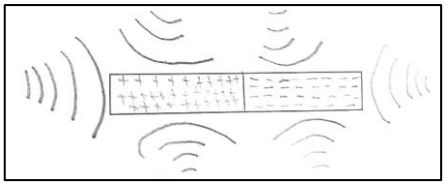


Figure 8. S244's Model Representation of Structure of a Magnet.

S104 employed the term "direction" to describe the poles of the magnets. However, it is important to note that the use of positive and negative direction terms is more commonly associated with kinematics, which defines velocity, acceleration, force, and vector position. As a result, S104's model may indicate a conceptual mixture that goes beyond the conventional charge model. It is plausible that students like S104 constructed their models based on fundamental kinematics concepts, not solely influenced by electricity.

Similarly, in the case of S124, although she presented a model with a "+" and "-" pole, the information provided did not sufficiently warrant categorizing it solely as an electrical charge model. As such, we should be cautious about assuming that these students' Models are always inspired by or influenced by electricity, and we should refrain from labeling them as "charge models." In S124's drawing, she used arrows to depict the repulsive effect when the "+" and "+" or "-" and "-" sides of two magnets are brought together, as well as the attractive effect when the "+" and "-" or "-" and "+" ends of two magnets are brought closer. This representation suggests a more comprehensive understanding of magnetic interactions beyond a simple charge-based model.

In the second study, S244 also indicated the presence of "+" and "-" poles in the magnet by depicting them halved in his drawing. Furthermore, he illustrated the attractive and repulsive effects of these "+" and "-" poles on the external surface of the magnet. This depiction demonstrates a more sophisticated grasp of magnetic interactions that extends beyond a basic charge model.

The students' terminological ambiguity is indicative of the underlying Models they hold, which subsequently influence their representations. Notably, a small subgroup of students (comprising 11.9% and 8.9%, respectively, in the two studies) demonstrated a hybrid approach by employing both N, S and +, - terminology to articulate the concept of magnetic poles.

For instance, in the first study, S103 presented + and - signs during his verbal explanation, but in his drawing, he employed N&S signs to depict the poles. Similarly, S229's drawing depicted both + and - signs, further exemplifying the coexistence of different terminological expressions within individual students' models even a decade apart.

> *S103: A magnet attracts iron. A magnet has two poles. "+" and "–"; plus pulls minus, plus pushes plus.*

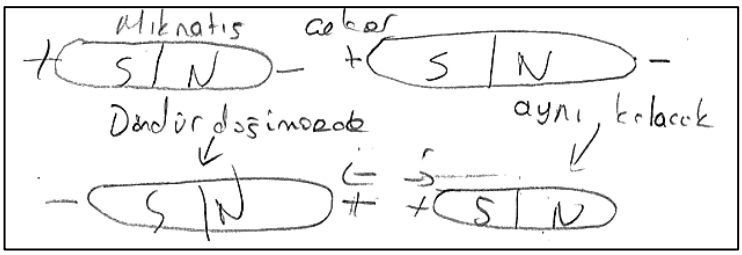


Figure 9. S103's Model Representation of Magnetic Poles *[Above: Magnet Attracts; above: when we turn it around, it will stay the same].*

S229: A magnet has two poles. If these poles are brought close to each other, they stick. But when the same pole approaches, they repel each other. The magnet can move and attract anything that is iron.

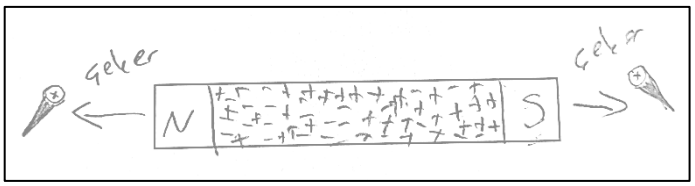


Figure 10. S229's Model Representation of Magnets and Magnetic Poles *[left: attracts; Right: attracts]***.**

These students expressed a conceptual model pertaining to magnetic poles, wherein they employed two distinct symbols to refer to the poles. However, there is a lack of consistent correlation between the symbols and the poles themselves. In other words, these students did not consistently associate the S pole in both phases of the study with either the - or + symbol. An examination of S103's initial drawing, which illustrates magnetic attraction, reveals an association of S with +. However, in S229's drawing, which depicts the distribution of both + and - symbols around the magnet, no clear correspondence is observed. Consequently, it can be inferred that these students lack a coherent model regarding the characteristics and nomenclature of the magnetic poles.

Composition and Functionality of Magnet

The question of what triggers magnets to attract an object and repel another magnet seemed to be a puzzle for students. More than half of the students (64.4%) pointed out the composition of a magnet as the main reason for its

attraction and/or repulsion feature in the first study. This rate decreased to 33.3% in the second study. It was observed that 8th-grade students attempted to establish a connection between the atomic structure of magnets and their magnetic behavior.

> *S101: There are matters that have magnetic features inside a magnet. These matters give attraction power to the magnet.*
>
> *S126: There are matters that have a magnetic feature inside [the magnet]*.

For example, S101 and S126 probably used the "matters" term to describe magnetic domains or atoms. Evidently, these students drew upon their understanding that all matter is composed of atoms when attempting to explain magnetic phenomena. However, as exemplified by S106' responses, some students employed terms not commonly used among individuals of their age level, such as nanoparticles, electromagnets, and elements. Presumably, they may not have fully grasped the precise meanings of these terms, but they used them to sound scientific and logical in their explanations.

> *S106: There are electro-magnets inside a magnet.*

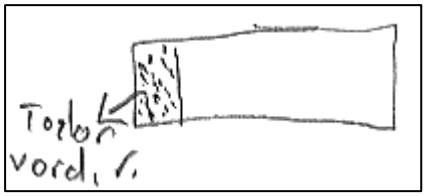


Figure 11. S106's Model Representation of "Magnetic Domains" *[There are powders]***.**

S106 and some others presented more than one term to describe these small particles responsible for magnetic behavior. For instance, S106 mentioned "electromagnets" in her verbal response while using the term "powders" to elucidate the small dots in her drawing.

It is noteworthy that the students in both studies did not mention magnetic domains or the motion of electrons as potential reasons for the attraction and repulsion features exhibited by magnets. Despite being aware of the existence of small particles that constitute a magnet, their responses revealed a degree of ambiguity, indicating that their Models were not entirely clear and comprehensive. Regarding the question about the expected inner structure of a magnet, the responses provided by the students further emphasized the lack of clarity in their conceptualizations and models. The variety

in their descriptions of the inner structure of magnets further underscores this point. Notably, it was observed that students in the first study offered more detailed and distinct answers to this question, suggesting potential differences in their conceptualization between the two studies.

In the context of the second study, students exhibited diverse perspectives regarding the internal structure of magnets, which is believed to be responsible for their magnetism. These viewpoints included references to sticky powders, liquid substances, and small magnets as potential components contributing to the magnet's magnetic properties.

> *S217: I think there are sticky powders in it. When they're the same, they repel when they're different, they attract.*

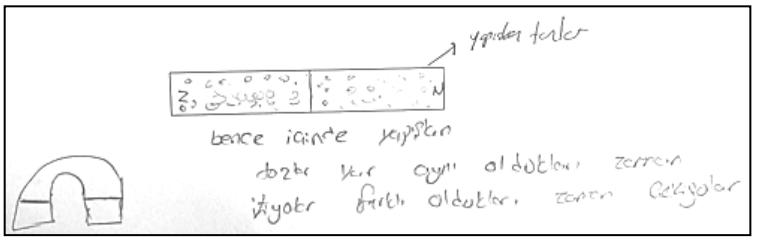


Figure 12. S217's Drawings Demonstrate How They Visualize the Attraction between a Magnet and Objects. *[Above: sticky powders; Below: I think there are sticky powders in it. When they are the same they repel, when they are different they attract.]*

> *S202: There's a substance outside the magnet that will bring things closer together. Inside, there's energy. There's a substance like glue.*

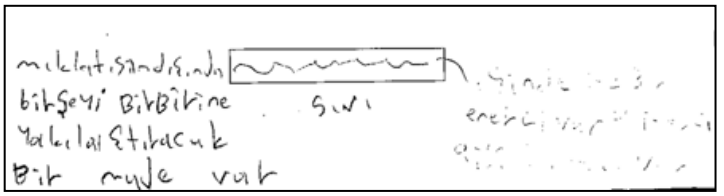


Figure 13. S202's Model Representation of "Magnetic Domains". *[Left: There is a substance outside the magnet that will bring them closer together; Right: There is an energy in it. There's a substance like glue.]*

S205: Magnet is a tool that attracts metal objects. A magnet is needed to find many lost metal objects.

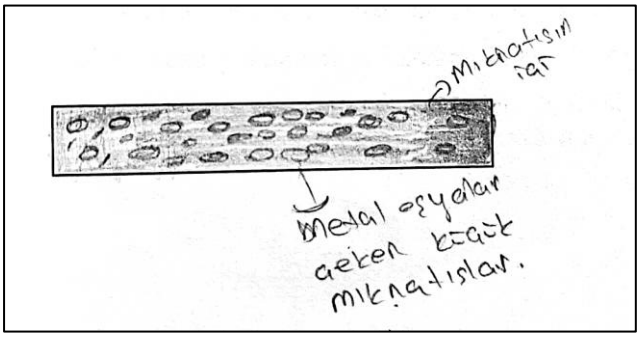


Figure 14. S205's Model Representation of "Magnetic Domains". *[Above: inside a magnet; Bottom: little magnets that attracts metal objects]*

Students' Models about the Nature of Magnetic Interactions

Another significant aspect investigated in this study pertained to the consistency of students' Models concerning magnetic interactions between a magnet and a nail. In this section, the examination revolved around determining whether students' accurate or inaccurate Models exhibited internal coherence when presented with similar scenarios, and it aimed to compare the levels of coherence or incoherence between two distinct groups of students, separated by a ten-year interval. These accurate and inaccurate models provided valuable insights into the coherence of students' comprehension of magnetic interactions and the extent to which their inaccurate Models were ingrained.

Specifically, the students' responses to two distinct questions, Q5 (inquiring about the magnetic interaction between a magnet and a nail when the magnet is turned around) and Q9 (inquiring about the magnetic interaction between a magnet and a nail when the nail is turned around), were analyzed. By probing the magnetic interactions between a magnet and an unmagnetized object in both cases, these responses shed light on the students' understanding of such interactions and the consistency of their comprehension across varying contexts.

Through the analysis of students' responses based on their accuracy levels, three assertions were derived, each further subcategorized according to the students' common Models:

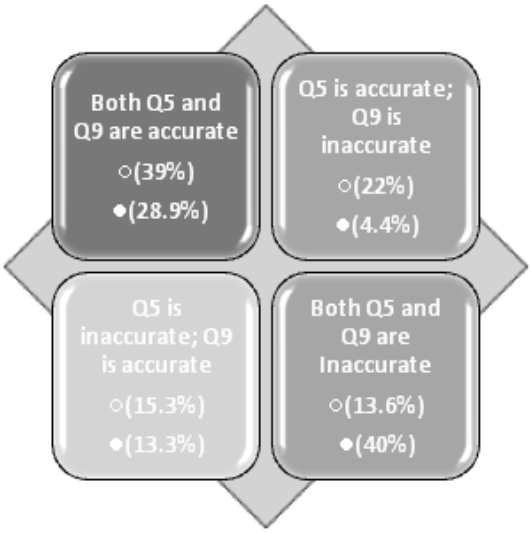


Figure 15. Frequency of Students' Answers to Q5 & Q9. *[○ Data from 2010-2011 academic year; ● Data from 2022-2023 academic year]*

Assertion 1: In the first phase, 23 students (39%) accurately answered both questions, whereas in the second phase, 13 students (28.9%) accomplished the same level of accuracy.

Assertion 2: In the first phase, 13 students (22%) responded correctly to Q5, but they provided incorrect or inappropriate (i.e., non-scientific terminology) responses to Q9. Similarly, in the second phase, only two students (4.4%) demonstrated this pattern. Additionally, nine students (15.3%) in the first study and six students (13.3%) in the second study gave an incorrect answer to Q5 but provided correct answers to Q9.

Assertion 3: In the first study, eight students (13.6%) provided inaccurate responses to both questions, while in the second study, this number increased to eighteen students (40%).

Assertion 1: Students have a full understanding of the attraction between a magnet and a nail in both contexts, i.e., their models are consistently applied across contexts.

Students falling into the first assertion exhibited a coherent model regarding the attraction between a magnet and a nail in both studies, consistently stat-

ing that "both sides of the magnet attract the nail." This consistent observation was attributed to the inherent nature of the nail. The responses of these students revealed that their Models of magnetic interactions between magnets and iron-like objects were based on a combination of the magnets' attractive properties and their observational memory. Within this category, we identified two prevalent models:

i. Both sides of a magnet attract a nail

A prevailing response among students to this assertion was that a magnet attracts every side of a nail. However, throughout both phases of the study, students' reasoning exhibited a lack of specificity regarding the nature of this interaction. The following excerpts illustrate that students attributed the equal attraction on both sides to certain characteristic features of the nail.

> *S116: The magnet attracts all sides of the nail equally.*

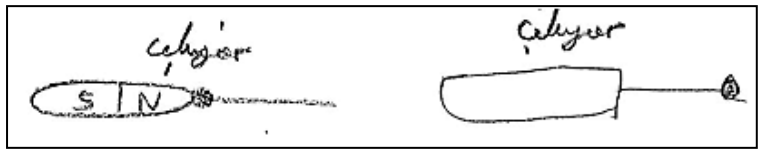


Figure 16. S116's Model Representation of the Interaction between a Magnet and a Nail *[Left: It is pulling; Right: It is pulling]***.**

> *S109: Zeynep is right because all sides of the magnet have the same characteristic.*
>
> *S245: All sides of the magnet attract with the same force. The gravitational force of the magnet does not change because it has the same feature on the front side as on the back side.*

In this assertion, students emphasized the isomorphic structure and composition of the objects while describing the interaction between a magnet and a nail when held in close together. Another prevalent model was the notion that the attractive force exerted by both sides of the magnet had an equal effect on both sides of the nail. However, in the first study, aside from student S104, none of the students provided further elaboration on the connection between these phenomena and the underlying reason for the observed interaction.

S104:
Q9-a: The magnet attracted the head of the nail because there are many more atoms on the head of the nail.
Q9-b: Nothing has changed. It still attracts.

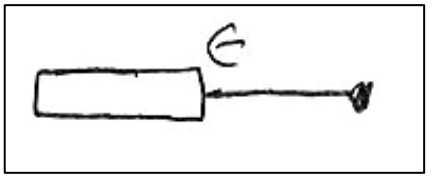


Figure 17. S104's Model Representation of the Interaction between a Magnet and a Nail.

Q9-c: There is no difference between the two cases.

S104 mentioned the atoms of a nail, but his explanation showed some confusion. To three different questions, his answers were that every side of a nail is attracted by a magnet. In the second phase, S242 explicitly stated that the particles within the magnet are responsible for the attraction between the magnet and a nail.

S242:
Q9-a: The particles inside the magnet attract the nail by acting on it.

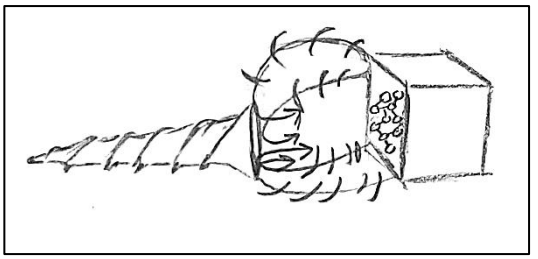


Figure 18. S242's Model Representation of the Interaction between a Magnet and a Nail.

Q9-b: the magnet exerts an attractive force on the nail.
Q9-c: If we turn the nail over, the magnet exerts the same force of attraction on the nail.

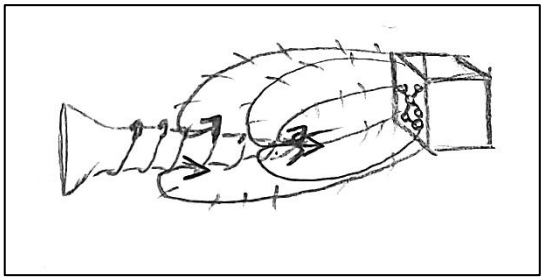


Figure 19. S242's Model Representation of the Interaction between a Magnet and a Nail.

ii. The nail is attracted because of its iron/metal structure.

When we analyzed students' models of magnetic interaction, we found that students distinguished between objects being attracted/repelled by magnetic force, while other objects were not. Throughout both studies, the prevailing reasoning among 8th-grade students for the interaction between a nail and a magnet was attributed to the iron/metal composition of the nail. In the first study, six out of fifteen students, and in the second phase, seven out of nineteen students, offered the rationale that the mere composition of iron was adequate to account for magnetic attraction. Several illustrative examples from the students' responses are provided below:

> *S108: The magnet's attraction towards the nail is attributed to the nail's iron composition.*
>
> *S126: The head of the nail is iron; that's why the magnet still attracts it [the nail].*
>
> *S202: Due to the properties of the magnet, it attracts iron or steel.*
>
> *S205: Since the nail is made of iron, the magnet attracts such objects. In my drawing the magnet attracts the nail.*

In general, the responses from the students revealed a comprehension of the interaction between iron objects and magnets. However, in both the initial phase and the follow-up phase after ten years, the concepts of domain, alignment, and magnetization of ferromagnetic materials were noticeably absent from their explanations. These findings demonstrate children's empirical approach toward scientific phenomena. On the contrary, students tended to limit their understanding to situations in which magnets solely at-

tract iron objects, neglecting the possibility that an iron object could also be magnetized and repel a magnet.

Assertion 2: Students have a partial understanding of the interaction between a nail and a magnet; their models are not consistently applied across contexts.

The students in this category exhibited responses containing inaccurate information to one of the questions among Q5 and Q9. Although both questions necessitated the same conceptual knowledge, a subset of students (N = 16 (27.11%) in the first study and N = 8 (17.8%) in the second study) approached each question with distinct understandings. Consequently, it can be inferred that these students' Models lack internal coherence. In the first phase of the study, nine students demonstrated an understanding of the interaction between a nail and a magnet when the magnet is turned around (Q5), yet this number decreased to only two students in the second phase. Conversely, in the first phase, seven students displayed confusion when asked about the same concept but in the context of the magnet being turned around (Q9), while six students did not provide accurate answers to the question in the second phase.

Nail's two-sided entity model was one of the recurring ideas among students' model representations in early survey questions. However, some students with correct answers held a second belief that the nail will be attracted when one side is near the magnet but repellent when the other side is facing the magnet (Q9). Their logic followed the rule that opposite poles attract and same poles repel. Even though this idea seems to support the magnetized nail feature, they did not mention it, and their answer to Q5 confirms that. Moreover, since these two questions address the same concept, contradictory answers indicate that some students did not understand the mechanism by which attraction between a magnet and a nail occurs. For example:

S131:
Q5: Can's explanation is wrong and does not make sense. Scientifically, it cannot happen.
Q9:
a)

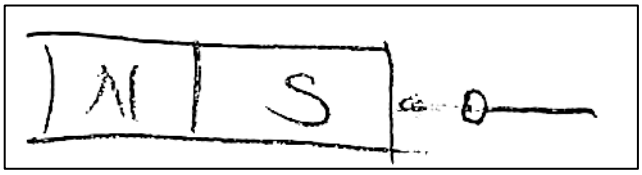


Figure 20. S131's Model Representation of the Interaction between a Magnet and a Nail.

b) The magnet pulls the object.
c)

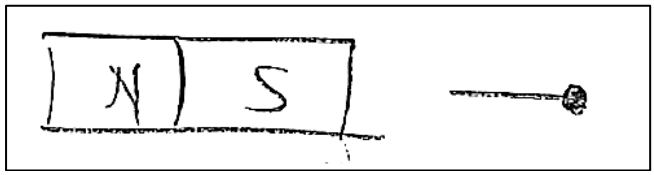


Figure 21. S131's Model Representation of the Interaction between a Magnet and a Nail.

d) It [magnet] attracts the object in the first one, repels the object in the second.

S243:
Q5: Zeynep drives the nail in the right place and the magnet attracts the nail by its tip. So the magnet attracts the nail even if we turn it upside down.
Q9:
a)

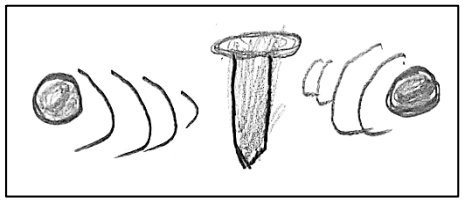


Figure 221. S243's Model Representation of the Interaction between a Magnet and a Nail.

b) If you hold the magnet against the iron, they immediately stick together.
c)

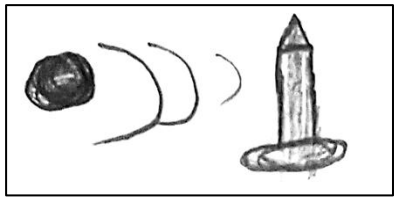


Figure 23. S243's Model Representation of the Interaction between a Magnet and a Nail.

d) Hardly pulls the nail.

The discrepancy in S131's conceptual model became apparent through an examination of his responses to Q5 and Q9. In Q5, he asserted that Can's explanation regarding the interaction when the magnet is turned around was not "scientific." However, in Q9, S131 contended that the magnet attracts one end of the nail and repels the other end.

In contrast, even a decade later, S243's responses to Q5 and Q9 continued to demonstrate divergent perspectives. In Q5, S243 stated that the magnet attracts the nail even when the nail is turned upside down, while in Q9, S243 asserted that the magnet attracts the nail in its original orientation but exerts minimal attraction when the nail is reversed. Much like these students' inconsistent responses, other students may also provide two entirely distinct explanations for the same phenomenon. These observations indicate that these students' Models appeared to revolve around two distinct ideas.

i. Magnets attract the head and repel the tip of the nail.

Within this category, certain students argued that magnets attract the head but repel the tip of a nail. In both studies, a noteworthy finding emerged among students who stated that in the interaction between the nail and the magnet, the nail is repelled by the magnet when it is reversed. These students demonstrated a tendency to associate larger surfaces with attractiveness and smaller surfaces with repulsiveness in their conceptualizations of the magnetic interaction. Below, the students' drawings for Q9 (where the nail is turned around) and their explanations to Q5 from both studies exemplified the emergence of non-normative Models among the students.

S117: The head of the nail has the same polarity as the magnet and the opposite direction has the opposite polarity. Therefore, the one with opposite polarity attracts and the other one repels.

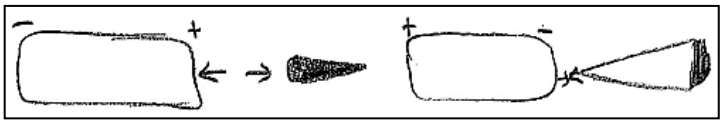


Figure 24. S117's Model Representations of the Interaction between a Magnet and a Nail.

S239: The second time the magnet repelled the nail. Since there are fewer electrons at the tip of the nail, the chemical in it decreases towards there. That's why it repels. The head

and the tip of the nail have different properties. The electrons there are different.

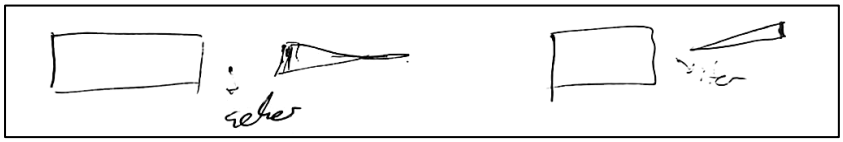


Figure 25. S239's Model Representation of the Interaction between a Magnet and a Nail *[Left: attracts; Right: repels]***.**

The impression that large surfaces are affected by magnetic force more than small surfaces presumably derives from another piece of conceptual knowledge. Students may think that many atoms on the head of a nail increases the possibility of interaction with a magnet's atoms.

ii. The interaction between a magnet and a nail depends on the poles of the magnet.

Most students in this category who provided accurate responses to Q9 (i.e., a nail is turned around) demonstrated awareness of the non-polarized structure of a nail. However, they encountered challenges when attempting to transfer this knowledge to their responses to Q5 (i.e., a magnet is turned around). Notably, five students in the first phase and eight students in the second phase asserted that while one side of a magnet always attracts, the other side always repels. For instance, the inconsistent answers given by students S128 and S228 indicated the existence of an incomplete model regarding the magnetic condition of nails (in the absence of being magnetized).

S115: Because the magnet has two poles. If one pole attracts an object, the other pole does not. That's what Can is trying to say.

S228: Because a magnet has opposite poles. If one pole of the magnet attracts, the other pole repels.

These students may hold the belief that the two poles of the magnet serve distinct functions. Notably, in the second phase of the study, some students explicitly stated that the north or + pole of magnets exhibits an attractive force, whereas the south or - pole elicits repulsion.

S206: Because I think the south side is pushing.

Assertion 3: Students do not have a scientifically accurate understanding of the interaction between a nail and a magnet.

In the first study, ten students and in the second study, eighteen students were identified to possess inaccurate Models of the interaction between the nail and the magnet. These students consistently displayed a particular pattern in their responses to all questions. Initially, in response to Q1, which inquired about the nature of a magnet, all of these students mentioned that magnets attract objects such as iron and metal. However, when presented with Q5 and Q9, which asked about the interaction between a magnet and a nail, these students stated that a repulsion effect would occur when either the magnet or the nail was reversed.

Despite the lack of scientific accuracy in their responses, these students' answers demonstrated consistency across Q5 and Q9. The prevailing model that emerged from the students' responses was based on the notion that unlike poles attracts each other, while like poles repel.

i. Unlike poles attract, like poles repel.

The pole entity is one of the recurring ideas among these age-group students. Despite the absence of references to magnetization of the nail in any of the questions posed, certain students asserted the presence of poles in the nail in both phases of the study. In the first study, seven students (11.9%) and in the second study, six students (13.3%) indicated that the poles of the nails influenced the interaction between the magnet and the nail.

By knowing students' models of polarization of unmagnetized nails, the non-normative models about interaction between a nail and a magnet could be deciphered expressively. One example from each study is given below to reflect the students' models:

S103:
Q5: When the nail is changed [turned around], then the poles will change, too.
Q9:
a) The "+" pole of iron pulls that part of the nail.
b)

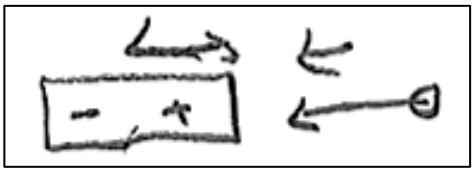


Figure 26. S103's Model Representation of the Interaction between a Magnet and a Nail.

c)

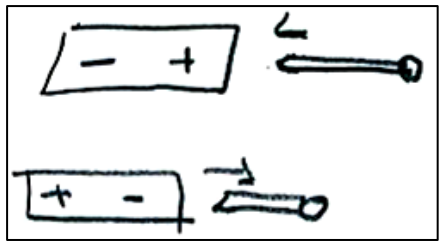


Figure 27. S103's Model Representation of the Interaction between a Magnet and a Nail.

d) The nail is affected by the first pulling force. The influenced nail pushes another pole when this pulling force is applied to it.

S212:
Q5: Because what Can says is scientific and logically convincing.
Q9:
a)

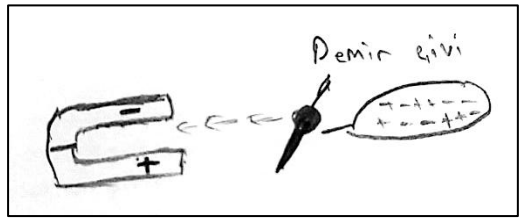


Figure 28. S212's Model Representation of the Interaction between a Magnet and a Nail *[Above the nail: Iron nail].*

b) The positive and negative poles of an iron nail attract each other
c)

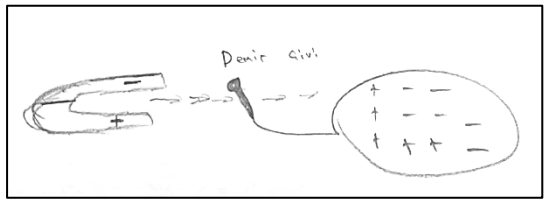


Figure 29. S212's Model Representation of the Interaction between a Magnet and a Nail *[Above the nail: Iron nail].*

d) Since the iron nail has more negative charges, the negative pole will push the nail.

In the first example, S103 presented several conceptual confusions. For Q5, he asserted that if the nail is turned around, the poles will also change their direction, potentially stemming from the second reasoning mentioned earlier that contributes to the "opposite poles attract, like poles repel" model held by students. He posited that the magnet's "plus" pole pulls the nail, while the "minus" pole pushes it. On the other hand, S212 did not appear to fully grasp Q5; however, the student arrived at a conclusion that Can's idea is more scientific. He also depicted a cross-section illustration that revealed the internal structure of the nail, indicating the presence of both positive and negative charges within, in Q9. These results demonstrate that even after a decade, students maintain the belief that the nail can be "charged" while remaining oblivious to its magnetization property.

Discussion

Modelling is considered and utilized as a common scientific practice (Burgin et al., 2018; Giere, 2004; Schwarz et al., 2009). Models, on the other hand, have primarily two major missions: serving as the cognitive tools that individuals develop in their minds and utilizing them to make sense of the world around them (Gentner, 2001; Johnson-Laird, 1983). Models are used to represent a phenomenon, a concept, or an object as well as for sharing ideas, making predictions, examining, and revising an idea, etc. Scientists take advantage of using model-based understanding to approach and solve a problem (Giere, 2004). Likewise, children use their models to understand and interpret a new piece of information (Greca & Moreira, 1997).

This study gave us the opportunity to examine normative and non-normative Models of Turkish students at 10-year intervals. When we analysed the data, we also focused on identifying if there is a consistency in the students' models regarding questions that have different contexts but address the same phenomenon. In the following sections, we will discuss our findings for these two questions and blend in current studies' findings about students' magnetism models to draw a holistic picture.

Models of Magnets

When the first phase of this study was conducted during the 2010-2011 academic year, it was observed that there existed several investigations dedicated to unveiling K-8 level students' Models related to magnetism prior to 2010 (Borges & Gilbert, 1998; Bradamante & Viennot, 2007; Kucukozer & Kocakulah, 2007; Ravanis et al., 2010; Saglam, 2010; Sederberg & Bryan,

2009; Şengören, 2010; Tanel & Erol, 2008; Yurumezoglu & Cokelez, 2010). However, it was noted that these studies predominantly fell within the scope of electricity-related topics, with a stronger emphasis on basic concepts. Subsequently, in the second phase of the study conducted during the 2022-2023 academic year, a noticeable decline in such studies was observed, indicating a decreasing trend, and the topic of magnetism was mentioned with diminishing frequency (Cai et al., 2017; Erickson, 2013; Henderson et al., 2019; Kähkönen et al., 2020; Kalogiannakis et al., 2018; Lemmer et al., 2020; Sederberg, 2012).

The existing studies, which encompassed students at both higher grade levels and elementary schools, have revealed a significant issue concerning students' meaningful comprehension and Models, particularly when advancing into more complex learning experiences, such as electricity and electronics. Within the scope of this study, we identified numerous non-normative models concerning the nature of magnets, which could potentially pave the way for the development of other non-normative models. Intriguingly, these non-normative Models exhibited relative stability over a span of ten years, despite any curriculum changes in magnetism topic that might have occurred during this period.

We gathered students' Models about nature of magnets and magnetic interactions under three main categories and elaborated them. The first category was about magnets' attractive and repulsive entities. In the two separate studies involving 8th-grade Turkish students, conducted with a ten-year interval, a majority of the students contended that magnets solely attract metal and iron materials. This observation aligns with the findings of prior studies conducted by Sederberg (2012) with American students, Kähkönen et al. (2020) with Finnish students, and Lemmer et al. (2020) with African students.

Magnets, owing to their easy accessibility, affordability, and practical utility, find frequent application in everyday life, prompting students to often depict them in terms of their benefits. Notably, in both studies with a decade apart, certain students asserted that magnets are used for picking up objects such as needles or nails and for keeping these objects together. This noteworthy finding underscores how children construct their Models through direct interactions with objects within their immediate environment, indicating that their conceptualizations are influenced by practical experiences (Kalogiannakis et al., 2018). This aligns with the observations made by Brademante & Viennot (2007) and Lemmer et al. (2020), wherein students also presented real-life examples of magnet applications, such as sticking to needles or refrigerator magnets. However, a salient finding in comparing the results of the first and second studies was that students in the recent study provided fewer examples of daily life applications of magnets compared to students from a decade ago. This discrepancy may imply alterations in the

students' social lives, motivational factors, or their interaction with the environment over the intervening decade between the two studies. It is plausible that changes in their experiences and exposure to different contexts contributed to the divergence in their Models. The underlying basis for the robust inclusion of the attraction phenomenon in students' models during the first study could be attributed to their exposure to childhood toys, such as magnetic building blocks and fishing games, as well as daily-utilized magnets like those affixed to refrigerators or used as tool holders and telescoping devices. Further investigation is warranted to better comprehend the intricacies influencing the evolution of their conceptualizations over time.

The second category pertained to magnetic poles, an aspect of considerable interest in both studies conducted a decade apart. The findings revealed that students encountered difficulties in comprehending and describing magnetic poles. Over the ten-year interval, students' representations of magnetic poles fell into three main types. The most accurate representation observed in both studies was the N-S representation, with 52.5% of students in the first study and 24.4% in the second study consistently labelling magnetic poles as N and S. The second most common representation was through charge symbols, with 28.8% of students in the first study using + and - symbols to describe magnetic poles. Remarkably, this percentage increased to 33.3% in the second study, suggesting a notable shift in students' conceptualizations of poles over time. This widely encountered model is commonly referred to in the current literature as the "charge model" (Borges & Gilbert, 1998; Kähkönen et al., 2020; Lemmer et al., 2020; Sederberg, 2012). However, it is crucial to note that there is insufficient evidence to directly associate students' representations with the concept of electrical charges, as none of the children explicitly referenced electrical charges in their responses. Consequently, it remains uncertain whether students were genuinely inspired by electrical charges or simply employed + and - symbols to denote opposites.

The third pole representation was mixed poles. A subset of students, accounting for 11.9% in the first study and 8.9% in the second study, combined + and - signs with N and S labels to describe magnetic poles. These students exhibited scientifically appropriate models yet appeared hesitant to relinquish their pre-existing Models. Saglam and Miller (2006) previously elucidated this paradox by noting that students often associate positive charges with N poles and negative charges with S poles. However, the present study's findings did not confirm this assertion, as students did not establish any direct correlation between + and -, or S and N. Instead, they randomly assigned these symbols to the poles. These diverse findings underscore the complexity of Models among students and the evolving nature of their conceptual frameworks concerning magnetic poles. Further investiga-

tion is warranted to unravel the underlying factors that influence the development and transformation of these Models over time.

The third category was composition and functionality of magnets, which appeared to show differentiations in both studies a decade apart. Upon examining the data gathered from students a decade ago and at present in the current study, it was observed that the majority of students in the initial study provided a greater number of properties of magnets (see **Table 1**) and offered more detailed illustrations in their drawings.

In our investigation of students' descriptions pertaining to the properties and internal structure of magnets as viewed through "magic glasses," significant disparities emerged between the responses gathered a decade ago and those from a decade later study. In the initial study, students demonstrated a variety of Models and presented diverse drawings. For instance, certain students in the first study proposed that magnets were constituted of coal or powder, whereas in the second study, none of the students mentioned coal as a constituent of magnets, and two students referred to the presence of powder. Further analysis of the drawings revealed contrasting depictions of magnetic fields between the two studies. In the first study, students employed field lines emanating from N (North) to S (South) poles, incorporating a semi-circular pattern to illustrate the magnetic field. Conversely, in the second study, the field lines adopted a sound wave-like appearance. These findings align with prior research conducted by Sederberg (2012) with American students and Kähkönen et al. (2020) with Finnish students, and Lemmer et al. (2020) with African students which also reported similar outcomes.

Moreover, it was revealed that students in both studies shared similar Models concerning magnets. In both phases, some students asserted that magnets contained matter or elements within. Additionally, certain students in both studies posited that magnets consisted of atoms, nanoparticles, or electromagnets. The presence of such common patterns in both studies correspond with Sederberg's (2012) previous study findings as well.

Models about Magnetic Interactions between a Magnet and a Nail

While many magnetism studies focused on the structure of magnets, we discovered non-normative models about the structure of nails and attributed some of the accuracy of models about the nature of interaction between a nail and a magnet to these fundamental non-normative models. Students' models about interactions between a magnet and an unmagnetized object (i.e., a nail) were examined across two questions. The results indicate a similar pattern with Kähkönen et al. (2020) and Lemmer et al. (2020)'s study that

two models predominate in eighth grade students' minds: magnets (and all iron objects, according to some students) have two opposite poles, and opposite poles attract while the same poles repel. In addition to these models, students asserted the idea that one end of a magnet always attracts while the other end always repels.

Students who possessed a sound understanding of the nature of magnetic behavior could effectively utilize their prior knowledge and experiences to describe the outcomes when either the nail or the magnet was rotated. Nevertheless, the findings also indicated that a considerable proportion of students, accounting for 37.3% in the first study and 17.7% in the second study, exhibited difficulty in establishing a cognitive connection between two identical concepts presented in different contexts. Despite a reduction in the percentage of such students in the second study, their models of magnetic interaction remained incomplete and inadequately developed. This confusion arises from both students' limited knowledge of magnet properties and their inconsistency in determining whether the nail is magnetized or not. Lemmer et al. (2020) reported that students are aware of magnets having two poles, but they tend to believe that magnets encountered in their daily lives, like refrigerator magnets, possess only one pole. Furthermore, Kähkönen et al. (2020) observed that students treated nails as if they were magnetized, even though their study did not explicitly mention the magnetization of nails. The same inconsistency in Models was identified in both student groups in our study.

The findings suggest that students often grapple with inconsistent Models when navigating between their informal observations in daily life and the formal knowledge presented in scientific studies. The decline in the number of students exhibiting inconsistent Models in the second study could be attributed to a reduced engagement with magnets in their daily lives, as mentioned earlier.

Finally, a noteworthy percentage of students, comprising 13.6% in the first study and 40% in the second study, demonstrated internally consistent but unscientific Models of the magnetic interaction between the magnet and the nail. These students' non-normative Models appear to stem from the perception that the nail possesses two distinct poles, akin to a magnet. The origins of this model may be attributed to two factors. First, students might generalize that all matter composed of iron, metal, nickel, etc., inherently possesses two poles with similar magnetic effects, even though they may not be aware of the possibility of the nail being magnetized. Second, the concept of magnetic poles might lead students to believe that certain objects (such as iron, metal, etc.) consistently exhibit attraction and/or repulsion, independent of their structural composition or atomic alignments. This observation aligns with the findings of Sederberg (2012) and Kähkönen et al. (2020) in related studies.

Conclusion and Suggestion

The study presented in this paper is framed by the premise that learning and understanding derive from learners' current models and knowledge (Gentner, 2001; Von Glasersfeld, 2013). Therefore, the present study endeavors to unveil the Models of eighth-grade students in Türkiye concerning magnets and magnetic interactions, with a specific focus on identifying both ingrained and nonnormative Models. The research seeks to shed light on the depth of students' conceptualizations and the extent to which nonnormative Models persist in their understanding of the subject matter. In recent years, there has been a scarcity of research investigating K-8 students' Models of magnetism. The prevailing studies often focused on assessing students' Models at a specific time or examined the impact of interventions on their Models. A distinct feature of the current study is its unique approach of comparing Models of students within the same age group at 10-year intervals, employing a consistent data collection tool. This method allowed for the identification of changes in the mental model patterns among Turkish students over the specified time frame. Furthermore, refocusing our attention on the underlying factors that influence the development of students' constructed models holds vital importance in helping students enhance or revise their existing models.

Novice students use Models built via informal education such as personal observation, media, or people, and prior concept knowledge (di Sessa et al. 2004; Shepardson et al., 2007). Hence, it is not surprising that students' explanations were less sophisticated and lacked detail since magnets are parts of daily life and these students have not seen a comprehensive magnetism topic in their prior science courses. However, the findings in this study should suggest teachers how to design their lessons and what their activities should be focusing on to help students overcome their inaccurate as well as inconsistent Models. Additionally, as indicated by the findings of this study, the passage of ten years can significantly influence the formation and development of students' Models on a specific subject. Although all cognitive scientists agree that the construction of models takes place as an internal process for individuals, outside social, cultural, and environmental factors also play a significant role in an individual's modelling process (Moreira, 2000). Therefore, it becomes essential to conduct periodic studies at regular intervals, while also considering the prevailing social and societal context. Such repeated investigations provide valuable insights into the evolution of Models over time and offer valuable guidance for educators to align their instructional practices with the latest research findings.

While the outcomes of this study provide valuable insights for educators as outlined above, it is essential to acknowledge that the data collected through the employed data collection tool may have limitations in fully explicating certain aspects of students' inaccurate and inconsistent Models.

Therefore, it is advisable that future research endeavors be undertaken to explore and elucidate these specific details further.

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ORIGINAL ARTICLE

The Effect of Block Coding (Scratch) Activities Integrated into the 5E Learning Model in Science Teaching on Students' Computational Thinking Skills and Programming Self-Efficacy

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***Abstract**: This study was carried out to determine the effect of Scratch-based coding applications integrated into the 5E learning model used in science teaching on students' computational thinking skills and self-efficacy towards block-based programming. In addition, students' perceptions of the activity were measured after each Scratch activity, which was applied at different stages of the course and with different difficulty. The study employed the pretest-posttest control group less design, one of the quasi-experimental methods. The study sample consist of 22 6th grade students attending a public school in Turkey located in a district center in the Eastern Black Sea region. The study was carried out in a five-week period in the 2022-2023 academic years. Computational thinking scale and robotics attitude scale, self-efficacy perception scale related to block-based programming and activity perception scale were used as data collection tools. The data were analyzed using the dependent samples t-test. The findings suggest that computational thinking skills level of students and their self-efficacy perception related to block-based programming increased significantly with the Scratch-based activities integrated into 5E learning model applied in science subjects. In addition, students have positive attitudes towards these activities. Thus, it is recommended to apply Scratch-based coding applications in teaching science subjects.*

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Introduction

FOR science education to be more effective, it is a very common approach to create teaching environments that allow students to learn by doing and experiencing. Constructivist approach that focuses on active learning and the creation of knowledge by connecting prior knowledge with newly encountered knowledge (Appleton, 1997; Cakir, 2008; Copley, 1992; Hand & Treagust, 1991) becomes an essential tool used in science education. It also helps to facilitate the learning process by using learning cycle models. One such model is the 5E learning model. Based on the relevant literature, the 5E learning model can be described as one of the most useful models of constructivist learning theory in the teaching process (Çoruhlu, 2013). The 5E model, developed by Bybee et al. (2006), is named after the English initials of the model (Engage, Explore, Explain, Elaborate, and Evaluate). In these stages, all the steps of a learning-teaching process that is based on research and inquiry are covered, and the roles of teacher and student are expressed in a rich way structurally and pedagogically throughout the process. When the relevant literature is examined, it is seen that there are very few studies in which science education is designed by integrating technology into the 5E learning model. However, there are studies in which technologies such as augmented reality (Abdusselam et al., 2018), robotics (Cakir & Guven, 2019), interactive simulation (Lye et al., 2014) and mobile learning (Celik et al., 2020; Lai et al., 2015) are adapted to the science teaching process through the 5E learning model.

Technology and Education

Technology can take many forms in science education, from online simulations to interactive whiteboards, or from virtual labs to educational software (Fraser, 2023; Özbek & Uslu, 2021). The most important reason for the widespread use of technology in science education is that it can make abstract or complex concepts more concrete and understandable for students. For example, simulations and visualizations can be used to explore scientific phenomena that may be difficult to observe in the real world or to model complex systems and processes that are difficult to replicate in a classroom setting (Oliveira et al., 2019). Students can design and conduct experiments, collect and analyze data using technology. Thus, they experience applied, inquiry-based learning environments using digital tools (Unlu & Dokme, 2020). Using technology, students not only learn more deeply about science-related topics, but also develop skills such as scientific inquiry, problem solving and critical thinking (Kim & Hannafin, 2011).

Although the use of technology in educational processes has a certain cost and there are difficulties such as the educational needs of the educators

who will use it, it can be said that technology is one of the most powerful tools students must benefit for life. (Hew & Brush, 2007; Hsu, 2016). The use of technology in science education has become increasingly prevalent in recent years, with computers being one of the most widely used tools. Computers have become an important tool in modern science education, considering their easily accessible and increasing usage areas (Jong et al., 2013). As a result, educators are increasingly using computers to enhance their teaching and students' learning experiences in science.

Coding and Education

In recent years, there has been a movement led by Code.org, a non-profit organization aimed at promoting the teaching of programming in schools around the world. This movement primarily focuses on filling the shortage of IT professionals that exist today and is expected to increase in the coming years (Moreno-León & Robles, 2016). Academics from both education and science circles state that data on the potential benefits of children learning to code is important, regardless of their future professional field. It aims not only to teach coding itself, but also to serve as a tool to develop other skills, improve learning outcomes, and enhances student motivation (Resnick, 2013). The idea of coding for learning was first introduced by Seymour Papert in the 1970s. Logo programming language has been developed for children to create games, music, and repetitive drawings on computers (Papert & Solomon, 1971). While programming was taught in many schools in the 1980s, it vanished from the educational landscape in the 1990s because it was not integrated into subjects beyond mathematics and physics, and classroom activities didn't appeal to students' interests (Kafai & Bruke, 2013).

Another theory that supports teaching programming by integrating it into other courses is related to computational thinking. Computational Thinking (CT) refers to the thought processes involved in formulating problems so their solutions can be represented as computational steps and algorithms (Aho, 2012). Although the concept of computational thinking dates to the 1950s (Tedre & Denning, 2016), it was introduced to education world by Jeannette Wing's article published in Communications of the ACM in 2006 (Wing, 2006; Grover & Pea, 2013). The article suggested that computational thinking is a fundamental skill for everyone, not just computer scientists, and argued for the importance of integrating computational ideas into other subjects in school. The trial also said that by learning to think computationally, children would do better at many everyday tasks.

Visually Based Programming Languages and Scratch

Although it is a very effective process for students to learn a subject by coding, it requires students and branch teachers to have coding knowledge to be

applied in the classroom environment. Learning text-based programming languages is a very challenging process. Block coding, on the other hand, is a visual programming language that uses pre-written blocks or stacks of code that can be dragged and dropped to create programs. It is an excellent tool for coding beginners as it offers several advantages over traditional text-based scripting languages (Resnick et al., 2009).

In recent years, visual-based programming languages such as Alice, Code, and Scratch have rekindled interest in programming among educators. Scratch permits the creation of many different types of projects, so learners with varying interests and learning styles can express themselves through programming. As a result, teaching children and teens extracurricular activities, summer camps, and classroom programming has become more common. However, for this interest in coding in schools to continue, evidence of the educational impact of programming is needed (Kafai & Bruke, 2013).

One of the most widely used block-based programming languages is Scratch. Scratch is a free block-based programming language developed by MIT Media Lab that allows users to create interactive stories, animations, and games. In educational processes, it is widely used in teaching computer science and computational thinking concepts to students of all ages (Resnick et al., 2009). In recent years, Scratch has been recognized as an effective tool for teaching science concepts as it allows students to model scientific phenomena, simulate experiments, and explore complex systems in an interactive and engaging way. By using Scratch to create interactive simulations, students can develop a deeper understanding of scientific concepts and processes, and gain valuable experience in experimental design, data analysis, and scientific reasoning (Blikstein et al., 2013). There are many resources available for educators who are interested in using Scratch in science education, including online tutorials, lesson plans, and project ideas. One great place to start is the ScratchEd website, which offers a variety of resources and support for educators who are using Scratch in their teaching practice (Ogegbo & Ramnarain, 2022).

Using Scratch in Education

There have been many studies reporting both positive and non-significant results regarding the use of Scratch in education (Talan, 2020). Shamir, Kocherovsky and Chung (2019) used Scratch applications in mathematics and computer teaching in their study with 7th grade students. According to the results of the study, the mathematics and computer ability of the students in the group using Scratch applications improved significantly compared to those who do not. Another result obtained from this study, which was applied in STEM classrooms, shows that students' interest in STEM increased sfter using this application. In another study on STEM education, which

aims to gather science, technology, engineering, and mathematics applications under one roof, it has been suggested that Scrath can be an alternative to very expensive robot sets (Yamamori, 2019). The researcher suggested that the time spent on assembling the small parts of the robot can be used more efficiently with Scratch for the same purpose, especially when the lesson hours are limited. Aiming to investigate the effectiveness of scratch programming in teaching science to 5th grade students, Lai and Lai (2012) asked students to program while teaching the "Observation of the Sun" and "The Weather has Changed" units. The outcomes of this research revealed that students' performance in logical thinking and problem-solving improved after using Scratch Programming.

In some studies where Scratch is used in the teaching process, there are also cases where significant differences do not occur. For example, Momcilovic (2020) used Scratch applications to teach geometry subjects in mathematics class and obtained positive results. The results of the study show that the academic performance of the students, who use both three-dimensional modules and scratch applications, has increased. There was no statistically significant difference between the two groups. In another study Jiang and Li (2021) aimed to analyze the effects of Scratch language learning on the computational thinking skills (creativity, algorithmic thinking, cooperativity, critical thinking, and problem solving) of primary school students. While the research findings show that there is a significant difference in creativity, collaboration, and critical thinking skills, it is seen that learning with Scratch does not cause a significant difference in the problem solving and algorithmic thinking skills of primary school students.

With the inclusion of block-based programming (BBP) education in the curriculum in Turkey simultaneously with many countries, studies are still being carried out to make programming education more effective. When the relevant literature is examined, studies that emphasize the relationship between individuals' self-efficacy perception and programming performance draw attention (Aşkar & Davenport, 2009; Yükseltürk & Altıok, 2016; Akar & Altun, 2017). Albert Bandura (1977) defined self-efficacy perceptions as individuals' judgments about how well they could perform the actions necessary to cope with possible situations. Self-efficacy perceptions related to BBP refer to students' confidence in their ability to move the Scratch's puppets with code, and this perception is important in teaching programming (Altun & Kasalak, 2018).

As a result, when the studies in the field are examined, the use of both the 5E teaching model and Scratch in the education process has positive effects in general. However, there are few studies where both (5E teaching model and Scratch) are used together. In addition, the related literature lacks data on the reactions of students to coding applications with different difficulties during these applications. Thus, the aim of this study is to examine

the effects of Scratch applications with different difficulties on students by applying them to different steps of the 5E teaching model. The effect of Scratch-based activities integrated into the 5E teaching model in science teaching on students' computational thinking skills and self-efficacy perception regarding block-based programming was examined. In addition, students' perceptions of the activity were measured after each Scratch activity, which was applied at different stages of the course and with different difficulty.

Accordingly, the following research questions were examined.

1. *What is the effect of Scratch-based activities on students' computational thinking skills levels?*
2. *What is the effect of Scratch-based activities on students' levels of self-efficacy perception regarding block-based programming?*
3. *What is the experience of students regarding Scratch-based activities?*

Method

Experimental research method, one of the quantitative research methods, was employed in the study. The pretest-posttest control groupless design, a quasi-experimental research method, was utilized. Experimental studies aim to test the effect of the independent variables on the dependent variable. The main purpose of these studies is to reveal the cause-and-effect relationship between the variables. For this purpose, the independent variable is manipulated and the variables that may affect the dependent variable are controlled (Büyüköztürk et al., 2018; Fraenkel et al., 2012). In the study, the independent variable whose effect on the dependent variables of "computational thinking skills" and "self-efficacy perception related to block-based programming" was examined is the "Scratch-based activities integrated into the 5E teaching model". The design of the research was given in **Table 1**.

Study Group

The study was carried out with 6th grade students who were attending a public school in Turkey located in a district center in the Eastern Black Sea region in the 2022-2023 academic years. Two classrooms were included in the study. The reason for choosing the study group students is that the relevant school has a computer laboratory and before the application, the students get basic coding and Scratch training in the "Information technologies and software" course. In this direction, the study group was determined by purposive sampling method and the study was carried out with the participation of 22 6th grade students (12 females and 10 males).

Table 1. Standard Notation of Study Design.

Pretest	← APS (After Each Activity) → Application	Posttest
CTS1 SPSRBP 1	X1	CTS2 SPSRBP 2

X1: Scratch-based activity applications.
CTS: Computational Thinking Scale
SPSRBP: Self-Efficacy Perception Scale Related to Block-Based Programming
APS: Activity Perception Scale

Data collection Tools

Computational Thinking Scale (CTS)

The "Computational Thinking Scale", which was developed by Korkmaz, Çakır, and Özden (2015) first for university students and then adapted to the secondary school level, was used to measure students' computational thinking skills. The scale is a five-point Likert type scale consisting of 22 items with 5 factors: creativity (4 items), problem solving (6 items), algorithmic thinking (4 items), collaboration (4item) and critical thinking (4 items). As a result of the confirmatory factor analysis of the scale using the maximum likelihood technique, the regression values of the items varied between 0.507 and 0.872. Item test correlation coefficients ranged from 0.655 to 0.862. To calculate the reliability of CTS, internal reliability analyzes were performed on the data and the Cronbach Alpha reliability coefficient of the scale was determined as 0.809.

Self-Efficacy Perception Scale Related to Block-Based Programming (SPSRBP)

The "Self-Efficacy Perception Scale Related to Block-Based Programming" (SPSRBP) developed by (Altun & Kasalak, 2018) was utilised to measure the students' self-efficacy perceptions related to Block-Based Programming. The scale consists of 12 items and 5-point Likert type. The scale has two sub-dimensions: "simple block-based programming tasks" (5 items) and "complex block-based programming tasks" (7 items). The overall Cronbach's Alpha reliability coefficient of the scale was calculated as 0.893.

Activity Perception Scale (APS)

The original version of the Activity Perception Scale, which was used to determine student experiences regarding coding activities, was developed by Deci et al. (1994) for uninteresting (boring) computer tasks. The adaptation of the perception of effectiveness scale into Turkish was carried out by Kasalak (2017). As a result of the evaluations, it was predicted that the translation of only 11 items of the 25-item scale would be understood correctly by the students in Turkey due to the differences in cultures and education systems, and the scale was finalized. Student experiences are evaluated in terms of finding activities enjoyable, contribution of activities to personal development, willingness to do activities and finding activities interesting.

Research Process

Before the application, the students were given basic Scratch training within the scope of the "Program Solving and Programming" unit of the "Information Technologies and Software" course. Before starting the applications in the science course, the Computational Thinking Scale (CTS) and Self-Efficacy Perception Scale Related to Block-Based Programming (SPSRBP) were administered to the students as a pre-test.

In the present study, the unit "Force and Motion" was selected as it was compatible with the Scratch activities to be done. Before starting the applications for the learning objectives, teacher instructions and student worksheets were developed. At one stage of the lesson plans developed in accordance with the 5E learning model (Engage, Explore, Explain, Elaborate or Evaluate), the Scratch activity was included. The developed Scratch activities were related to the learning objectives of the 6th grade science lesson "Force and Motion" unit.

In the five-week practice, the Scratch activities according to the topics and the phase of the lesson to be used in these activities are as follows.

Week 1 (Engage stage): The first Scratch activity was used in the introduction to the topic "Force and its properties". Students, who used the Scratch application only in the "Information Technologies and Software" class before, used it for the first time in the science class. The students were introduced to the concepts of "application point", "direction", "direction and magnitude" of the force by running the previously prepared program. In the interactive Scratch application, firstly, the scenes with rotating or moving objects with the effect of the applied force were shown to the students. Afterwards, they were asked to predict the direction of motion of these objects under force (**Figure 1**). The answers given are discussed and explained in the exploration and explain stages of the course.

Figure 1. First Week Scratch App.

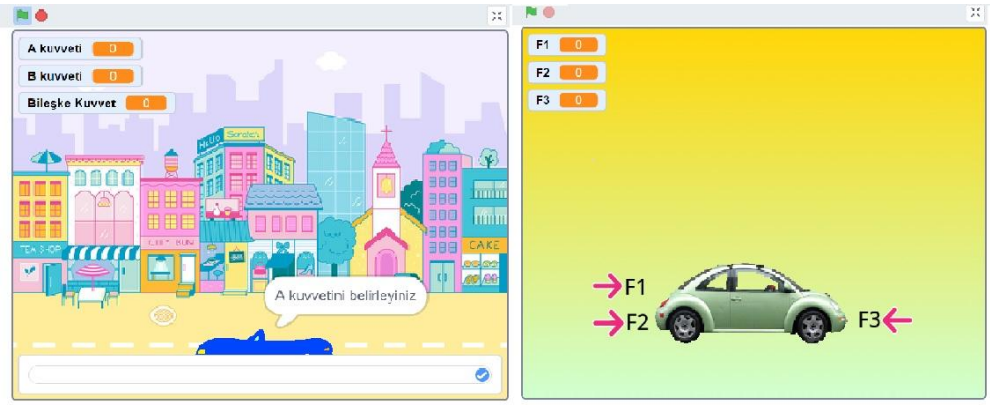

Figure 2. Second Week Scratch App.

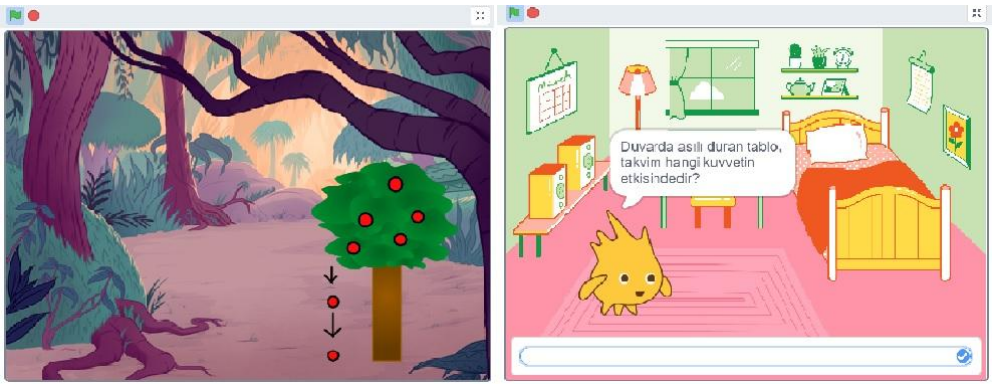

Figure 3. Third Week Scratch App.

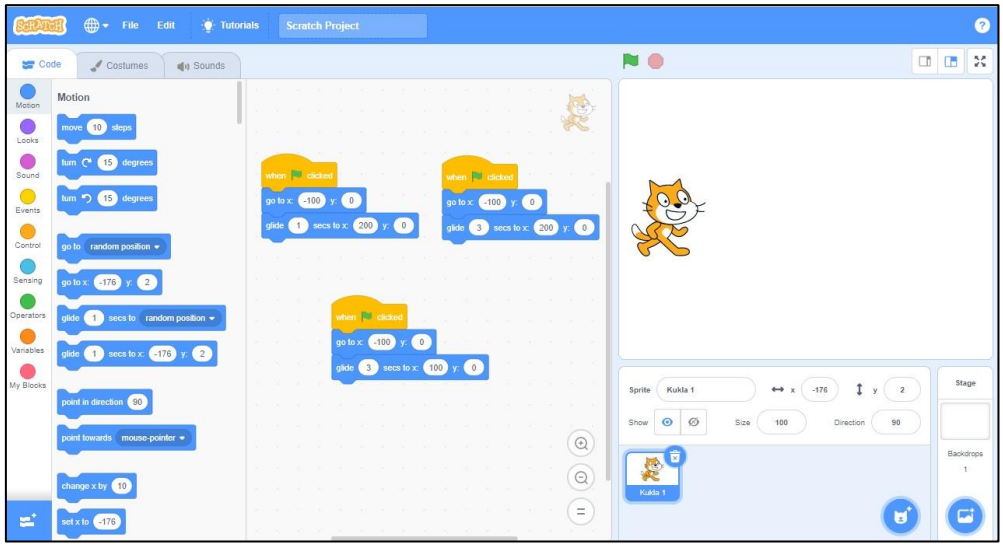

Figure 4. Fourth Week Scratch App.

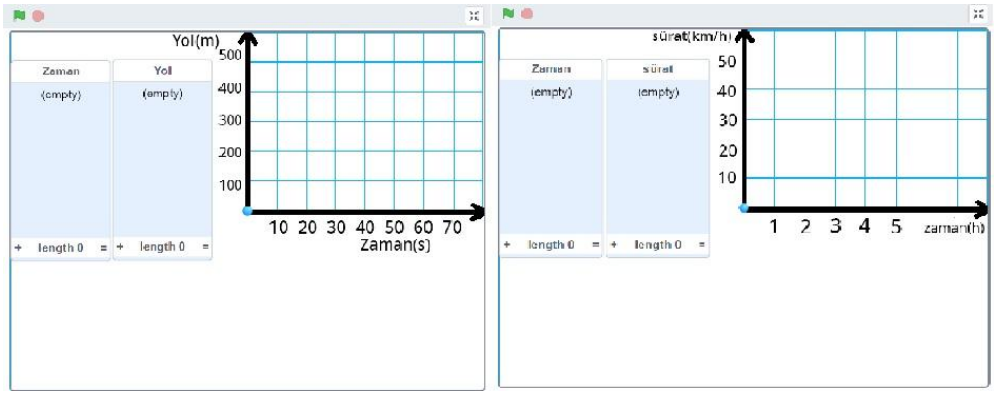

Figure 5. Fifth Week Scratch App.

Week 2 (Explore phase): The second Scratch activity was used in the explore phase of the "Result force" topic. The interactive Scratch activity was implemented in two stages. In the first stage, two forces acting on an object were given in opposite directions, and students were asked to enter magnitude values for both forces and estimate the resultant force. In the second stage, the number of forces was increased to three, and similarly, students were asked to enter force values and estimate the resultant force (**Figure 2**). The answers given were discussed in the explain phase of the lesson.

Week 3 (Explain stage): The third Scratch activity was used in the explain stage of the "Balanced and unbalanced forces" topic, which is a special case of the "Result force" topic. In the engage phase of the third week, students were given a rope planting activity to make them realize the balance of forces. In the Explore step, the balance of forces is explained, and in the explain step, the concepts of "balanced and unbalanced force" are defined by adapting them to some examples around us by using the Scratch activity. In the Scratch application, first some examples were given, such as an apple standing on a tree and falling, and then students were asked to adapt the concept to daily life (for example, a painting hanging on the wall) (**Figure 3**).

Week 4 (Elaborate stage): The fourth Scratch activity was used in the elaborate stage of "Constant velocity movement". In the first three stages of the fourth week, students were taught the concept of speed. In the elaborate step, students were asked to investigate how speed depends on the distance travelled and time. For this purpose, students were asked to use the motion commands of the Scratch platform. The selected sprite was asked to travel a specified path at different times, and then at the same time, different paths (**Figure 4**). For both cases, students were asked to record their observations with different values.

Week 5 (Evaluate phase): The fifth Scratch activity was used in the evaluate phase of "Path-time and velocity-time graphs of constant velocity motion". In the first four phases of the fifth week, students were taught how to draw and interpret graphs of constant velocity motion. In the Evaluate stage, the students were given a part of the path-time and velocity-time table values of a motion and were asked to complete the missing data and draw graphs with the Scratch program, which were prepared before, if the motion would continue with a constant velocity **(Figure 5**). In the prepared program, it was requested to enter the path-time and speed-time data pairs to be used for drawing. For the graphs to be created with a total of 5 data pairs, the first data pair was given completely, while one of the next data pairs was given incomplete and the students were asked to guess. After each data pair is entered, the relevant point is marked in the graphic area and finally the graph is completed.

The applications designed for the unit learning objectives continued for five weeks (a total of 20 periods, four periods a week, as stipulated by the curriculum. One of the researchers was the class teacher and carried out the application, while the other researcher participated as an observer. In the week following the completion of the activities, the CTS and the SPSRBP were administered to students as a posttest. APS was applied to the students after each activity for five weeks. The study continued for a total of seven weeks, with the administration of the pretest and posttest (excluding the basic Scartch training).

Data Analysis

A statistical software program SPSS 20 was used in the analysis of the data. Appropriate statistical methods were tried to be determined by investigating the suitability of the data to the normal distribution. Since the number of participants in each group was less than 50, Shapiro-Wilk test was used for the assumption of normality (Mishra et al., 2019). As a result of the analysis, it was decided to use parametric tests because the data sets had a normal distribution ($p > 0.05$). In this context, to test whether there was a significant difference between the variables, the collected data were analyzed using the t-test for dependent groups. For interpretation, the significance level for the hypothesis tests was set to 0.05.

Findings

In this section, the findings are presented, and the data are explained in tables. Findings, interpretations, and tables are organized in order of the study research questions.

The results of the dependent samples t-test analysis regarding the first research question are given in **Table 2**.

When **Table 2** is examined, it is seen that the students' scores from the Computational Thinking scale in Creativity, Algorithmic thinking, Collaboration, Critical thinking and Problem solving dimensions and Computational Thinking total scores increased after they practiced Scratch supported activities:

$$\Delta\bar{X}_{(\text{Creativity})} = +0.91$$
$$\Delta\bar{X}_{(\text{Alg. thinking})} = +0.69$$
$$\Delta\bar{X}_{(\text{Collaboration})} = +0.78$$
$$\Delta\bar{X}_{(\text{Crit. thinking})} = +0.54$$
$$\Delta\bar{X}_{(\text{Prob. solving})} = +0.91$$
$$\Delta\bar{X}_{(\text{Total CTS})} = +3.81\ )$$

While this increase is statistically significant for Creativity ($t(21) = -2.83$, $p < 0.05$) and Collaboration ($t(21) = -3.04$, $p < 0.05$) dimensions, it is not significant for Algorithmic thinking ($t(21) = -1.88$, $p > 0.05$), Critical thinking ($t(21) = -1.63$, $p > 0.05$) and Problem solving ($t(21) = -1.39$, $p > 0.05$). However, the increase in Computational Thinking total scores is statistically significant ($t(21) = -4.16$, $p < 0.05$). The Cohen d effect sizes of these determined significant differences were found to be medium for Creativity ($d = 0.60$) and Collaboration ($d = 0.65$) and large for total Computational Thinking ($d = 0.89$).

The results of the dependent samples t-test analysis regarding the second research question are given in **Table 3**.

Table 2. Dependent Samples T-Test Results Related to Computational Thinking Scale (CTS).

Dimensions of CTS	N	$\bar{X}$	SD	df	t	p
Creativity (Pre) Creativity (Post)	22	14.14 15.05	2.10 2.06	21	-2.83	0.010
Algorithmic thinking (Pre) Algorithmic thinking (Post)	22	11.36 12.05	2.11 2.08	21	-1.88	0.074
Collaboration (Pre) Collaboration (Post)	22	14.86 15.64	3.26 2.63	21	-3.04	0.006
Critical thinking (Pre) Critical thinking (Post)	22	12.05 12.59	2.48 2.21	21	-1.63	0.117
Problem solving (Pre) Problem solving (Post)	22	16.55 17.46	2.43 2.44	21	-1.39	0.179
Computational Thinking (Pre) Computational Thinking (Post) (Total score of the scale)	22	68.96 72.77	7.25 6.00	21	-4.16	0.000

p < 0.05.

Table 3. Dependent Samples T-Test Results Related to Self-Efficacy Perception Scale Related to Block-Based Programming (SPSRBP).

Dimensions of SPSRBP	N	$\bar{X}$	SD	df	t	p
Simple tasks (Pre) Simple tasks (Post)	22	15.36 16.73	1.84 2.05	21	-8.80	0.000
Complex tasks (Pre) Complex tasks (Post)	22	15.36 16.73	2.38 2.96	21	-4.57	0.000
SPSRBP (Pre) SPSRBP (Post) (Total score of the scale)	22	30.73 33.45	3.93 4.89	21	-7.09	0.000

p < 0.05

When **Table 3** is examined, the scores of the students in the simple and complex tasks dimensions from SPSRBP and the total scores of the scale are higher after the Scratch-supported activity applications than before, and they are statistically significant ($t(21)_{(Simple\ tasks)} = -8.80$, $t(21)_{(Complex\ tasks)} = -4.57$, $t(21)_{(Total\ SPSRBP)} = -7.09$, $p < 0.05$). The Cohen d effect sizes of these determined differences were found to be large for Complex tasks ($d = 0.97$) and very large for Simple tasks ($d = 1.88$) and total SPSRBP ($d = 1.51$).

The results of the analysis regarding the tirtd research question are given in **Table 4**.

When the average values for the 1st and 3rd items related to "Finding activities is enjoyable" in **Table 4** are examined, it is seen that the average scores given are the lowest 4.00 and the highest 4.76. The average scores given to item 6, which contains a negative statement, ranged from 1.18 to 1.59. These values show that student perception levels of finding Scratch

Table 4. Average Values of Students' Activity Perception Scores Related to Scratch Activities.

		Act. 1	Act. 2	Act. 3	Act. 4	Act. 5
Finding activities enjoyable	It was fun doing this activity. (Item 1)	4.23	4.56	4.64	4.46	4.59
	I had a lot of fun doing this activity. (Item 3)	4.00	4.18	4.76	4.27	4.59
	I think it was such a boring activity. (Item 6)	1.46	1.46	1.27	1.59	1.18
Contribution of activities to personal development	I believe this activity is important for my development. (Item 2)	3.73	4.14	4.09	4.05	4.14
	I think this was a really important activity. (Item 4)	4.00	3.91	4.41	3.86	4.09
	I would like to do this activity again Because I think it is useful. (Item 7)	4.05	4.23	4.09	3.77	3.91
	I believe that doing this activity can be beneficial for me. (Item 8)	4.18	4.18	4.46	4.05	4.09
	I believe this activity can help me get better at school. (Item 9)	3.46	4.05	4.09	3.96	3.86
	I would like to do it again because there are some things that this event contributed to me. (Item 11)	3.73	4.10	4.27	4.09	4.05
Willingness to do activities and finding activities interesting	I did this activity because I wanted to do it. (Item 5)	3.41	3.64	3.50	3.50	3.96
	I thought this was a very interesting event. (Item 10)	3.68	3.68	4.00	3.91	4.00
	Total	43.02	45.22	46.99	44.19	46.10

activities fun are quite high, and their perception levels of finding them boring are quite low. In the same table, it is seen that the average score given by the Scratch activities to the items related to the activity perceptions of the students regarding their personal development is between 3.73 and 4.46. Finally, when the table values are examined, it is seen that the average score given by the students to the item prepared to determine their perceptions of doing activities willingly varies between 4.41 and 4.00. From this, it is understood that the students do not have a perception that they do the activities because they want to do it, or that they must do the activity even if they do not want to.

Results and Discussion

The first result of the research is that Scratch-based activities increase computational thinking skills of students. The increase in the total score of the scale and the increase in the creativity and cooperation factors are statistically significant. Even though the scores on algorithmic thinking, critical

thinking and problem-solving factors increased, it was not statistically significant. When we look at the literature, it is possible to come across studies that use Scratch activities as course material. Rodríguez-Martínez, González-Calero and Sáez-López (2020) examined the effect of Scratch activities used in mathematics lessons on gaining mathematical concepts and developing computational thinking skills. Their results were in line with Scratch's development of both. The adaptation of Scratch applications to the mathematics lesson was applied not only at the k12 level (Benton et al., 2018; Foerster, 2016; Shamir et al., 2019; Vinayakumar et al., 2018) but also at the higher education level (Molina-Ayuso et al., 2022), and generally positive results were obtained. Adaptation studies of Scratch applications to the science curriculum are much less than that in mathematics (Hacıoğlu & Dönmez Usta, 2020; Silva et al., 2020; Yamamori, 2019).

In a study conducted with 5th grade students, Jiang and Li (2021) taught Scratch within the scope of "Basics of Information Technologies" course and its effect on computational thinking skills was examined. The research findings indicate that there was a significant difference in the skills of creativity, cooperatives, and critical thinking. However, in this study, Scratch learning did not cause any significant differences in the problem-solving and algorithmic thinking skills of students. These results are quite consistent with our findings. In both studies, while Scratch applications were effective on students' creativity and cooperation skills, they did not have a significant effect on problem-solving and algorithmic thinking skills.

The second result of the research is that Scratch-based activities increase self-efficacy perception of students related to block-based programming. The increase in all sub-dimensions (simple and complex tasks) together with the increase in the scale total score is statistically significant. Looking at the literature, no research has been found that examines the effect of Scratch activities adapted to science lessons on students' self-efficacy perception towards Block-based programming. However, there are studies examining the effect of Scratch or Scratch-based robotic coding training on self-efficacy perception towards block-based programming (Buyukkarci & Taslidere, 2021; Durak et al., 2019; Güleryüz, 2022). The related literature suggests that training increased the perception of self-efficacy towards block-based programming. Coşkunserçe (2023), in his study with sixth grade students, compared Scratch and Scratch-based robotic coding (mBlock) trainings in terms of increasing self-efficacy perception towards block-based programming. According to the findings, Scratch-based robotic coding (mBlock) training is more effective. Another study examining how the size of the study groups affects self-efficacy versus coding was conducted by Arslan and İşbulan (2021). According to the results of this research, in which the Scratch programming platform was used, there is no effect on self-

efficacy related to block-based programming if the studies are done individually or as a group.

The findings of the study suggest that students have positive attitudes towards these activities. When total scores for each activity in the data in **Table 4** are examined, it is seen that the scores gradually increase in the first three activities, and there is a decrease after the fourth activity. In the fourth activity, instead of using a previously prepared program, students were asked to write the codes themselves. This situation caused the students to have difficulties. Thus, this may have negatively affected their perceptions of the activities. After the fifth activity, an increase was detected in the total scores again. Although challenging tasks negatively affect perceptions of students for a short time, they are thought to have positive effects in the long run.

As a result, it is known that block-based programming education is a very effective method for primary and secondary school students who have no previous programming experience (Resnick et al., 2009). As mentioned in the introduction, considering the contributions of coding education to students, it has been included in educational environments since the 1970s, but the desired success could not be achieved because it did not attract the attention of students. It is thought that coding education can be more successful by integrating it into courses such as mathematics and science. Considering the results of this study we conducted, the use of coding activities in science lessons can be a very effective method for overcoming the problems encountered in the 1970s.

Recommendations

Assuming that basic education about block-based programming is given in courses such as information technologies, it is thought that it would be appropriate to use coding activities in science classes to reinforce and improve students' coding skills. For this purpose, the 5E teaching model, which is used effectively by many teachers, can be used. Since the 5E teaching model allows Scratch activities to be used in different ways, it offers a variety of usage. First, we recommend that students use ready-made Scratch activities in their science lessons. It will be beneficial to complicate the activities by encouraging students to intervene in the codes over time in accordance with the level of students' programming skills. In case of positive results, it will be appropriate for students to code their own programs.

In this study, data on computational thinking and self-efficacy were collected. It would be useful to examine the effect of including coding activities in science lessons on different skills and achievements. In addition, this adaptation can be tried with different teaching models such as problem-based, project-based, or cooperative learning.

Limitations

This study is limited to the "Force and Motion" unit and was carried out over a five-week period excluding the pre-test and post-test applications. The study was carried out with 22 students and the students encountered Scratch-based applications for the first time in the science lesson.

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REVIEW

A Policy Analysis of the Development of Balanced Compulsory Education in Chinese Counties

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***Abstract**: The development of balanced, high-quality compulsory education is a national strategy of China. County-level education serves as the building block of its basic education. The nation's realization of equitable compulsory education largely depends on its endeavors at the county level. The Chinese government has issued a series of educational policies to support developing balanced compulsory education in counties. This article focuses on studying governmental policies on this issue and examining them in detail according to their distinct purposes.*

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COMPULSORY education is public-funded national education mandated by legislation in China (State Council of China, 2021). Educational policies are tools in the form of texts used by governmental authorities to solve educational issues and achieve specific educational goals (Gao, 2022). Policies on developing balanced compulsory education manifest the state's commitment to public education, which is a basic requirement for a service-oriented government. The development level of equitable compulsory education depends on the maturity of the policy framework in this regard and represents the state's education governance capability (Lai, 2006).

According to *The Strategic Plan for the National Medium- and Long-term Education Reform and Development 2010-2020 (Ministry of Education of China, 2010e) and Opinions of the State Council on Intensifying the Development of Balanced Compulsory Education* (State Council of China, 2012a), the Chinese compulsory education system emphasizes county-dominated management, with the county-level government and educational authorities held responsible for promoting the development of balanced compulsory education between urban and rural areas and among all schools within the county. To develop an even compulsory education at the county level, it is necessary for the local government to allocate compulsory education resources in a balanced manner to schools within the county, providing them with unified educational conditions and standards, teacher staffing and quality standards, and equal educational quality, so that every student is guaranteed a development opportunity (Liu, 2021). Specifically, there are three main aspects to the development of balanced compulsory education. First, improve the basic operational conditions of disadvantaged compulsory education schools in impoverished areas, advance the standardized construction of compulsory education schools, promote the sharing of educational resources, and allocate educational resources in a balanced and judicious manner to achieve a rudimentary balance in education investment, educational facilities, teacher supply, and student source distribution between schools within the county and between urban and rural areas. Second, allow special groups such as disabled children, children of migrant workers, and left-behind children equal access to compulsory education. Third, implement competence-focused education and improve school management to enhance the overall quality of education (Shan, 2015).

In the transition from unbalanced to rudimentarily balanced compulsory education in Chinese counties, the government has introduced a series of policies and mandated nationwide implementation of them. **Table 1** includes the state-level strategic policies on compulsory education formulated in the past two decades, from the 1999's *State Council of China's Decision on Intensifying Educational Reform and Advancing Competence-focused Education to the 2019's The Implementation Plan for Accelerating the Mod-*

Table 1. Strategic Policies on Developing Balanced Compulsory Education.

Years	Policies
1999	State Council of China's Decision on Intensifying Educational Reform and Advancing Competence-focused Education (State Council of China, 1999)
2001	State Council of China's Decision on Basic Education Reform and Development (State Council of China, 2001)
2001	The Tenth Five-year Plan for National Education (Ministry of Education of China, 2001a)
2003	State Council of China's Decision on Further Strengthening Rural Education Work (State Council of China, 2003)
2004	Notice of the State Council on the Approval of the "Ministry of Education's Education Revitalization Action Plan 2003-2007" (State Council of China, 2004)
2005	Several Opinions of the Ministry of Education on Further Driving the Development of Balanced Compulsory Education (Ministry of Education of China, 2005)
2006	Compulsory Education Law of the People's Republic of China (Revised at the 22nd Meeting of the Standing Committee of the 10th National People's Congress on June 29, 2006) (State Council of China, 2006)
2007	Notice of the State Council on the Approval of the Ministry of Education's 11th Five-Year Strategic Plan for the Development of National Education (State Council of China, 2007a)
2008	The Chinese Government's Decision on Several Major Issues Concerning the Promotion of Rural Reform and Development (State Council of China, 2008)
2010	Opinions of the Ministry of Education on Implementing the Scientific Development Theory and Further Promoting the Development of Balanced Compulsory Education (Ministry of Education of China, 2010d)
2010	Strategic Plan for the National Medium- and Long-term Education Reform and Development 2010-2020 (Ministry of Education of China, 2010e)
2010	Notice of the Ministry of Education on Issuing the "Work Priorities of the Ministry of Education in 2010" (Ministry of Education of China, 2010b)
2011	Striving to Advance Rural Education: A Speech by Wen Jiabao at the Rural Teachers' Conference (State Council of China, 2011b)
2012	Opinions of the State Council on Intensifying the Development of Balanced Compulsory Education (State Council of China, 2012a)
2016	Several Opinions of the State Council on Supporting the Integrated Reform and Development of Compulsory Education in Urban and Rural Areas of Counties (State Council of China, 2016a)
2016	Accelerating the Development of Balanced Compulsory Education in All Localities (Ministry of Education of China, 2016)
2018	State Council's Report on Promoting the Integration of Urban and Rural Compulsory Education and Improving the Quality of Rural Compulsory Education (Chen, 2018)
2019	Emphasizing Policy Implementation: A Speech at the 2019 National Conference on Education Work (Chen, 2019)
2019	"The Implementation Plan for Accelerating the Modernization of Education 2018-2022" Issued by the State Council's General Office (State Council of China, 2019a)

ernization of Education 2018-2022 issued by the General Office of the State Council.

National education policies offer guidelines for the division of power and responsibilities and management methods in developing compulsory education. Policy tools such as mandatory measures, publicity, and incentives have been utilized to support policy execution to achieve the goal of compulsory education (Fan, 2015). In implementing these policies, the county-level government moderates the relationships between all educational stakeholders and actively addresses issues such as educational resource limitations, inter-school competition, school picking, and underprivileged groups,

Table 2. Financial Policies on the Development of Balanced Compulsory Education in Counties.

Years	Policies
2005	Notice of the State Council on Intensifying the Reform of the Guarantee Mechanism for Rural Compulsor Education Funding (State Council of China, 2005a)
2005	Notice of the State Council's General Office on Circulating the Opinions of the Ministry of Finance and the Ministry of Education on Accelerating the Implementation of the "Two Exemptions and One Supplement" Policy in Targeted Counties Listed in the Nation-level Poverty Alleviation Program (State Council of China, 2005b)
2006	Urgent Notice of the Ministry of Education on Implementing the New Mechanism for Securing Funds for Rural Compulsory Education (Ministry of Education of China, 2006f)
2007	Notice of the Ministry of Education on Further Advancing the Reform of the Guarantee Mechanism for Rural Compulsory Education Funding (Ministry of Education of China, 2007a)
2007	Report on the Execution of the "Two Basic Educational Goals" Program for Western China 2004-2007 by the Ministry of Education, National Development and Reform Commission, and Ministry of Finance (Ministry of Education of China, 2007c)
2011	Opinions of the State Council on Further Increasing Financial Investment in Education (State Council of China, 2011a)
2015	Notice of the State Council on Optimizing the Guarantee Mechanism for Urban and Rural Compulsory Education Funding (State Council of China, 2015b)
2015	Decisions on Unifying the Funding Mechanism for Urban and Rural Compulsory Education to Promote the Equalization of Public Services in the Field of Education at the State Council Executive Meeting Presided Over by Premier Li Keqiang (State Council of China, 2015a)
2018	Opinions of the State Council's General Office on Further Adjusting and Optimizing the System to Improve the Efficacy of Educational Funds (State Council of China, 2018c)

with the aim of meeting the educational needs of the vast majority of people and thus optimizing fairness in the distribution of educational resources (Xie, 2021). In addition, policies on developing balanced compulsory education over varying periods have been reflecting the constant adjustment of national education goals and requirements to suit the changing educational needs of the public (Ren, 2019). Driven by national education policies, compulsory education at the county level has achieved substantial advancements.

Financial Policies on the Development of Balanced Compulsory Education in Counties

The mandatory, universal, and public nature of Chinese compulsory education determines that its main sponsors are the state and government. As a public good, compulsory education mainly relies on financial support from the central and local governments. Financial policies on compulsory education not only represent the government's commitment to this public service but also serve as important tools to direct educational investment at all levels of government (Li, 2009). In 2001, the State Council of China issued the *Decision on the Reform and Development of Basic Education*, proposing building a management system for rural compulsory education that is led by the

State Council and hierarchically managed by local governments with the county-level government as the main actor. County-level governments are thus primarily responsible for rural compulsory education.

Policies for Securing Investment in County-Level Compulsory Education from All Levels of Government

To actualize more equal compulsory education, the Chinese government has issued a series of financial policies concerning national education investment, educational expenditures, and the division of financial responsibilities between the central and local governments since 2005 (**Table 2**) (Liu, 2021). The purposes of these policies include:

- To clearly define the responsibilities of governments at all levels to secure investment in rural compulsory education. The provincial government must evaluate the financial status of all counties within its administrative region, balance its financial resources, and increase transfer payments to financially disadvantaged counties. The county-level government is obligated to increase investment in compulsory education and incorporate all expenditures on rural compulsory education in its budget.
- To emphasize the financial investment in rural compulsory education as the priority of governments at all levels.
- To establish and optimize mechanisms for securing funds for rural compulsory education. The level of public funds should be progressively increased according to the development needs of compulsory education and the growth in financial capability of the state and the regions (Xie, 2015).

Preferential Financial Policies for Underprivileged Groups

The uneven distribution of educational resources is the root cause of the unbalanced development of compulsory education (Gao, 2014), which at the county level is revealed by issues such as urban vs. rural inconsistency in school construction standards and school infrastructure and facilities; exacerbating problems with compulsory education for left-behind children and children living with their migrant worker parents; and large-size classes in urban schools vs. closure and merging of rural schools (Bai & Wang, 2018).
In order to address these issues and safeguard the right to a fair and high-quality education for school-age rural children, the Chinese government has made a series of specialized financial regulations since 2002 (**Table 3**), with key components highlighted as follows:

Table 3. Financial Policies on Regulating the Operation of Rural Compulsory Education Schools for the Interest of Underprivileged Groups.

Years	Policies
2003	Notice of the Ministry of Education on Several Issues Concerning the Management of Basic Education School (Ministry of Education of China, 2003)
2006	Notice of the National Development and Reform Commission and the Ministry of Education on Rectifying and Regulating Charges of Schools of Changed Ownership (National Development and Reform Commission of China, 2006)
2006	Notice of the Ministry of Education on Reasonably Adjusting the Deployment of Rural Primary and Secondary Schools (Ministry of Education of China, 2006c)
2007	Notice of the State Council's General Office on Circulating the Opinions of the State Council's Rural Comprehensive Reform Working Group on Carrying out the Pilot Work of Clearing off the "Nine Year Compulsory Education-induced Debts" in Rural Areas (State Council of China, 2007b)
2009	Guidelines Issued by the Ministry of Education on Strengthening the Management of Primary and Secondary Schools and Standardizing their Operation (Ministry of Education of China, 2009b)
2010	Guidelines Issued by the Ministry of Education on Addressing the Issue of Improper Charge Induced by School Picking at the Compulsory Education Level (Ministry of Education of China, 2010a)
2012	Opinions of the State Council's General Office on Regulating the Adjustment of Compulsory Education School Deployment in Rural Areas (State Council of China, 2012b)
2012	A State Council Executive Meeting Presided Over by Premier Wen Jiabao on Advancing Balanced Development of Compulsory Education, Regulating the Adjustment of Compulsory Education School Deployment in Rural Areas and Approving "Regulations on Education Supervision." (State Council of China, 2012c)
2016	Ten Major Measures of the State Council to Promote the Integration of Urban and Rural Compulsory Education Including Eliminating Large-size Classes and Reforming the School Enrollment of Children of Migrant Workers (State Council of China, 2016b)
2018	Guidelines Issued by the State Council's General Office on Strengthening the Construction of Small-sized Village Schools and Township Boarding Schools (State Council of China, 2018a)

- To reasonably adjust the number and deployment of compulsory education schools in urban and rural areas, give additional support to rural and disadvantaged schools, and set uniform standards of school construction and equipment for urban and rural schools.
- To establish an effective financial backing system for rural, underprivileged students at the compulsory education level. Governments at all levels must deploy specialized funds to enable schools to exempt students with financial difficulties from miscellaneous expenses and to provide living subsidies for boarding students from impoverished families.
- To create a compulsory education guarantee mechanism for the children of migrant workers and provide the children of economically disadvantaged migrant workers employed in urban areas with support in school enrolment by offering scholarships, reducing their miscellaneous fees, and providing free school supplies (Xie, 2015).

Policies on Balancing Teacher Supply for County-Level Compulsory Education

Table 4. Policies on Balancing Teacher Supply for County-level Compulsory Education.

Years	Policies
2006	Opinions of the Ministry of Education on Encouraging the Employment of Urban Teachers in Rural Areas (Ministry of Education of China, 2006e)
2006	Notice of the Ministry of Education on the Implementation of "Special Position Program" in Rural Compulsory Education Schools in 2007 (Ministry of Education of China, 2006b)
2006	Notice of the Ministries of Education, Finance, Personnel on the Implementation of the "Special Position Program" for Rural Compulsory Education Teachers (Ministry of Education of China, 2006d)
2006	"Notice on Engaging College Graduates in Education, Agriculture, Medicine, and Poverty Alleviation Work in Rural Areas" Issued by the Central Organization Department, Personnel Department, Ministry of Education, Ministry of Finance, Ministry of Agriculture, Ministry of Health, Poverty Alleviation Office, and the Central Committee of the Communist Youth League (Ministry of Education of China, 2006a)
2008	Guidelines on Strengthening the Performance Assessment of Compulsory Education Teachers Issued by the Ministry of Education (Ministry of Education of China, 2008a)
2008	Notice on Revising "Ethics and Norms for Primary and Secondary School Teachers" Issued by the Ministry of Education and the National Committee of the China Education, Science, Culture, Health, and Sports Union (Ministry of Education of China, 2008c)
2008	Notice of the Ministry of Education's General Office on Publishing the" National Training Program 2008 for Primary and Secondary School Teachers" (Ministry of Education of China, 2008b)
2009	Notice of the Ministry of Education on Further Augmenting the Supply of Primary and Secondary School Teachers (Ministry of Education of China, 2009c)
2011	Striving to Advance Rural Education: A Speech by Wen Jiabao at the Rural Teachers' Conference (State Council of China, 2011b)
2014	Opinions on Promoting the Rotation of Compulsory Education School Principals and Teachers within the County (District) (Ministry of Education of China, 2014)
2015	Notice of the State Council's General Office on the Release of the Rural Teacher Support Program 2015-2020 (Ministry of Education of China, 2015)
2018	Opinions of the State Council on Deepening the Reform of Teacher Education and Training in the New Era (State Council of China, 2018b)
2018	Notice of the Ministry of Education and Other Four Departments on Issuing the "Action Plan for Revitalizing Teacher Education 2018-2022" (Ministry of Education of China, 2018)
2019	Opinions of the State Council on Deepening Education and Teaching Reform and Improving the Quality of Compulsory Education (State Council of China, 2019c)
2020	Opinions on Augmenting Rural Teacher Supply in the New Era (Ministry of Education of China, 2020)

Teacher staffing disparities are one of the main factors in the imbalance of compulsory education development between regions, between urban and rural areas, and between schools in China (Lai, 2011). The overall teacher quality in developed eastern regions is higher than that in western and central regions. The higher level of economic development a region has, the more professional and competent its teaching staff are (Meng, 2021). The teacher supply differences between urban and rural areas within a county have also been significant: The former have had a sufficient supply of teachers with high professional competence, whereas the latter have been faced with a variety of teacher staffing issues such as staff supply shortages, low qualifications of teachers, weak awareness of professional development in teachers, and low salaries and perks for rural teachers (Lin, 2019). In addition, there are staffing disparities between schools within the same area (Peng & Chang, 2022).

To achieve the balanced development of compulsory education in Chinese counties, the Chinese government has released a succession of policies on balancing teacher supply for urban and rural compulsory education (**Table 4**). These policies cover a wide range of aspects such as teacher staffing, training, rotation, salaries, and pre-service education (Liu, 2021), with highlights summarized as follows:

- Offer rural teachers preferential treatment in terms of performance-based salaries, professional title appraisal, professional rank promotion, and award granting.
- Increase rural teacher supply through a variety of measures, such as the Special Position Program, Intra-county Principal and Teacher Rotation Program, Targeted Peer Support Program, and teachers with key urban schools holding concurrent positions in rural schools.
- Promote rural teachers' professional development (Liu, 2021).

Policies on the Supervision and Evaluation of Compulsory Education Equalization at the County Level

The development of compulsory education is a long-term, progressive process involving the execution of a wide range of policies from the top to the bottom. In this process, obstacles to the effective implementation of educational policies may emerge, compromising their efficacy. As a result, it is necessary for the state to establish monitoring mechanisms for spotting and tracking problems arising in the course of policy enforcement (Li, 2022). Article eight of the Compulsory Education Law of the People's Republic of China stipulates that educational supervision institutions of the government are obligated to monitor the implementation of compulsory education law and regulations, the quality of compulsory education, and the progression of compulsory education equalization, and to make their supervisory results public to society (State Council of China, 2006).

Policies on the supervision and evaluation of the equalization of compulsory education (**Table 5**) have played a vital role in advancing balanced basic education. Through supervision and evaluation work, county-level governments can take effective and pertinent actions to improve local compulsory education and advance its equal development. The supervision and evaluation programs include specific indicators for balanced compulsory education, providing local governments and education authorities with guidelines on promoting equalized compulsory education. In addition, regulatory authorities can utilize the variances in coefficients of indicators to direct local governments to address weak links in the development of balanced compulsory education (Tao, 2014).

Table 5. Policies on the Supervision and Evaluation of Compulsory Education Equalization in Counties.

Years	Policies
2007	Opinions of the Ministry of Education on Further Strengthening the Inspection and Supervision of the Work on the "Two Basic Educational Goals" at the Provincial Level (Ministry of Education of China, 2007c)
2012	Notice of the Ministry of Education on Issuing the "Interim Methods for the Supervision and Evaluation of the Development of Balanced Compulsory Education in Counties" (Ministry of Education of China, 2012)
2013	Opinions of the Ministry of Education on Promoting the Reform of Comprehensive Evaluation of Primary and Secondary Education Quality (Ministry of Education of China, 2013a)
2013	A Speech at the On-the-spot Meeting for the Supervision and Evaluation of the Development of Balanced Compulsory Education in Counties by Yuan Guiren (Ministry of Education of China, 2013b)
2017	Notice of the Ministry of Education on Issuing the "Supervision and Evaluation Methods for the Development of Balanced, High-Quality County-level Compulsory Education" (Ministry of Education of China, 2017)
2017	Notice of the General Office of the State Council on Issuing the "Methods for Evaluating Provincial Governments' Performance in Fulfilling Educational Responsibilities (State Council of China, 2017b)
2021	Notice of the Ministry of Education and Other Five Departments on Issuing "Guidelines for the Evaluation of Compulsory Education Quality" (State Council of China, 2021)

Table 6. Policies on Enhancing the Quality of Compulsory Education.

Years	Policies
2001	Notice of the Ministry of Education on Issuing the "Guidelines for Basic Education Curriculum Reform (Interim)" (Ministry of Education of China, 2001b)
2009	The Fifteenth Announcement of the List of Counties that Have Realized the Basic Popularization of Nine-Year Compulsory Education and Basic Elimination of Illiteracy among Young Adults by the Ministry of Education (Ministry of Education of China, 2009a)
2010	Opinions of the Ministry of Education on Deepening the Reform of Basic Education Curricula and Further Advancing Competence-focused Education (Ministry of Education of China, 2010c)
2013	Opinions of the Ministry of Education on Promoting the Comprehensive Evaluation of Primary and Secondary Education Quality (Ministry of Education of China, 2013a)
2017	Notice of the State Council's General Office on Consolidating the Retention Rate of Compulsory Education Students (State Council of China, 2017a)
2018	A State Council Executive Meeting Presided Over by Premier Li Keqiang on Strengthening the Construction of Small-sized Village Schools and Township Boarding Schools to Provide Equitable and High-quality Compulsory Education for Rural Children (State Council of China, 2018d)
2019	Opinions of the State Council on Deepening Education and Teaching Reform and Comprehensively Improving the Quality of Compulsory Education (State Council of China, 2019c)
2019	"Modernization of Chinese Education 2035" Issued by the State Council (State Council of China, 2019b)
2020	"Overall Plan for Deepening the Reform of Education Evaluation in the New Era" Issued by the State Council (State Council of China, 2020)
2021	Notice of the Ministry of Education and Other Five Departments on Issuing "Guidelines for the Evaluation of Compulsory Education Quality" (State Council of China, 2021)

Policies on the Equalization of Quality Compulsory Education at the County Level

The fundamental purpose of developing balanced compulsory education is to enhance the quality of education. The compulsory education policies of earlier years placed an emphasis on the even distribution of educational resources, mainly the equality of educational funding and facilities. A transition to quality enhancement took place after the realization of the rudimentary balance of resources (Xue, 2013). The release of *Supervision and Evaluation Methods for the Development of Balanced, High-Quality County-Level Compulsory Education* marked the establishment of "equality of quality education" as the goal of the new era's compulsory education (Ministry of Education of China, 2017). A higher order requirement, namely, student all-round development, was raised for balanced compulsory education.
Policies on enhancing the quality of compulsory education (**Table 6**) focus on:

- Advancing competence-focused education by modifying educational concepts, revising compulsory education curricula, reforming the test and evaluation system, and so on.
- Establishing an evaluation framework for the quality of primary and secondary education based on the requirements of competence-focused education.
- Adjusting the deployment of rural primary and secondary schools, increasing regulation on schools for migrant workers' children, and maximizing the retention rate of compulsory education children.

Conclusion

A balanced basic education has been recognized as being crucial for social development across the world. In China, county-level governments act as the providers and distributors of resources for compulsory education as well as the supervisors of education and teaching quality. This necessitates systematic frameworks of rules and policies to clearly define their responsibilities and regulate their behavior. Currently, there still exist problems with county-level governments' execution of national policies on compulsory education equalization, such as a lack of specific, workable measures and accountability mechanisms, immature educational management, and a paucity of measurable criteria for local educational officials' work. To close disparities between urban and rural compulsory education and between advantaged and disadvantaged schools, it is essential for the central government to optimize the institution of compulsory education and for the local governments to rig-

orously enforce national education policies and, in the meantime, make necessary adjustments according to grassroots circumstances.

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REVIEW

Developing Equitable and Balanced Compulsory Education in Chinese County Regions: Achievements and Challenges

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***Abstract**: The balanced development of county-level compulsory education is of vital significance for realizing quality and equity in education in China. This article expounded on the accomplishments China made in developing equitable compulsory education at the county level in terms of educational input, staffing, and educational quality. It also displayed the challenges and complications the country faces in this area, using facts and data from a number of counties as evidence.*

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EDUCATION is one of the fundamental civil rights as well as the groundwork for a nation's prosperity. Educational equity is critical to social fairness and justice, ensuring equal opportunity for personal development. The equity of compulsory education (in China, compulsory education officially includes primary and junior secondary schooling) is deemed to be of the greatest importance as it is the "outset" of formal education. In recent decades, China has prioritized educational development, particularly compulsory education development, in promoting its socioeconomic advancement. In 2001, the "Decisions of the State Council on the Reform and Development of Basic Education" were issued, stipulating that the county-level government is the main actor in compulsory education management and bears the key responsibility for the development of local compulsory education (State Council of China, 2001). To further improve rural basic education, the "Decisions of the State Council on Further Strengthening Rural Education Work" was released, reiterating that the county-level government accounts for the management of basic education in terms of education development planning, fund distribution, and human resources in its jurisdiction (State Council of China, 2003). The 2006 revision of the *Compulsory Education Law of the People's Republic of China* marked legislation for the development of balanced compulsory education. It explicitly stressed that governments at and above the county level must judiciously allocate educational resources and prioritize improving the operational conditions of disadvantaged schools to support the even development of compulsory education (State Council of China, 2006).

Major Achievements of China's Development of Balanced Compulsory Education

By 2011, all provincial administrative regions (autonomous regions and municipalities directly under the central government included) in China had realized the universalization of "nine-year compulsory education" (State Council of China, 2012a). All school-age children have been provided with the opportunity to attend school, and as a result, the overall quality of the nation has been significantly enhanced. Over the years, the state has attached increasing importance to the development of balanced compulsory education and proposed higher requirements for compulsory education, namely, the transition from the "equity of education" to the "equity of quality education."

Increased Investment in Compulsory Education

To improve the quality of compulsory education and narrow the regional disparities in this sphere, the central educational authorities introduced uni-

form standards for the construction of schools. The overall operational conditions of compulsory education schools have been greatly ameliorated as a result of the implementation of the "*Construction Standards of Regular Primary and Secondary Schools in Rural Areas*" (Ministry of Education of China, 2008), "*Opinions of the State Council on Intensifying the Balanced Development of Compulsory Education*" (State Council of China, 2012a), "*Opinions on Further Improving the Basic Operational Conditions of Disadvantaged Compulsory Education Schools in Impoverished Areas*" (Ministry of Education of China, 2015), and other policies. By the end of 2021, all 2,895 counties in China had passed the national evaluation in terms of the rudimentary balanced development of compulsory education (Education Inspection Office of the Ministry of Education of China, 2022).

Increased Expenditure on Education

Due to the ongoing improvement of its overall national power in recent years, China's expenditure on education from central, provincial, and municipal governments has shown an increasing share of its overall investment in social development, giving powerful impetus to the development of equitable and high-quality education. According to relevant statistics from the Ministry of Education and the Ministry of Finance, China's investment in education has significantly increased between 2012 and 2021. Its national fiscal funding for compulsory education rose from 1.17 trillion CNY to 2.29 trillion CNY, accounting for more than 50% of the total state expenditure on education. The yearly state expenditure on each primary school student was elevated from 7,447 to 14,458 CNY, while that on every junior high school student increased from 10,218 to 20,717 CNY (Wei, 2023). In 2022, China's gross domestic product was 121 trillion CNY, and its aggregate social expenditure on education was 6.1 trillion CYN, representing 5% of the GDP, with compulsory education's share being 2.68 trillion CYN (Ministry of Education of China, 2023a).

Significant Improvement of Facilities in Compulsory Education Schools

As of 2022, among all Chinese average primary schools, 97.07%, 93.52%, 96.81%, 96.79%, and 96.62% of them reached the national standards for the school's area of sports venues, sports equipment, music instruments, art equipment, and science experiment instruments, respectively. Among ordinary junior secondary schools, the percentages were 95.68%, 98.08%, 97.88%, 97.88%, and 97.75%, respectively, all of which experienced growth compared to the previous year (Ministry of Education of China, 2023a).

Advancements in Digital Education

As a result of the execution of a succession of policies, all Chinese primary and secondary schools (including teaching sites) had attained access to the Internet by the end of 2022. Over 4 million schools, representing 99.5% of them, had multimedia classrooms, with 87.2% having full coverage of multimedia teaching equipment. There is a rudimentary framework of educational resources and public service in place in China (Ministry of Education of the People's Republic of China, 2023b).

China's national smart education platform, consisting of the "Smart Primary and Secondary Education of China," "Smart Vocational Education of China," and "Smart Higher Education of China" platforms, was run on the principle of "prioritizing application, service, efficiency, and safety". In 2022, the Ministry of Education conducted two rounds of platform application pilot projects in various areas and schools. The platform has gathered 44,000 pieces of primary and secondary education resources, 1,295 teaching resource banks for vocational education, and 27,000 top-tier MOOCs for higher education, aiming to serve 529,000 schools, 18.44 million teachers, 291 million students, and a wide range of social learners across the country (Ministry of Education of China, 2023b).

Augmented Teacher Labor Supply and Quality for Compulsory Education

To universalize compulsory education, China has implemented a series of teacher supply augmentation programs in recent decades. In 2007, the State Council issued the *Measures for the Implementation of Free Education for Students of Teachers' Universities Affiliated to the Ministry of Education* (Ministry of Education, 2007), requiring the six teachers' universities affiliated to the Ministry of Education to provide free education to their students. By 2017, approximately 101,000 free education pre-service teachers had been recruited under this program by teachers' universities, and roughly 70,000 of them fulfilled their prescribed employment agreements, of whom 90% taught in primary and secondary schools in central and western provinces. Since 2021, initiatives such as the "High-quality Teacher Education Program" and "Targeted Education Program" have been implemented to increase the supply of teachers with a university degree in 832 impoverished counties as well as those in central and western border areas, with a special focus on alleviating the shortage of teachers on subjects such as music, sports, and art to ensure a comprehensive and complete basic education curriculum for students in disadvantaged areas (Li, 2020).

Since the 2013 initiative of "Supervision and Evaluation of Balanced Compulsory Education at the County Level," 1.72 million more teachers were recruited nationwide, and there were 2.43 million teachers and principals participating in inter-school rotation programs, thus significantly alleviating the teacher shortages in underdeveloped areas. According to the "National In-Service Teacher Training Program" Blue Book (2010-2019) by the Teacher Education Centre under the auspices of UNESCO, the Chinese government invested 17.2 billion CNY in the program between 2010 and 2019, supporting the training of approximately 16.8 million teachers from 31 provincial administrative regions, including teachers from all impoverished counties. It also established specialized projects for rural school principals from remote and underdeveloped areas, providing training for 13,900 rural kindergarten and primary and secondary school principals to guarantee the successful operation of all rural schools (UNESCO TEC, 2020).

Furthermore, several teacher support policies have been released to bolster teacher recruitment and retention. In 2017, the central government increased financing for subsidies to rural teachers in impoverished areas, which considerably improved their quality of life. As of 2020, this subsidy policy was implemented in 725 counties in 22 provinces, covering approximately 80,000 rural schools and benefiting 1.325 million rural teachers (Ministry of Education of China, 2020).

In addition, recent years have witnessed a remarkable elevation in education levels among compulsory education teachers. Currently, there are 6.6294 million full-time primary school teachers in China, with 99.99% of them having a qualified education background for their positions and 98.90% having a junior college degree or above; there are 4.0252 million full-time junior secondary school teachers, with 99.94% of them qualified for their positions regarding education levels and 91.71% holding a university degree or above. In the meantime, the age structure of compulsory education teachers shows a trend toward becoming more desirable. The majority of them are young and middle-aged (Ministry of Education of China, 2023a).

Enhanced Quality of Compulsory Education

According to the Statistical Report on China's Educational Achievements in 2021, the average net enrolment rate in primary schools was 99.96%, and the average gross enrolment rate among junior high schools was 102.5% in 2020. The progression rate in primary school graduates is 99.5%, and that in junior secondary school graduates is 94.6%. These rates are on par with the levels of high-income countries in the world (Ministry of Education of China, 2022).

In 2012, *the 12th Five-Year Plan for the Development of National Education* introduced the concept of "retention rate of compulsory *education*

students" as an additional parameter for the quality of compulsory education (Ministry of Education of China, 2012a). Subsequently, the dropout prevention mechanism has been strengthened, especially in those areas with high dropout incidence, resulting in a steady rise in the student retention rate. By the end of 2022, nationwide compulsory education had a retention rate of 95.5% (Ministry of Education of China, 2023).

China initiated the "Rural Compulsory Education Student Nutrition Improvement Program" in 2012 to enhance the nutritional and physical conditions of primary and middle school students in impoverished areas (Ministry of Education of China, 2012b). As of 2020, the program engaged 131,600 rural compulsory education schools in 1,732 counties in 28 provinces, benefiting 37.9783 million students. Surveys in the pilot areas showed that the program has significantly positive effects on students' nutritional state and learning capacities (Ministry of Education of China, 2021).

Challenges in Developing Balanced Compulsory Education in China's County Regions

In the wake of the 2012 launch of "Interim Measures for the Supervision and Evaluation of the Even Development of Compulsory Education in Counties", the Ministry of Education of China began to assess the equality in compulsory education development in counties across the nation. Nevertheless, factors such as the vast territory of the country and uneven socioeconomic levels among regions have been obstacles to more productive compulsory education development at the county level (Qi, 2019).

Urban vs. Rural Disparities in Student Sources

Since the reform and opening up, the acceleration of urbanization has led to the expansion of the urban population. With the heightened level of urbanization, an increased number of parents prefer to have their children educated in urban areas of the county or even in other developed regions. As a result, a new imbalance in county-level compulsory education emerged: packed urban schools as opposed to rural ones with shrinking scales (Ministry of Education of China, 2015).

Large-Size Classes in Urban Schools

As of 2011, the Chinese urban population increased to 51.27% of its total population (Wang, 2012), marking a significant change in China's demographic structure and triggering a substantial adjustment in the distribution of basic education resources. In sharp contrast to the decline of rural schools,

urban schools underwent rapid expansion, thus producing numerous large-size classes in the latter, with most of them in urban areas of counties in central and western China (Wu, 2019).

A normal primary or secondary school in China typically has 40-45 students. However, the expedited universalization of nine-year mandatory education led to a drastic increase in the demand for compulsory education. In the meantime, the growth of urbanization, the increasing demand of the public for high-quality education, severe shortages of educational resources in certain regions, the large and continuous influx of children from migrant workers, and inadequate teacher supply, among other reasons, all contributed to the expansion of the class size in urban basic education schools (Huang, 2020). As the Statistical Report on China's Educational Achievements in 2022 revealed, there were approximately 2.8605 million primary school classes in China, including 32,100 large-size classes with 56-65 students each and 923 super-large-size classes with 66 or more students each, while the number of junior secondary school classes is roughly 1.0734 million, including 12,500 large-size classes with 56-65 students each and 225 super-large-size classes with 66 or more students each (Ministry of Education of China, 2023a).

According to a survey in Fenxi County of Shanxi Province, which was listed among the targeted counties in the nation-level poverty alleviation program, 80% of primary school students and 90% of middle school students in this county were enrolled in urban primary and junior secondary schools (Fan & Zhan, 2016). From a national standpoint, three-quarters of the large-size classes in China are concentrated in urban areas of central and western counties; in some central and western provinces, the proportion of large-size classes even exceeds 20% (Qi, 2019).

A Steady Outflow of Rural School-Age Children

Amid the progression of industrialization in China, a large number of rural children have moved from their original school districts based on their registered residence to schools in urban areas where their parents work as migrant laborers. As per the *Statistical Report on China's Educational Achievements in 2022*, there were approximately 13.6468 million rural compulsory education students who outflowed with their migrant worker parents (Ministry of Education of China, 2023a). Consequently, the school and class size in urban areas is in constant expansion, while that in rural area is shrinking due to the reduced number of residents and school-age children. For instance, a teaching site in Taohuajian Village, Damu Township, Xianning City, Hubei Province, was once a nine-year school built in the 1960s with more than 300 students in its prime. In the 1980s, it became a sole primary school with over 200 students. It was reduced to a teaching site by the end of the 1990s with

only 43 students and 3 teachers, covering only the first three grades, as a result of the advancement of urbanization and the outflow of students to urban schools. This is also the situation at C Primary School in Tuanfeng County, Hubei Province. The school was reduced from a nine-year central school to a teaching site, with a sharp decrease in the number of students from a few hundred to 47 (Fan & Zhan, 2016).

Relevant investigations found that rural parents generally had low recognition of the educational quality of rural schools because of the disproportionate concentration of high-quality educational resources in urban schools. Those rural parents who cannot afford to send their children to urban schools tend to think that the kids have grim prospects for academic advancement and that it is more practical for them to seek employment at a young age rather than to "waste time" in schools. That increases the risk of dropping out among rural students (Wang, 2016).

The *Report of Rural Education Development in China 2020-2022* by Northeast Normal University's Chinese Rural Education Development Research Institute revealed that in 2021, 79.15% of primary school-age children received education in urban areas, and 87.85% of middle school-age teenagers were educated in urban schools. On average, 81.91% of compulsory education students had schooling in urban areas (Wang, 2023). The student source disparities between urban and rural schools impede the even development of compulsory education at the county level. The influx of rural students to urban schools poses an excessive burden on the latter. Consequently, urban schools in the county must substantially increase the number of classes to accommodate additional students from rural areas, which significantly decreases their overall education quality. Also, the frequent move on the part of children of migrant workers is a complication to the urban schools' management; the discrepancies of academic levels among them add complexities to teachers' instruction (Ding & Wu, 2015). In the meantime, the outflow of rural students causes the waste of rural educational resources. The reduction of student sources results in a corresponding decrease in the number of rural school classes and, worse yet, in the closures of certain schools. The deserted campuses and facilities are a severe waste of educational resources (Zhang, 2013). In addition, class reductions and school closures in rural areas lead to a relative surplus of rural teachers. The drastic decrease in the number of rural students also means an unreasonable increase in the per capita share of educational resources among the remaining students, which is another form of waste of educational resources (Fan, 2019).

Existing Gaps in Facilities between Urban and Rural Schools

First off, despite the universalization of nine-year mandatory education in China, the issue of deficient school operational conditions still exists in county-level compulsory education in certain regions. A survey of 50 county-level primary and secondary schools in Hubei Province showed the status quo of their school conditions. In terms of school buildings, ordinary classrooms needed to be renovated, and library rooms needed to be expanded. Student living environments, including dormitories, canteens, and toilets, should be significantly improved. Regarding sports venues, the expansion of the playground area was a pressing issue, and the absence of basketball and volleyball courts was common. School equipment to be added included teaching aids and experimental instruments; apparatuses for PE, music, health, and art lessons; multimedia devices with recording and video conferencing functions, as well as computers for teachers' lesson preparation; books and computer networks for the library; and routine life-related items such as heating, drinking water, and cookware (Xiang et al., 2021).

Furthermore, there are considerable disparities in infrastructure and facilities between urban and rural compulsory education schools in western China. In contrast with their relatively modernized urban counterparts, rural schools are faced with issues such as insufficient funds, outmoded infrastructure, a lack of advanced digital equipment, and inadequate sports facilities. According to an investigation by Guo (2017), the average expenditure on teaching equipment for each primary school student in extremely impoverished counties in A Province in western China was 1,290 CNY, which was 1,008 CNY less than that in non-extremely impoverished counties. Every 100 primary school students in extremely impoverished counties had 10.70 computers for teaching purposes on average, whereas their counterparts in non-extremely impoverished counties had 20.40 ones.

Even though the reasons for the uneven development of compulsory education within a country are many, the fundamental one is its underdeveloped economy. China's compulsory education is directly managed by the local governments, who are in charge of allocating educational funds to primary and middle schools in their jurisdiction. In economically underdeveloped counties, the local governments often choose to prioritize investment in key and central schools in urban areas over that in rural compulsory education schools due to their financial limitations (Jiao, 2014). This preferential treatment of urban schools further exacerbates the imbalance of county-level compulsory education.

The Imbalance in Staffing between Urban and Rural Schools

Disparities in Education Levels between Urban and Rural School Teachers

In county-level compulsory education institutions, teachers in urban schools typically have higher education levels than their rural counterparts (Zhou, 2018). In Shilin Yi Autonomous County in Yunnan, for instance, the percentage of full-time teachers with a bachelor's degree or above in urban schools was 79.97% in 2022; 90% of the county's "excellent teachers" work in urban schools, while rural schools only serve as the "springboard" for excellent teachers' future careers in urban schools (People's Government of Shilin Yi Autonomous County, 2023).

In certain remote rural schools, teachers may have to teach subjects that do not match their educational backgrounds. There are plenty of Chinese, mathematics, and English teachers in these schools, but they may not have enough music, PE, and art teachers. Consequently, "all-mighty" teachers emerge who need to conduct instruction for various disciplines and grades (Wang, 2023). Even though they can become qualified for their "additional positions" through self-education or in-service training, it is not a professional way of managing compulsory education.

Differences in Age Structure between Urban and Rural School Teachers

A 2020 survey of 21278 teachers from counties in 31 provinces across China found that young teachers under the age of 29 accounted for 22.2%, 21.3%, and 16.1% of the entire teaching staff in village, township, and urban schools, respectively, with a 6.1% gap between the shares of young teachers in village and urban areas. On the other hand, the percentages of teachers aged 55 and above were 8.8%, 4.5%, and 3.3% in village, township, and urban schools, respectively; Village schools had 5.5% more older teachers than urban ones. It is noteworthy that there also exists an unbalanced age distribution among teachers at the provincial level. In those counties that have not implemented the "Special Position Program" (sponsored by the central government to hire college graduates to work in rural compulsory education institutions), the proportion of young teachers under the age of 29 was less than 10%, whereas that of teachers aged 55 and above was as high as 33.8%, and even exceeded 50% in certain areas (Wang, 2023).

High Turnover of Rural Teaching Staff

Due to regional differences in economic levels and teacher salaries, the flow of talented teachers to major cities has become a prevalent issue throughout

China. As data from the Ministry of Education of China revealed, from 2012 to 2019, approximately 510,000 teachers were recruited under the "Special Position Program" in central and western provinces of China. They have played a crucial supportive role in rural compulsory education. However, after their minimum service period in rural schools was fulfilled, some of the program participants opted to apply for civil service positions, some were seconded to urban schools in the county, and some were selected and recruited by city schools, resulting in low retention rates of these "special position" teachers. Relevant data indicated that the turnover rate of this category of teachers in some areas could be more than 50% (Zhang, 2023).

According to the "Free Education Program" policy, public-funded graduates of teachers' colleges and universities should work in rural schools for at least two years before they can move to urban ones. Nevertheless, monitoring results of the program revealed that some of these graduates managed to be employed by urban high schools right after graduation rather than being assigned to rural schools, where teaching staff shortages have been the most severe (Yan, 2015). This is evidently an impediment to the establishment of a balanced compulsory education system in China.

Conclusion

Developing balanced compulsory education is a fundamental policy of education as well as a key national strategy. Equitable compulsory education, a steppingstone to an equal society, benefits every citizen. Despite the universalization of compulsory education in China, the discrepancy in education quality between urban and rural schools remains significant. As the county-level government is primarily responsible for managing rural primary and secondary schools, a balanced compulsory education at this level is of fundamental significance for the fulfilment of overall educational equity and equality. Due to current limited educational resources and incomplete educational regulations, China still has a long way to go before it attains the balanced development of compulsory education within its counties. To make breakthroughs in this regard, it is necessary to learn from global practice of educational reform and in the meantime, make thorough evaluations of the basic conditions of the national education.

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