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The Integration of the 4MAT Teaching Model with the Interdisciplinary Structure: A New Model Proposal and Test

Burcu Sezginsoy Şeker [1*], Filiz Tuba Dikkartın Övez [1]

[1] Balıkesir University, Faculty of Necatibey Education, Balıkesir, TURKEY

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ABSTRACT

In this study, the "4MAT (4 Mode Application Techniques) Teaching Model" and "Interdisciplinary Concept Model", the applications of which aimed to gather different disciplines around the selected concepts, were integrated within the scope of the disciplines of mathematics and social studies. For this study, these two models were combined to develop and test what was designated the I4MAT (Interdisciplinary 4MAT) model. The study was planned with a pretest-posttest, control group, experimental design. The study involved 65 students (primary school, 2016). This study found that the attainment level of students and their mean scores significantly favored the experimental group. It also found that education with the I4MAT model effectively and fully attained the learning aims and achievement and that the scores differed in the control group according to their learning styles.

Keywords: 4MAT model, interdisciplinary concept model, new model proposal, mathematics education, social studies education

INTRODUCTION

In today's world, people who have a single source of information and use this information in accordance with a single discipline cannot effectively generate multiple solutions. In social life, which has become more complicated due to new technologies and communication instruments, when people use different perspectives to find solutions to problems encountered in social life and thereby gain the habit of lifelong learning, the application of interdisciplinary methods can be successful. Therefore, teaching that is based on an interdisciplinary structure and qualified teachers who can carry out this teaching are required in the education process. The interdisciplinary study approach is an integration process (Klein, 2002). Integration constitutes the most challenging and critical component of the interdisciplinary process. The component that Klein (1990) cites as being the "complicated reality of conducting an interdisciplinary study" is integration. Interdisciplinary integration is an assessment process involving the analysis of targets of relevant disciplines (Boix Mansilla, 2005; Lattuca, 2001). Integration is based on the analysis of discipline-based targets and the perspectives or resolution of a problem, followed by their subsequent integration within the frame of various methodologies in the light of this analysis (Lattuca, 2001). Integrated disciplines and curriculum models developed along this perspective follow the constructivist perspective closely (Davis & Knobloch, 2002), as the more teaching is integrated, the more it will be constructivist (Klein, 2002, p. 14). Lattuca (2006: 355-356) discussed constructivism and the interdisciplinary approach together and defined it as "constructivist pedagogy." According to Lattuca, constructivist pedagogy does not reduce the teaching responsibility of the teacher but rather extends the definition of teaching. Teaching is realized not only by presenting the content, but also by designing experiences that encourage and ensure learning. Constructivists assume that students are endowed with the requisite information and beliefs to form the basis for them to understand the world, no matter how inexperienced they may be.

To foster interdisciplinary teachers, interdisciplinary teaching must be based on the perception of constructivist pedagogy and programs need to be developed based on this perspective. In this context, it is important to create models that combine constructivist methodology and interdisciplinary perspective and to present the results of the practices related to these models. The models and approaches that are used for applying the constructivist approach

✉ burcusezginsoy@hotmail.com **(*Correspondence)** ✉ f.tubadikkartin@gmail.com

Contribution of this paper to the literature

- To ensure meaningful learning, it is necessary for students to realize and apply the uses of mathematics in social life. In this study, an interdisciplinary teaching model based on the learning styles using social mathematics as a base was planned and implemented, and its effectiveness was demonstrated. In the literature teachers need the guidance of interdisciplinary lesson plans that are integrated with student-centered models based on the approaches in the curriculum. The curriculum design in this study integrates primary-level social studies and mathematics curriculum and is a step towards meeting this need. Studies referred to in this study prove that teachers make only associations between concepts and disciplines, and they have problems how to design an interdisciplinary curriculum design teaching environment. The literature showed that there have been various studies conducted based on the 4MAT teaching model and on the interdisciplinary concept model; (Blair &Judah, 1990; Bonk, & Zhang 2006; Nicoll-Senft, & Seider, 2009; Nowacki, 2011; Pruekpramool, 2011). In today's world, it has become important to improve the skills of the 21st century. For this reason, teaching environments should be organized based on the interdisciplinary perspective in line with the changing needs. Today, interdisciplinary learning frameworks should be created, and educational programs should be connected with the STEM (Scinece Technology Engineering and Mathematics) education in order to provide an opportunity to train individuals who focus on appropriate production for the skills of the 21st century.
- We meet mathematics not only in positive sciences, but in all stages of our lives, and it is related with social sciences as well. For instance; mathematical models are used in social life, economy, the subjects related to humans and environment, geographical regions and maps, health sciences, social psychology, education, sociology, behavioral sciences in addition to the use of mathematical skills such as obtaining, organizing, interpreting, and synthesizing. These practices prove the strong relation between these disciplines and the discipline of mathematics. In the simplest sense, mathematics is described as "an abstract form of life" (Altun, 2006). The realist understanding of mathematics education, which does not separate mathematics education from real life and is based on the opinion that mathematical knowledge in history began with real life problems and real life was mathematicized, does not isolate mathematics from social life either. Mathematics not only builds a relation among science, art, and technology, it is also a universal language that provides a bridge among all the other disciplines. Accordingly, the researcher believes that it is important to do more than just correlating acquisitions with each other in the process of teaching mathematics, which is a part of social life, and to design and analyze the effects of interdisciplinary teaching environments that will make students feel the strength of mathematics.
- In this respect, this study is considered to be a pioneer since it allows the evaluation of different disciplines in this process as well as the sciences and mathematics.

in the teaching process include the 5E learning cycle model, project-based learning, problem-based learning, brain-based learning, cooperative learning, the 4MAT teaching model and active learning. These models and approaches were developed for the purpose of facilitating a learning environment that encourages applying prior knowledge to new information about the content and using the results (McManus, 2001, p. 425).

Among the aforementioned models, the 4MAT teaching model is an integrated teaching approach, which enables different teaching strategies and methods based on the constructivist theory to be compiled. This model also encourages students to develop their own understanding and perceptions. Using different teaching strategies together in an integrated way makes learning more interesting and supportive and increases permanency (Merrill, 2001; Raija, 2001 cited by Pruekpramool, 2011). Many studies have revealed that using an integrated teaching approach, rather than traditional teaching approaches that adopt standardized strategies, allows students to structure the knowledge in their minds in a more effective way (Beane, 2016; Brears, MacIntyre & O'Sullivan, 2011; Czerniak & Johnson, 2014; Lafer, 1996; Lattuca, 2001). Additionally, integrated teaching approaches, such as the 4MAT, facilitates effective and substantial learning and directs students to cooperative learning and relational thinking (Ahuja & Jahangiri, 2003). The 4MAT teaching model is commonly used by teachers, and it helps them to perform cooperative activities. Therefore, to develop a strong interdisciplinary program, the use of this model is effective, as it includes the advantages mentioned and an integrated teaching approach (Blair & Judah, 1990).

Accordingly, this study proposes a model involving the interdisciplinary approach and the 4MAT teaching model, which as an integrated teaching approach will serve to contribute to the establishment of an interdisciplinary teaching environment within the framework of the constructivist pedagogy. In effect, this study integrates the "Interdisciplinary Concept Model" developed by Jacops and Borland (1989) and the 4MAT teaching model, which is student-centered and based on different teaching styles. This study also introduces and tests a model within the framework of mathematics and social studies disciplines. The "Interdisciplinary Concept Model" was selected in this study because the aim was to gather different disciplines around a concept. Moreover, the reason for the selection of the 4MAT teaching model based on the constructivist pedagogy was that this approach allows the teaching environment to be organized around targeted concepts and supports the use of different strategies by facilitating an integrated teaching approach (Jacops & Borland, 1989; Mccharty, 1987; 2003).

The 4MAT Teaching Model

The 4MAT teaching model was created by Bernice McCarthy in the 1970s. This model transforms the concept of learning styles into educational strategies and is based on the constructionist approach. The model is founded on the four learning styles examined by Kolb (1984). In this model, individuals perceive and process knowledge in different ways. Individuals' ways of perceiving knowledge are based on concrete experiences and abstract conceptualizations. When learning new things, some individuals consider their concrete experiences directly and perceive by sensing and feeling. Their processing of knowledge highlights reflective observation and active experience abilities. On the other hand, some individuals process or organize knowledge by observing, and others by doing and practicing (Gülpınar, 2005; Peker, 2003).

In this model, students have concrete experiences that produce reflective observations.

Reflective observation is described as the process in which individuals make sense of opinions from a variety of perspectives in the circle of learning. For instance; Type 2 learners, who are called analytical learners, perceive knowledge by abstract conceptualization, and process it through reflective observation. They integrate their observations with the things they already know, and create theories. They feel the need to know what specialists think. They evaluate the knowledge they obtain and encounter, and examine their experiences based on systematic thinking with use of this knowledge.

These observations enable them to make abstract conceptualizations that create generalizations and rules. Using these generalizations, students reach active testing which result in highly concrete experiences. This process is called the learning circle which is based on learning styles. McCarthy (1987) divided the circle, which she called the 4MAT wheel into eight steps, and designed it as a process consisting of activities that are suitable for students with different learning styles. McCarthy also called this process the natural learning period. In this wheel, teachers wander around the wheel and they teach with the differences in students' personalities in mind using instructional strategies suitable for the learning style of each student. To achieve this, teachers are supposed to design their instruction in a framework that considers personal differences and includes the entire circle (Ballone, 2001, p. 123; McCharthy & McCharthy, 2003; p. 33).

The 4MAT teaching model is more than a model since it is a way to place the knowledge elements at the center and organize them around the concept being taught. In addition, the researcher believes that this model is suitable for structuring other instructional practices, including Bloom's taxonomy and cooperative learning. For the 4MAT to be successful teachers need to be aware of learning strategies. Teachers should determine conceptual goals, respect students' differences and create a learning environment that leads students to the core of concepts (Altun, 2007; McCharthy & McCharthy, 2003, p.123-124).

Discussions about real life experiences offer good opportunities to determine misconceptions. The 4MAT teaching method presents activities that have pupils find answers to the questions Why? What? and How? Mind maps, worksheets, experiments, preparing and presenting projects are among these activities, and they can easily be adapted to the steps of the 4MAT. In these activities, students continuously research and solve cases connected to the subject (McCarthy, 2000a; 2000b).

The 4MAT teaching model is an eight-stage instructional cycle that makes use of individual learning styles (Bıkmaz, 2001). The first quarter and the first step is "connect", and its second step is "examine"; the second quarter includes the third step, "image" and the fourth step, "define". Its third quarter includes the fifth step: "practice", and the sixth step, "extend". Its fourth quarter includes the seventh step, "refine", and the eighth step, "integrate" is named. The first and second steps of the first quarter are where students use their experiences. The aim of this stage is to make connections between the student's environment and concepts. The fundamental question at this stage is "Why?" The third and fourth steps of the second quarter are where individuals learn what a concept is. Students analyze their experiences and shape concepts. The fundamental question at this stage is "What?" The fifth and sixth steps of the third quarter are the stages where students implement the concepts and learning is individualized. The fundamental question at this stage is "How?" The seventh and eighth steps of the fourth quarter are the stages where practice and experience are integrated. The fundamental question of this stage is "If?"

The 4MAT model is a student-centered model. It organizes learning according to the needs of students, and it provides a framework for teachers to plan eight-stage learning activities in a systematic cycle. When all quarters of this cycle are brought together, they form a developmental learning cycle which includes the transition from subjectivity to objectivity for integrated learning (Kegan, 1982). Thus, the 4MAT teaching model effectively improves the holistic thinking style that is the basis of interdisciplinary approaches. The next section will comprehensively present the content of the eight-stage curriculum for mathematics and social studies with the interdisciplinary concept model and the 4MAT teaching model as well as the process of its development.

Interdisciplinary Concept Model

In today's world, each discipline has a specific doctrine, professional language, distinct terminology, pioneers and followers (Becher, 1989; Parker, 2002). It is possible to improve information and science literacy, comprehensive research skills and creative thinking by synthesizing methodologies and concepts of different disciplines and thereby adopting an interdisciplinary perspective. Jacobs (1989) describes the interdisciplinary approach as: "the approach that consciously employs the methods and knowledge of multiple disciplines to examine a concept, subject or problem". The interdisciplinary approach focuses on a single concept, problem or subject, and combines it with knowledge and skills from relevant areas that can illuminate that concept from different perspectives (Jacobs, 1989).

An interdisciplinary approach integrates areas rather than isolates them. To ensure effective learning, there should be consistency in synthesizing the different subject areas. Programs based on interdisciplinary approaches include more information than that of one-discipline approaches. However, it is not always possible to integrate all issues. With the interdisciplinary approach, integration is possible if there is significant and appropriate information between disciplines. Connections between disciplines should be strong and easily understandable (Chrysostomou, 2004; Tchudi & Lafer, 1996). Interdisciplinary teaching enables students to realize connections between subject areas (e.g. connections between literature and history or mathematics and science). It is different from discipline- and area-based teaching in that it does not create gaps in subject areas; rather, it connects the content and consciously defines relationships between subjects (Jacobs & Borland, 1986).

Jacobs and Borland suggest a four-step model to develop a program based on an interdisciplinary approach. The first step is to select a subject or theme on which the program will be based. During the selection of the subject, the primary concern should be to prevent the subject from being too comprehensive or too narrow in scope. For example, selection of "human" as the subject may cause difficulties in limiting the subject. Or a narrow-scoped subject such as "cell nucleus" cannot be effective in developing an appropriate interdisciplinary program. Therefore, the subject should be conceptual and comprise different fields. For example, the concepts such as economics, democracy, energy, revolution, inflation, environment, climate, and transportation can integrate various disciplines in accordance with the relevant interdisciplinary approach (Jacobs, 1989; Jacobs & Borland, 1986).

The second step is called "brainstorming aids". In this step, the sub-subjects that can be related to the selected subject and the disciplines that can be related to these sub-subjects are listed. During this process, it is important to identify as various disciplines and concepts as possible. Then, the teacher or educator determines the disciplines that can be important in teaching the selected concept. The selected concept, subject or theme is the focus when listing the related disciplines depending on this theme. The disciplines represent the standard school subjects such as mathematics, language, arts, social sciences, human sciences, philosophy, and science. Then, the teachers or educators who prepare the program indicate the relationships between the concept, theme or subject and the selected disciplines upon brainstorming, on condition that they are informed about the identified disciplines. This technique prevents overlooking some disciplines (Jacobs, 1989; Yıldırım, 1996).

In the third step, the scope and order are determined for the guiding questions. During the brainstorming, a systematic structure is created by associating the identified concepts and subjects with the disciplines. During this phase, the most important issue is to address the "Potpourri Problem" defined by Jacobs. The "Potpourri Problem" means teachers' tendency to make an interdisciplinary unit that includes sample information from each discipline. An important problem during this phase is that a slight association of a course on the selected theme or subject with the sciences, mathematics, social sciences and foreign language is perceived as interdisciplinary teaching. In this process, teachers should create interdisciplinary questions or questions for the identified concepts or themes similar to the section titles in textbooks. In the interdisciplinary learning environment, teachers should explain to the students why and within the scope of which discipline the study will be carried out to maintain the students' attention. Otherwise, there is a risk that the practice cannot take precedence over several interesting activities. Therefore, the questions should be developed within this framework. During the second phase, questions are created for all of the identified concepts. It is not aimed yet to ask a different question for each concept. The questions can cover multiple concepts. In the end, a certain framework is obtained (Jacobs, 1989).

During the fourth step, the teacher writes an activity for the plan, and forms a lesson plan as well. Appropriate activities are designed for the questions. Various methods and techniques, as well as all instructional experiences, can be included in the design of the activities. The practices included should promote both individual and cooperational learning. The activities should be prepared based on a well-structured behavioral objective. Each step should be evaluated. While developing the program, the related disciplines should be integrated by providing opportunities for the interdisciplinary development of the selected subject, and activities should be designed at each step. This process should be maintained considering the selected theme, concept or subject. The activities, objectives, content, practices and evaluation methods are determined based on the questions that are identified during the third step. The Interdisciplinary Concept Model is used at each educational stage such as primary schools, secondary schools, or universities. This model can be used for interdisciplinary integration and to combine many techniques. In addition, students can find an opportunity to benefit from a curriculum that involves an interdisciplinary approach rather than theories alone (Jacobs, 1989).

Accordingly, this study proposes a model involving the interdisciplinary approach and the 4MAT teaching model, which, as an integrated teaching approach, that will serve to contribute to the establishment of an interdisciplinary teaching environment within the framework of the constructivist pedagogy. In this context the aim of this study was to integrate the "Interdisciplinary Concept Model" with the "4 Mode Application Techniques" teaching model, which is a student-centered model based on learning styles and the learning circle for mathematics and social studies and to examine the effect of education on the attainment levels of the students and their learning acquisitions (Ministry of National Education 2015a; 2015b). Study problems include:

- What is the effect of the teaching practices on achievement of the students constituting the experimental and control group?
- What is the effect of the teaching practices on the level of attainment of learning acquisitions of the students constituting the experimental and control group?
- Is there any significant difference between students' learning styles and achievement scores of the control and experimental group?

METHODOLOGY

This study examined the effectiveness of a model developed based on the 4MAT teaching model and the interdisciplinary concept models on the students' level of attainment of learning acquisitions and achievement. A pretest-posttest, control group, experimental design was used to find out the cause and effect relationships between the variables that constituted its research model.

Developing Content for Model

This study created a curriculum that integrated the interdisciplinary concept model, which brings together a concept or concepts from different disciplines, and the 4MAT model, which focuses on elements of knowledge and makes it possible to organize the teaching environment based on the concepts being taught (Jacobs & Borland, 1986; McCarthy, 1987; 2003). The main aim of the interdisciplinary concept model is to bring together different disciplines around a subject, problem or theme (Jacobs & Borland, 1986). This model aims to teach interdisciplinary concepts using a holistic approach and create awareness in students about interdisciplinary connections. This model describes a four-stage process for developing an interdisciplinary learning environment. The first stage, selecting an organizing center, includes the selection of concepts or subjects that are suitable for the interdisciplinary approach and capable of integrating different disciplines. In this study, the concept of "production - consumption - distribution cycle" was selected since it may be appropriate for the interdisciplinary approach and is associated with the social sciences and mathematics curricula for the 4th grade. This concept is neither too comprehensive nor too narrow-scoped, and is appropriate for the interdisciplinary approach. In addition, the selected concept can cover different fields of the subject, such as various subjects and concepts in the discipline of mathematics.

The second stage is the brainstorming associations. This stage determines the sub-concepts or subjects that are related to the main concept or subject by brainstorming, and lists the disciplines to which they may be related. The aim of this practice is to find as many concepts as possible and make accurate connections between them and the disciplines. It is important to determine the disciplines in which the selected concept can be taught most successfully. For this reason, it is not necessary for all disciplines to be included in the process. This study made associations between the production, delivery and consumption and the skills of research. These include critical thinking, creative thinking, problem-solving, and reading tables, diagrams and graphs, which are taught in the fourth grade social studies curriculum, and the learning acquisitions of using presentations to demonstrate collected data, establishing and solving and problems related to daily life using data in bar graphs, tables and other graphs, communication and correlation skills, all of which are also taught in the fourth grade mathematics curriculum.

In the third stage, establishing guiding questions to serve as a scope and sequence, the model is used to create a systematic structure for the selected subjects. The students identify problems or questions that connect the concepts. For the purpose of integration, it is important that these problems address to the selected disciplines simultaneously. Holistic teaching can be achieved by organizing instruction around common problems and effectively integrating knowledge from different areas to solve them. It is important that the questions posed to students are arranged from the simplest to the most complicated and include the questions What? Why? How? and If? (Jacobs, 1989; Lattuca, 2001; Rosenfield, 1992; Yıldırım, 1996). The characteristics of this stage are similar to those of the 4MAT model. In the third stage of the interdisciplinary concept model, the roles of teachers and students

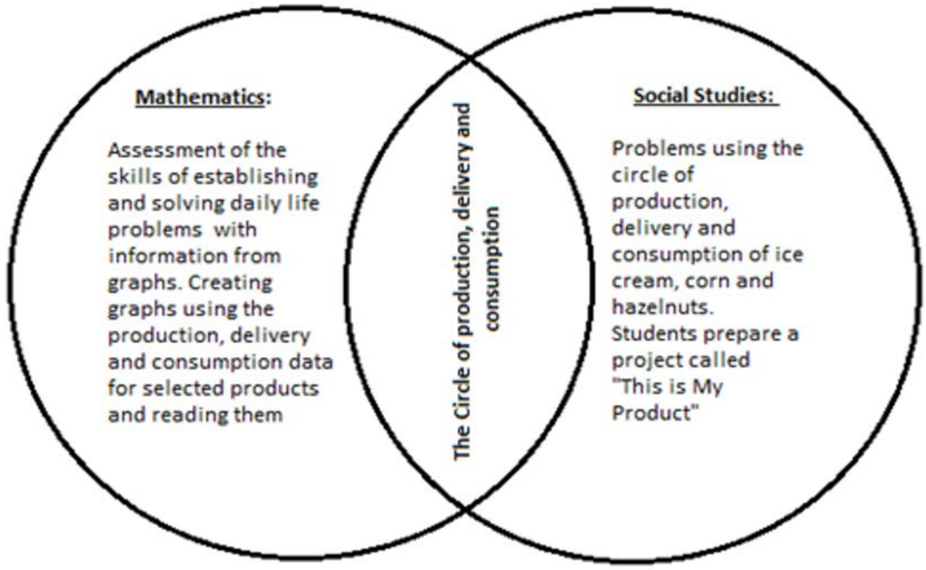


Figure 1. The Concept Model A Unit on The Circle of Production, Delivery and Consumption

shift depending on the question Why?, in the first quarter, What? in the second quarter, How? in the third quarter and If? in the fourth quarter (McCharthy, 2000b).

The questions created in the third stage serve as the basis for the next, writing activities for implementation, in which the curriculum is developed and the goals, content, implementation and evaluation methods are determined. As disciplinary instruction, the teaching techniques should be varied. The students should be given opportunities to do group projects, be involved in learning centers, discussions and research to reflect the interdisciplinary approach in the content of the curriculum. Multidimensional problems founded on the subject and the main discipline should be selected for activities. It is also necessary to identify the methods and principles for evaluating students' achievement while focussing on the process and the results. Moreover, it is important to collect data that make it possible evaluate the instructional process.

Figure 1 shows the conceptual model for the concept of the cycle of production, delivery and consumption. **Figure 2** presents the 4MAT learning cycle and shows curriculum-specific information about the goal, construct, activities and assessment stages.

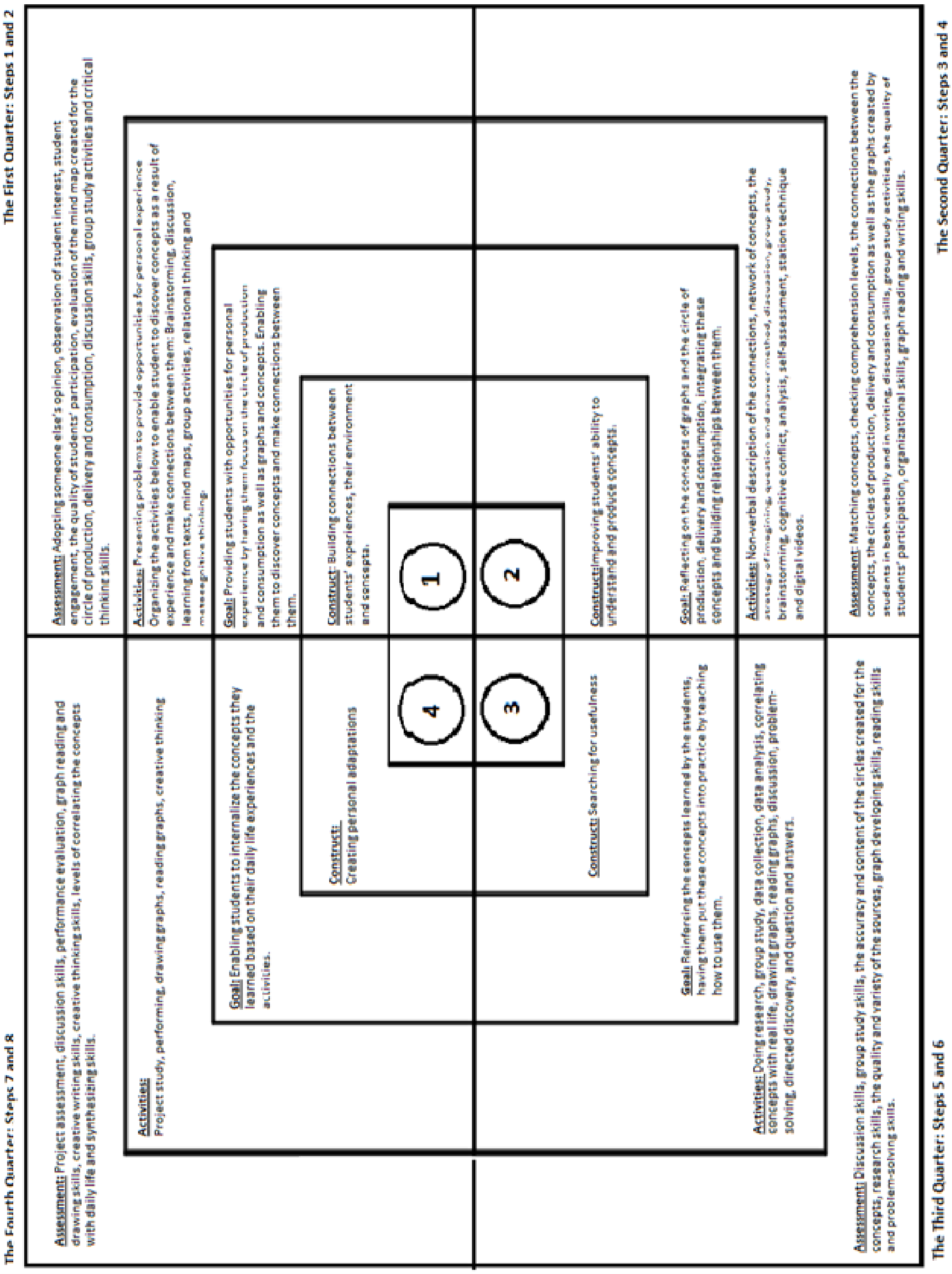


Figure 2. 4MAT Learning Circle Steps Content and Shows Curriculum-Specific Information About The Goal, Construct, Activities and Assessment Stages

Curriculum Design for Teachers

The first quarter: step 1 (building connections)

Goal: This step provides an opportunity for personal experience.

Activity: Given examples of the concepts of production, delivery and consumption in real life, the students make correlations between these concepts and their daily lives. They perform an activity that gives them an opportunity for a personal experience. With this purpose, the teacher presents students the text named "*An Ice Cream Story*" to give them ideas about the concepts of production, delivery and consumption.

In this story, a boy named Alican was talking with ice cream in his dream. This text tells, in the voice of milk, sugar and salep, how ice cream consists of a mixture of milk, sugar and salep, and how these ingredients reach the plant for the production process before being delivered and consumed.

The teacher poses questions to get the students to describe the production, delivery and consumption of ice cream, generating a discussion for them.

Questions about the text:

1. Which products are mentioned in the text given to you?
2. What are the stages in the production of these products? Who takes part in them?
3. How and by whom were the ice cream ingredients taken to the ice cream factory?
4. Where did the ice cream go after it was delivered to markets and groceries?

When students are answering the questions posed to them, the teacher creates a good environment for discussion and builds meaningful connections between their environment, personal experiences and the concepts of production, delivery and consumption. They are encouraged to share experiences like those in the production of the products in the text.

Evaluation: The teacher evaluates the quality of students' participation and their comprehension of the problem given to them.

The first quarter: step 2

Goal: In this step, the teacher analyzes the experiences gained in the first step.

Activity: The goal is to have the students discover the concepts of production, delivery and consumption as a result of the activity they performed in the first step, and create a network of production, delivery and consumption for the products. So the students are asked to go beyond the experience and look at the parts, analyzing them. The class is divided into groups to identify their shared experiences and individual perceptions. The students and the groups are asked to make mind maps of the stages of the circle of the products' production, delivery and consumption. Then, the groups' spokespersons are given the opportunity to present the mind maps to the entire class and exchange opinions afterwards. Thus, the students discover the whole by analyzing smaller parts of it and structure the cycle of production, delivery and consumption in their own minds. The students are encouraged to do metacognitive thinking by listing their opinions, analyzing the parts of the cycle of production, delivery and consumption and clarifying their experiences.

Evaluation: The teacher analyzes the data collected in the first step and examines students' ability to form the cycle of production, delivery and consumption and their participation in discussions. The accuracy of their mind maps is evaluated in class discussions.

The second quarter (concept development): step 3

The students' observations are conceptualized in this step. The teacher is more active.

Goal: In this step, individuals integrate their observations into concepts. The concepts of the cycle of production, delivery and consumption, which are discovered in the first and second steps, are conceptualized.

Activity: The teacher asks these discussion questions.

- When we think of the transformation of sugar, salep and milk used to make ice cream, how can we describe this operational process in real life?
- When we think of the process including the supply of the materials required to make ice cream, bringing them to factories and then delivering them to markets, how can we describe this operational process in real life?
- When we think of the purchase of ice cream by children and adults after it is delivered to markets and groceries, how can we describe this operational process in real life?

These questions will get students to analyze their experiences, and form concepts for the cycle of production, delivery and consumption. To do this, the students choose titles for each step of the mind maps created in the last step. The teacher uses the strategy of imagining giving students the chance to look at the concepts from another perspective.

The purpose of this implementation is to make the concepts deeper, give the students an opportunity to improve the concepts in their minds by using their creativity and critical thinking abilities, and ensure that the students anticipate the probable situations where the cycle of production, consumption, and distribution is not performed in a qualified manner.

Then, the teacher asks these questions:

- What would happen if one of the steps in the production of the ice cream were not performed?
- What if the ice cream was not delivered to markets after it was produced?
- Millions of foods and necessary materials are transported to Istanbul every day. What if these foods and materials were not transported? Draw a picture of a city in this situation.

Evaluation: Their understanding of the phrases.

The second quarter (concept development): step 4

In this step, the concepts of production, delivery and consumption are explained to the students. The students are asked to create a graph based on the annual production and consumption data given to them for a selected product, with the purpose of having them use presentations to show the data they collected and students establish and solve problems related to daily life using the information shown in bar graphs, tables and other graphs, which are learning outcomes in the fourth grade curriculum. These are associated with these learning outcomes from the third grade mathematics curriculum: "The students read the primary data represented by tables and graphs, explain the data and its form using comparative language," "The students examine the bar graph and make interpretations and estimations based on the graph," and "The students create a bar graph."

Goal: The goal was to transform students' informal sentences on production, consumption, and distribution into formal sentences with the guidance of the teacher. The study aimed to have the students use graphic reading and creating skills addressed to the daily life problems that were presented in the framework of production-consumption-distribution cycle concept. Accordingly, the students created frequency tables for the frequency tables presenting the data of the selected product. With this process, the study aimed to interpret the data and convert them into a bar graph, which will improve the skills of interpreting the form of mathematical representation by correlating it to the concept of production-consumption-distribution. This process will also give students the opportunity to leave the operational meanings of the didactic tasks they were assigned by mathematics course books, interpret the data and the relations between them, and discover the mathematical relations between the representational forms of tables and graphs, which will lead them to the improvement of their mathematical thinking skills. Thus, students should be expected to relate to the underlying concepts of rules rather than just memorizing the rules directly. With this practice, the aim of this approach is to improve students' skills of building relations between real life situations and forms of representation, e.g. tables and graphs.

Activity: The teacher creates a good environment for discussion for the students and includes them in the content. Thus, the students will improve their information and concept-producing abilities, and they will use these abilities and concepts in their presentations and activities. Moreover, the teacher will have the students make non-verbal descriptions of the concepts by creating networks for them, which will also reveal how the ideas have been structured by the students and, if any, misconceptions.

The study developed a digital story activity named "The Adventure of Hazelnut" to deepen the concepts of production, consumption, and distribution that were created in the implementation of the "ice-cream's story", and improve students' abilities to produce knowledge and concept. The study also aimed to enable students to use different representations and think about the mathematical relations within this scope by interpreting the data and creating bar graphs.

For this purpose, the class will be divided into groups, and all students will watch the video, "The Adventure of the Hazelnut." Then, the students are given various pictures of the cycle of its production, delivery and consumption so that they can create this cycle for themselves, along with files containing the annual consumption data for hazelnuts so that they can prepare relevant bar graphs. These are for the activity, "Pass the File to the Other Group". Each group will examine the pictures in their own file and discuss which in stages in the cycle of production, delivery and consumption. The groups will analyze the other groups' files one by one, and they will complete all pictures of the cycle. The teacher will ask the groups to create and interpret bar graphs. The teacher will also ask the student groups to create and interpret bar graphs based on the frequency graphs showing the hazelnut production and consumption data. The groups will elect spokespersons, and they will present the cycle and tables they created to the rest of the class, while the teacher elicits different opinions and, misconceptions, if any. This environment of cognitive conflict will help to eliminate students' misunderstandings of the concepts. The selected products may be changed according to the cultural differences and interests of the students.

Evaluation: The teacher makes a written and verbal check of students' comprehension levels, concept matching, descriptions, the graphs they created by interpreting the frequency tables, mathematical communication and correlation skills and the relationships they built.

The third quarter (implementation): step 5

This step includes activities using the concepts learned so far.

Goal: The teacher guides the students in activities that reinforce the concepts they have learned. The activities are used to review the concepts and skills learned in the second quarter.

Activity: The students are divided into groups and given a research question about corn's cycle of production, delivery and consumption. The cycles prepared by the groups are presented to the whole class.

Evaluation: The teacher evaluates the students' creation of "Cycle", their cooperative studying skills, their contributions to group work, the accuracy and content of the cycles, the variety and reliability of the resources used and the quality of their efforts.

The third quarter (implementation): step 6

In this step, students implement their own knowledge by adding things themselves. The students are more active and make their own contributions.

Goal: To apply the concepts learned while enhancing the students' ability to make choices based on their curiosity and interests.

Activity: The teacher has students perform activities using the concepts from their research project to so that they attain the fourth grade mathematics curriculum learning outcomes: "The students use presentations to show the data they collected," and "The students establish and solve problems related to daily life using bar graphs, tables and other graphs."

Evaluation: Evaluation of problem-solving skills, graph reading skills and communication skills in social studies with the concepts of production, delivery and consumption.

The fourth quarter (beginning to perform new practices): step 7

In this step, the teacher analyzes students' ability to put the concepts into practice.

Goal: The goal of this step is to have students analyze the activities and internalize the concepts they have learned.

Activity: The teacher asks students these questions as preparation for the project. This is My Product.

- Draw a product that you imagine and plan to produce.
- For whom would you like to produce this type of product?
- Who would need this product?
- How would you transport this product?
- Where or in what fields can this product be used?
- Draw an annual consumption graph for your product.
- Write down the adventure of this product.

Evaluation: Rubric (Rubric Form for The Project, "This is My Product")

The fourth quarter: step 8

In this step, the teacher allows students to discover things themselves and share them with the other students. The students are more active in this step.

Goal: The goal of this step is to have students internalize and comprehend the subject based on their daily life experiences.

Activity: The students make their personal presentations in the context of the project, This is My Product, and introduce the product they imagine to their classmates. The teacher creates a good environment for in-class discussion and attempts to eliminate the possible deficiencies of peer assessment. In this step, the teacher acts as the guide, and the students are active. The steps of the 4MAT cycle are completed, and the information is reshaped. The teacher asks the students to express the formal descriptions of the concepts as well as the relationships between them. The teacher also asks students these questions to complete the cycle.

With this purpose in mind, the students are asked questions that involve concept-level knowledge. To complete the cycle, the teacher asks students the questions below. In this process, the students are requested to put forward how they structure in mind the concepts of production, consumption, and distribution as well as the relations and circle of these concepts. The students are also asked to create arguments about the economic dimension of using

Table 1. Specified Learning Outcomes in Social Studies and Mathematics

Disciplines	***Outcomes***
Social studies learning outcomes	Explains the concept of production by giving examples from daily life.
	Explains the concept of consumption by giving examples from daily life.
	Explains the concept of distribution by giving examples from daily life.
	Explains the production steps in some products that students use.
	Explains the production, distribution and consumption network of some products that students use.
	Describes a product that students choose and explains its production, distribution and consumption network.
Mathematics learning outcomes	Uses different formats (bar charts and tables) to display the data obtained.
	Interprets the production and consumption data of a product and explains them in tables and graphs.
	Interprets mathematical ideas in the tables and bar charts.
	Poses and solves problems about daily life by using the data shown in the bar charts, tables and other graphics.

these concepts in daily life, and how they would explain the mathematical results of these economic facts. With these practices, the approach aims to have students interpret the concepts of production, consumption, and distribution in the process of interpreting and converting the data into bar graphs, and to demonstrate the extent to which students integrate the learned knowledge in the framework of social sciences and mathematics disciplines.

1. Which new concepts have you learned in this lesson?
2. How do you describe these concepts?
3. Can you explain the relationships between the concepts?
4. When do you think we use these concepts in our daily lives?
5. Do you think the concepts we learned are necessary and useful? Why?

Evaluation: Describing the concepts of production, delivery and consumption formally, stating accurately the correlations of these concepts with each other in the cycle, testing the associations that students make between these concepts and their graphs and occurrences in their daily lives and assessing students' synthesizing skills.

Participants

A total of 65 fourth-grade primary school students, including 33 in the experimental group and 32 in the control group who were studying in a primary school in Balıkesir Province and were selected by simple random sampling, participated in the study. Of them, 28 were male, and 37 were female and they were 10 years old.

These students were selected out of 95 students from two equally successful classes. The students were selected by taking into consideration their first-term grades. According to the results of the t-test performed for independent samples to compare the first term academic achievement of students in the experimental and control groups, no significant difference was found between their academic achievement before the practices ($\bar{X}_{experimental}$=3.59,$\bar{X}_{control}$=3.43; $p< 0.05$).

Data Collection Tools

Consisting of 12 items, the Kolb Learning Style Inventory was developed and reorganized by Kolb (1984). Its validity and reliability study in Turkey was conducted by Aşkar and Akkoyunlu (1993). This scale was used to determine the learning styles of students. The reliability coefficients obtained from the learning styles were found to be .58 for concrete experience, .70 for reflective observation, .71 for abstract conceptualization, .65 for active experimentation, .77 for abstract-concrete and .76 for active-reflective. According to Kolb, four learning styles are defined. These are Type I learner: the highly imaginative student who favors feeling and reflecting. Type II learner: the analytic student who favors reflecting and thinking. Type III learner: the common-sense learner who favours thinking and doing. Type IV learner: the dynamic learner who favors creating and acting (Kolb, 1984). An achievement test consisting of open-ended questions was developed to determine the students' level of attainment of outcomes. The intended learning outcomes are shown in **Table 1**.

Three questions measuring the learning outcomes separately in each discipline were prepared for the scale. The Lawshe technique (1975) was used to determine the content validity of items on the achievement test (cited by Yurdagül, 2005). According to this technique, first of all, the prospective scale was presented to a group of two expert mathematics instructors, two classroom teaching expert instructors and four expert classroom teachers. Their opinions about the clarity of the questions, the suitability of confusing elements and their suitability to the attainments were considered. The experts were asked to rank each item as "the item measures the target structure," "the item is related to the structure, but unnecessary," "the item partially measures the target structure," and "the item does not measure the target structure." The content validity rates (CVR) of the items were determined using the opinions of the experts. If an item's CVR minimum value was 0.78 (Veneziano & Hooper, 1997) and higher the α = 0.05 significance level, it was considered significant. The questions found to measure the learning outcomes best according to expert opinion were selected, and the achievement test was developed. The 10-item scale was administered to the experimental and control groups before and after the implementation, and the data were obtained.

Process of the Implementation and Planning Directions

The teaching plan was designed by integrating the outcomes of mathematics and social studies within the scope of the selected concepts It was implemented by the researchers to the experimental group 3 hours a week for a total of 12 hours for 4 weeks. Activities were organized within the frame of the eight stages of the cycle and a cyclical teaching appropriate to the students' learning styles was carried out. The activities were intended to enable students to structure their knowledge. To enable students to acquire high level thinking skills, a teaching model was designed and implemented to make interpretations, analyze information and activate knowledge. In the control group, the outcomes in the curriculum were taught by the researchers in mathematics and social studies lessons without the interdisciplinary perspective for 4 weeks. A primary school curriculum based on the constructivist approach was used. The education provided was based on activities in the school textbook published by the Head of the Ministry of Education's Council of Education Programs. All the experiments in the experiment and control group were carried out in the classroom environment.

The aim was to follow a process based on learning styles and learning cycle and to introduce the identified concepts based on the interdisciplinary perspective in line with the developed model. The reflections of the learning process are explained in phases as follows:

1st quarter (1st and 2nd steps)

The students were provided with real-life examples including the concepts of "production, distribution and consumption," identified within the framework of the interdisciplinary approach, in order to give them a chance to have personal experience and enable them to associate these concepts with daily life. The students were engaged with the course using the text "An Ice Cream Story," which was presented to enable the students to associate with real life the formally-defined concepts that they will learn despite using them in daily life.

The story tells of the ingredients required to produce an ice-cream and the production, distribution and consumption processes of these ingredients. The students were asked various exploratory questions about the process of bringing the products in the text to the factory as raw materials. This question process lasted for 20 minutes. The students shared their opinions and tried to answer these questions. Each student tried to participate in the discussion since the subject was interesting for them. At this stage, it is important to provide the students with the opportunity of individual experience. Therefore, it is recommended that the selected practices be organized considering the students' age and cultural background to enable them to be the subject of their own knowledge. Otherwise, they may not be interested in the course.

After the practice about the text, the students were asked to analyze the parts and create the production, consumption and distribution network for salep, milk and sugar. The class was divided into groups of 4-5 students to reveal the students' common experiences and individual perceptions. Each group was given colored papers and asked to list the stages of the changing process for the products in the text. The spokespersons from each group presented their group's mind maps in the class and had an exchange of ideas. This practice was turned into a competition to ensure the students' active participation in this process. The groups were asked to defend their suggestions and evaluate the other groups' suggestions for being correct. The competition increased the students' participation and motivation. This process lasted for 30 minutes.

At this stage, the first goal was to ensure that the students begin an analysis process based on their individual experiences that they had acquired in the first step. Therefore, both the individual and the group activities should be organized meticulously. Sharing information is very important at this stage to enable the students to shift from informal information to formal information based on their knowledge. Various games, computer programs or dynamic software appropriate for the students' age can be used to motivate them and increase their participation. Another factor is the number of the students and their skill levels in group activities. Teachers should be able to select the materials, methods and techniques appropriate for the students. In addition, the students should be provided with an environment where they can freely express their opinions. However, misconceptions may occur in this process.

In a bar graph, there are bars that represent the categories, and the heights of these bars are in direct proportion with the number of categories. Bar graphs are interpreted by determining the height of the bars, and conducting rating and comparison. In the fourth grade curriculum, it is expected that students create bar graphs by showing the frequencies of data groups with the height of the bars, or creating data groups by interpreting the bar graph. However, the study found that the students in different stages had a number of mistakes and misconceptions in reading, interpreting and creating graphics considering their comprehension and use. The misconceptions that were observed to be repetitive and clear in the qualities of students' knowledge about graphics were divided into four groups: misconception of resembling the graphic to an image, height-curve misconception, dot-interval misconception, and continuous-interrupted graphic confusion (Leinhart, Zaslavsky & Stein, 1990). Additionally, some students made mistakes in interpreting the graph due to having problems in scaling the axes (Hotmanoglu, 2014)

In the social sciences, past studies have shown that students make mistakes and have misconceptions in the framework of the production-consumption-distribution concept which is included in the concepts of economy. As the reasons for these mistakes and misconceptions, studies have put forward the statements "the savings that an individual obtains to meet a personal need", "contributing the national economy", and "making production within the country" in relation to the subject of production. Also, some other studies in the relevant literature claim that students may have misconceptions due to an over-specific view about the concept of economy as they consider it a "cycle of production, consumption, and distribution" (Kılıçoğlu and Akhan, 2014).

Teachers should be prepared for this problem; they should be aware of the misconceptions about the subject and be prepared to eliminate them. No misconception was observed in the practice in this study.

2nd quarter (3rd and 4th steps)

In the third step, the objective was that the students integrate their observations and the concepts they created. The students named the concepts of production, consumption and distribution based on the process of being treated for ice cream and their daily life experiences. Another practice found interesting by the students was the practice of "imagine," which aimed to allow the students to approach the concepts from a different point of view. For this purpose, the students were asked questions such as "Millions of foods and requirements are brought to İstanbul every day. In your opinion, what would happen if these foods and requirements could not be brought? Please draw a picture of a city to which these materials could not be brought." This practice provided the students with the opportunity to develop the concepts in their minds using their creativity and critical thinking skills. They discussed the problems that may occur with their classmates by presenting the opinions they indicated in their pictures. Although the students had different levels of skills in drawing, their answers showed that they internalized the concept.

After the practices, the students' informal sentences about the concepts of production, consumption and distribution were transformed into formal sentences with the teacher's guidance. Then, the students created graphics and interpreted them using a digital video called "The Adventure of the Hazelnut". This video was relevant to the concept. Each group was given pictures symbolizing the stages of the network of the production of hazelnuts, consumption and distribution and the data of hazelnut production and consumption based on years, and asked to create the production, consumption and distribution network for hazelnut (**Annex 1**).

The students were divided into 5 groups and took part in the "pass the file to the others" activity. Five files were created and randomly distributed to the students. Each group reviewed the files and made conclusions about the stages of the production, consumption and distribution network of the pictures in the files. The groups respectively reviewed their own and other groups' files, and thereby the pictures of the cycle were put in an order by all of the students. Then the students were asked to create the column charts for the frequency tables including the data of hazelnut production and consumption. The spokespersons presented the graphics they created based on their previous learning to their classmates. The students used their knowledge on interpreting the primary data represented via tables and graph, reviewing a column graphic, and creating a graphic which they learned in mathematics in the third grade. They passed to the stage of solving the problems about graphic interpretation and creation by means of the real-life example of the hazelnut. Some students had difficulty in creating the graphics because they could not remember how to do it. They managed to create the graphics by cooperating with their friends in the group. Incorrect graphics were corrected with teacher's questions and discussions. The mistakes regarding the column width and unit ranges could be corrected since they did not arise from misconceptions.

Misconceptions may occur at this stage. Therefore, teachers should be prepared for this problem and try to eliminate misconception by means of texts on conceptual change or concept cartoons. In addition, the teachers that are specialized on the integrated disciplines can cooperate with each other, and even carry out the course together. Another issue is the necessity to design the student activities in a way to allow the development of the concept. It is recommended that different activities be designed for different age groups considering the interdisciplinary perspective (e.g. digital stories, scenarios, cartoons, and tools).

3rd quarter (5th and 6th steps)

During the implementation step of the model, the groups were asked a research question to create the production, consumption and distribution cycle of corn. This question aimed to strengthen the concepts they had learned. Corn was selected as a common product in order to allow the comparison of the interpretations regarding the graphics to be created for digital data during the next activities. It is recommended that the products be diversified considering the geographical region where the study group lives. The students were given one week to do research for the above-mentioned assignment. They did their research consulting the web pages recommended by the teacher. This limitation was due to the fact that the students were in primary school. Then, the students presented the projects they had built. During this process, students' cooperation skills, contributions to the group works, correctness and content of the cycles, research skills, and the variety and reliability of the resources that they used were prioritized. Some groups did their research in the school's computer laboratory. At this stage, providing the students with the opportunities or materials required to fulfill the duties is important for the healthy progress of the process.

The worksheet regarding the acquirements of "He/she uses different demonstrations to present the data he/she finds" and "solves and forms problems about daily life using the information shown in column graphics, tables and other graphics" was administered to the students based on corn after implementing the project. This worksheet is included in the mathematics curriculum for the 4th grade and given in the **Annex 2**. The worksheet includes various phased questions and the use of problem solving and graphic interpretation skills. During this process, many students succeeded in interpreting the graphics and comparing the amounts of consumption and production since they comprehended the cycle. The students easily answered the questions about the graphics because they understood the meaning of the concepts of production and consumption. For example, they easily answered the question "In which years the amount of produced corn could not meet the amount of consumed corn? Why?" that aimed to compare column graphics showing the production and consumption of corn in years.

4th quarter (7th and 8th steps)

During the final step of the model, the students performed the project called "This is my product." They were asked to create the cycle for a product they selected and the production and consumption graphics of that product in years. They built their individual projects by doing research for one week. Some students preferred well-known products such as wheat, and collected the production and consumption data for these products from web sites. Some students, on the other hand, selected the products they found interesting, such as watermelon, and created imaginary digital data about them. The most interesting product for the students was tomato grown without soil. The students stated that their imagination became stronger as they saw different ideas. In addition, they tended to do research on various subjects such as different agricultural ways, the products they did not know, different graphical presentations, and the relationship between economics and products.

Data Analysis

According to data obtained from the achievement test, the standardized absolute achievement scores were calculated and compared. The percentages of correct responses for the items were calculated to determine the levels of attainment of the learning outcomes, and these levels were interpreted using the 0.75 criterion (Bloom, 1998). The differences between the pretest-posttest mean scores on the scale items were assessed using the dependent samples t-test, and the significance of difference between levels of attainment by learning style was assessed using one-way variance analysis (ANOVA). This study used the Scheffe test to determine the source of the significant difference. The significance of social studies, mathematics and total achievement mean scores in terms of the experimental and control groups was analyzed using the independent t-test. Moreover, this study calculated the effect size to shed light on the practical significance of the results. In the variance analyses, the suggestions offered by Cohen (1988) were used as the basis for interpreting effect sizes. For t-test results and for the ANOVA test, Cohen's *d* and Cohen's f values were calculated, respectively. For Cohen's *d*, the effect sizes obtained were interpreted as small, if the value was between 0.20 and 0.50, as medium, if the value was between 0.50 and 0.80, and as large, if the value was greater than 0.80. According to the eta-squared value calculated, the effect sizes were interpreted as "0.01: small", "0.06: medium", and "0.14: large." For all result interpretations, the significance value was 0.05.

RESULTS

In this study, a teaching plan for mathematics and social science learning outcomes, which was designed through the integration of the 4MAT teaching and interdisciplinary concept models was administered to the experimental group. This study determined outcomes in the program separately for the students in the control group within the framework of activities in the course book used during mathematic and social studies courses. The significance of the difference between the pretest and posttest mean scores of the experimental group and the control group was compared using the dependent samples t-test. The data obtained are shown in **Table 2**.

Table 2. Result of t test analysis

Group		N	Mean	S	Sd	t	Sig
Experimental Group	Pre-test	32	3.75	6.09	31	38.86	0.000*
	Post-test		90.31	10.62			
Control Group	Pre-test	33	1.51	4.41	32	-21.36	0.000*
	Post-test		67.27	17.90			

**p*<.05

Table 3. Comparison of The Achievement of The Experimental and Control Groups

	Group	N	$\bar{X}_{achievement}$	S	Sd	t	p	Effect Size
General	Experimental	32	86.56	12.60	63	5.44	0.00*	1.36
	Control	33	65.75	17.68				
Social Science	Experimental	32	49.68	9.32	63	3.46	0.00*	0.85
	Control	33	40.00	12.99				
Mathematics	Experimental	32	36.87	6.44	63	4.98	0.00*	1.25
	Control	33	25.75	10.90				

**p*<.05

Table 2 shows that the posttest mean score ($\bar{X}$=90.31) of the experimental group was higher than its pretest mean score ($\bar{X}$=3.75), and that the posttest mean score of the control group ($\bar{X}$=67.27) was higher than its pretest mean score ($\bar{X}$=1.51). According to the results of t-test, the "t" value was significant for both groups at the level of 0.05 [$t_{control}$=-21.36, $p < .05$; $t_{experimental}$=38.86, $p < .05$].

After the experimental study, the level of mean achievement of the experimental and control groups were compared using the independent groups t-test. For this purpose, the difference between the pretest and posttest scores of groups within themselves was considered, the achievement score was compared in mathematics, social studies and in general. The results are shown in **Table 3**.

The t-test results showed that there was a significant difference between the achievement mean scores on the general scale [t=5.44; $p < .05$], the mathematics mean scores [t=4.98; $p < .05$] and the social studies mean scores [t=3.46; $p < .05$]. The general, mathematics and social studies' difference mean scores were found to be 20.81, 11.12 and 9.68, respectively, and were higher for the experimental group. This showed that the teaching practices were more effective for the experimental group. The Cohen's *d* factor, calculated to determine the effect of the independent variable of teaching method on the dependent variable of success grade, was found to be 1.36 for overall success, 0.85 for social studies, and 1.25 for mathematics. These results show that the teaching practices performed as part of the model proposed had a great effect on the enhancement of academic achievement in social studies and mathematics achievements. Moreover, the values of the effect size show that the results obtained were moderately significant for achievement in social studies, and highly significant for overall success and achievement in mathematics.

The percentages of correct responses for questions measuring each learning outcome (item difficulty index) were calculated for the pretest and posttest to determine the students' levels of attainment of the learning outcomes. The pj values of item difficulty indexes, the difference between them and t values were calculated, and the results are shown in **Table 4**.

The control and experimental groups were found not to attain any outcomes at the level of full learning before the instruction. The posttest results of the students in the control group showed that they attained the S1, S2, S3, M1 and M3 learning outcomes in the social studies and mathematics disciplines, and the students in the experimental group attained all the outcomes after instruction at the level of 0.75. The difference between the pretest and posttest scores of students in the experimental and control groups was found to be significant for each acquisition according to t values ($p < .05$). The level of attainment of outcomes was 100% in the teaching model carried out by integrating the 4MAT teaching and interdisciplinary concept models, while this percentage was 50% for both social studies and mathematics outcomes. To investigate the significant difference between students' learning styles and achievement scores of the control and experimental group one-way variance analysis is used. The results of one-way variance analysis (ANOVA) are shown in **Table 5**.

Table 4. The Levels of Attainment of Learning Acquisitions

	Control			Experimental		
Acquisitions	**Pre test (pj)**	**Post test (pj)**	**t**	**Pre test (pj)**	**Post test (pj)**	**t**
S1. Explains the concept of production by giving examples from daily life.	.03	**.78**	10.0*	.09	**.90**	9.76*
S2. Explains the concept of consumption by giving examples from daily life.	.00	**.75**	10.0*	.09	**.93**	-12.93*
S3. Explains the concept of distribution by giving examples from daily life.	.03	**.78**	8.67*	.00	**.94**	-21.56*
S4. Explains the production steps some products that students use.	.00	.48	5.48*	.06	**.88**	-11.59*
S5. Explains the production, distribution and consumption network of some products that students use.	.00	.66	8.00*	.09	**.87**	-9.00*
S6. Describes a product students choose and explains its production, distribution and consumption network.	.00	.57	6.59*	.00	**.78**	-10.52*
M1. Uses different formats (bar charts and tables) to display the data obtained.	.00	**.78**	10.9*	.00	**.93**	-21.56*
M2. Interprets the production and consumption data of a product and explains them in tables and graphs.	.00	.57	6.59*	.00	**.93**	-21.56*
M3. Interprets mathematical ideas in the tables and bar charts.	.06	**.81**	8.67*	.03	**.94**	-17.31*
I4 Poses and solves problems about daily life by using the data showed in the bar charts, tables and other graphics.	.03	.48	5.16*	.00	**.91**	-17.31*

*p<.05

Table 5. ANOVA Results of Posttest Scores of Students in the Experimental and Control Groups by Learning Style

Groups	Learning Styles	N	Mean	Sd	F	p	η^2	Scheffe
Control Groups	Type I	7	52.85	16.03	4.85*	.007	0.079	I-III
	Type II	13	70.00	16.32				
	Type III	10	75.00	12.69				
	Type IV	3	46.66	15.27				
Experimental Groups	Type I	8	87.50	19.82	.806	.501	-	-
	Type II	12	89.16	9.96				
	Type III	9	81.11	7.81				
	Type IV	3	90.00	10.00				

Sd standard deviation, , η^2 (eta squared), *p<.05

The achievement scores of the students in the experimental group did not differ significantly by learning style [$F_{(3\text{-}28)}$ = .501, $p > .05$]. The lack of a difference in the experimental group may have resulted from the fact that the teaching was based on learning styles.

However, there was a significant difference in the control group [$F_{(3\text{-}29)}$ = .007, $p < .05$]. According to these results, the hypothesis of H_0 (There is no significant difference between the success of the students with different learning styles in the control group) was rejected for the control group. In other words, there was a difference between the achievement means of the students in the control group when different learning styles were implemented. Despite reaching statistical significance, the actual difference in mean scores between groups was medium. The effect size, calculated using eta squared, was .08. This study determined that the mean achievement scores, in terms of learning styles, were $\bar{X}$= 52.85 for Type I, $\bar{X}$= 70.0 for Type II, $\bar{X}$= 75.0 for Type III, and $\bar{X}$= 46.66 for Type IV, according to the results of the Post Hoc comparison that was made using the Scheffe test. The learning achievement mean scores of students in the control group who had the third type of learning style ($\bar{X}$=75) were found to be higher than those of students with other learning styles. According to the results obtained, there was no significant difference in achievement mean scores between students in terms of the learning styles of Type I, Type II and Type IV. However, a significant difference was found between students who had learning styles of Type I and Type III.

DISCUSSION AND CONCLUSIONS

In this study, the "4MAT Teaching Model" and "Interdisciplinary Concept Model", the applications of which aimed to gather different disciplines around the selected concept or concepts, were integrated within the scope of the disciplines of mathematics and social studies. For this study, these two models were combined to develop and test what was designated the Interdisciplinary 4 Mode Teaching (I4MAT) model.

From the data collected on the practices, the following results were obtained:

Compared to the control group, the teaching practices related to the designed model had a significant effect on the enhancement of the general gain and the outcomes of social studies and mathematics in the experimental group,

Students in the experimental group achieved all outcomes at the full learning level, while the students in the control group achieved 50% of the outcomes.

This study found that the outcome scores of the students in the experimental group did not significantly differ according to their learning styles, although there was a significant difference in the outcome scores of the students in the control group.

Within the scope of the teaching practices designed in this study, the experimental group students, in contrast to the control group students, reached the outcomes requiring superior thinking skills at the full learning level.

The outcomes for social studies, such as explaining the steps in the production of products, sorting them correctly and describing the production, consumption and distribution cycle of a product, served as an indicator of the students' skill at the level of synthesis. The students in the experimental group attained mathematics and social studies learning outcomes, such as interpreting the production and consumption data of a product, explaining tables or graphical charts, associating information given on the bar chart, table and other charts with daily life, and posing and solving relevant problems. In contrast, the control group students did not achieve outcomes requiring superior thinking skills. This means that they could not understand and interpret the concepts of production, consumption and distribution cycle within the framework of the disciplines of social studies and mathematics. Moreover, they did not achieve a sufficient achievement level in problem posing and problem solving.

The content and development process of the eight-stage lesson plan prepared for mathematics and social studies by integrating the interdisciplinary concept model and the 4MAT teaching model were presented in detail in this study. The plan was administered for 12 hours, and the effect of this teaching on achievement and levels of attainment of learning outcomes was examined. The teaching of learning outcomes for activities in the mathematics and social studies textbooks was organized for the control group to whom the teaching plan was not administered.

This study found that; the teaching practices were more significantly effective for the experimental group's mathematics, social studies and general achievement than for the control group. The experimental group attained all of the outcomes at the level of full learning while the control group attained them at the level of 50%. The mean achievement scores of the students in the experimental group did not show a significant difference by learning style, but they did for the control group. The results obtained from some of the studies in the literature show similarities. (Lee& Lee, 2013; Özgen, 2013; Özgen & Alkan, 2012; Thomas, 2015; Yurt, Aydin & Sahin, 2015).

The students in the experimental group were found to attain fully the learning outcomes requiring superior thinking skills, unlike the control group. Explaining the steps in the production of products, sorting them correctly and describing the production, consumption and distribution cycle of a product selected by the student as an indicator of the students' skill at the level of synthesis are examples of social studies learning outcomes. The students in the experimental group attained mathematics and social studies learning outcomes such as interpreting the production and consumption data of a product, explaining tables or graphs, associating information given on the bar chart, table and other charts with daily life, and posing and solving relevant problems. However, the students in the control group were unable to not attain the outcomes requiring superior thinking skills. They were unable to interpret the production and consumption cycle and were unable to reach the adequate achievement level in posing and solving problems.

In today's world, where people aim to develop skills applicable to the 21st century, innovation and exploration are vital skills to have. This makes the configuration of information and interdisciplinary studies essential (Ministry of National Education 2015a, 2015b; NCTM, 2000; NCSS, 2010). The demand for people who can develop innovative projects and conduct interdisciplinary studies can be met by arranging teaching environments in accordance with an interdisciplinary perception. The I4MAT model, which was developed on the basis of the constructivist pedagogy approach, is a model that aims to organize and achieve the integration of different discipline areas. The prototype of the model is shown in **Figure 3**.

The I4MAT model aims to reveal potential common points of different disciplines by looking at the educational process with a more comprehensive perspective. The core of the model includes the integration of skills with the content of the disciplines selected. The model process involves integration based on learning styles and features eight phases of the learning cycle.

This integration phase consists of four phases. In the first phase, the basic interdisciplinary subject and concepts are determined. In the second phase, sub-subjects and concepts regarding these concepts are determined using the brainstorming method, and disciplines possibly related are listed. These disciplines should be selected from disciplines that can reveal the subject or concept in the best possible way. In the third phase, problem statements that serve to establish a connection between the selected disciplines are specified. It is necessary to integrate disciplines around the common problems specified. Therefore, this model provides the grounding from which problems can be examined through an interdisciplinary perspective and common skills can be developed. The skills

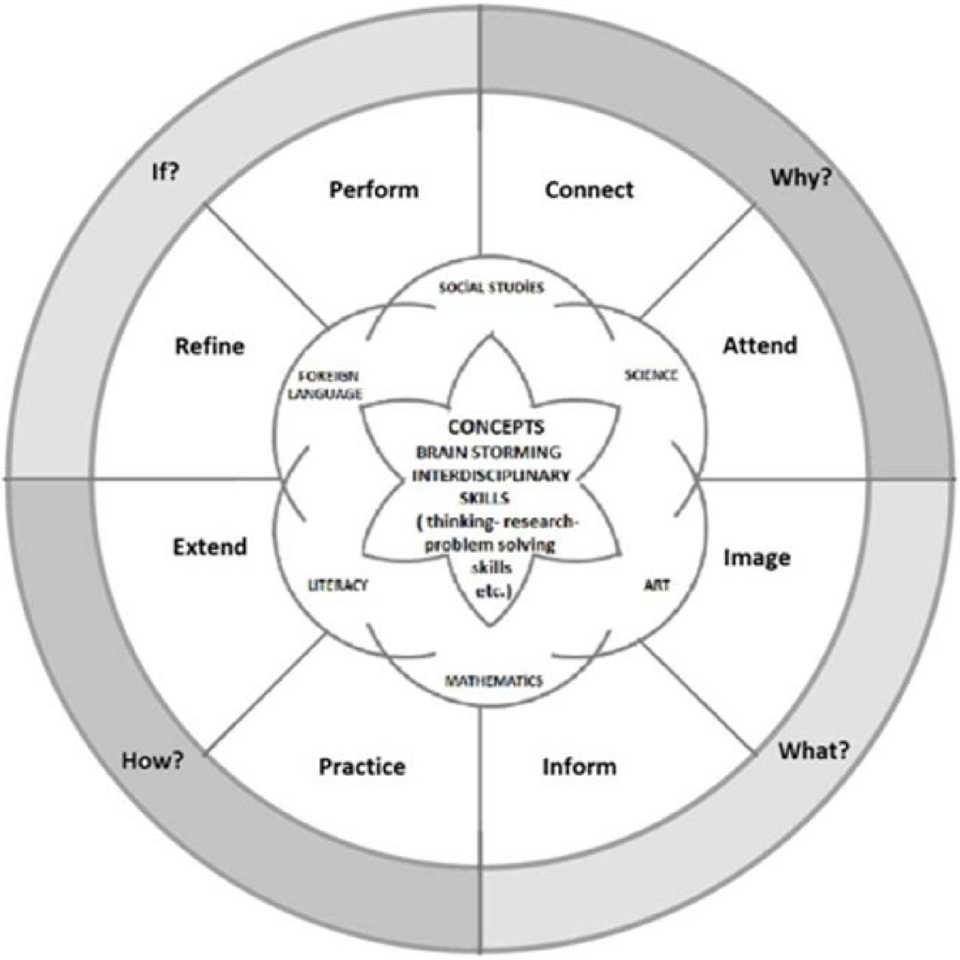


Figure 3. I4MAT Model

required by the 21st century and the specified interdisciplinary skills are handled using this perspective and then achieved with the 8-phase process of the 4MAT teaching model.

In this process, the learning environment is organized in such a way that students find answers to the questions of what, why, and if based on the characteristics of the learning styles. In activities and practices, it is important for students to discover concepts and to form the information on their own. The process is planned with problem situations, studies, projects and activities which enable improvement in the skills of problem solving, thinking (classification, interpreting, analyzing, synthesizing), communication, association, critical thinking, creativeness, cooperation, innovativeness, technology use and metacognition. Studies on the 4MAT teaching model and the interdisciplinary concept model (Blair & Judah, 1990; Nicoll-Senft & Seider, 2009; Repko, 2007) helped in the development of the proposed model. However, there is no model in the literature that integrates these two models. McGehee (2001) developed a disciplinary unit based on problem solving strategy in a long-term project. In this study, we developed a multi-disciplinary approach to mathematics education, based on the 4MAT system-based units and problem-solving steps. In his study parallel subject development in separate classrooms to humanities/mathematics/science teams united in one team/classroom, in which content is integrated through the actions of the problem-solving process In some studies, disciplinary units based on strategies have been developed. A number of studies have stated the difficulty of planning an interdisciplinary teaching process (Bromme, 2000; Capraro, & Jones 2013; Crow & Pounder 2000; Jacobs, 1989; Lattuca, 2006). The reason for this difficulty is that the process requires determining, evaluating, and eliminating the differences between the ways of comprehension involved in each discipline. For the continuation of the process, cognitive development should be ensured. However, cognitive development is not possible without integration or synthesis (Lattuca, 2001). The proposed I4MAT model enables the integration of interdisciplinary perceptions based on different perspectives by building a more comprehensive perspective. Thus, it aims to ensure cognitive development.

The I4MAT model offers a strong interdisciplinary model structure. Moreover, because it includes an integrated teaching approach, it enables information to be gained and assessed in an interdisciplinary environment. This feature gives the model its cognitive superiority over others. Results obtained in the testing of the model support this advantage claim.

It is well-known that teachers encounter different problems when applying interdisciplinary approaches, as planning an interdisciplinary process requires more than sharing the content (Schroth & Seitz, 1997). In general, there are problems in properly shaping the process due to the issues arising from the perspectives of the teachers on the interdisciplinary teaching process.

Jacobs (1989) defined two problems about this issue, the "Potpourri Problem" and the "Polarity Problem". The Potpourri Problem involves the tendency of teachers to turn an interdisciplinary unit into sample knowledge of each discipline. In other words, introducing a bit of mathematics, a bit of social studies, and a bit of history during the teaching of a course is perceived as interdisciplinary teaching. The Polarity Problem involves the issue of teachers being faced with the challenge of presenting the interdisciplinary nature of the subject without recourse to the content and practices dictated by the course book. Teachers are uncomfortable with having to develop the habit of considering disciplines outside of their own areas and with having to digress from the standard teaching methods and practices associated with their own field of discipline. It is here that the "Polarity Problem" emerges. To overcome these problems, teachers should be active curriculum designers. The interdisciplinary concept model also includes suggestions to address these problems. With its teaching design process, the I4MAT model offers a different perspective on these problems that teacher may encounter.

Teachers who have awareness of and are educated in interdisciplinary studies are necessary for the functionality of the model. Apart from its strong points, this model does include certain application difficulties that arise from its interdisciplinary structure. Ignoring these difficulties may reduce the effectiveness of this model. One of these difficulties is that the model requires teachers who are aware of the Potpourri Problem and the Polarity Problem, as this model rests on the interdisciplinary approach. In planning the teaching for the I4MAT model, it is important for teachers to work within the framework of the curriculum at the beginning of the education period. Therefore, it is necessary to create an environment in which teachers and school principals can work in close cooperation regarding timing and content (Schoch & Seitz, 1997). Moreover, teachers should have sufficient knowledge of and be well-prepared in interdisciplinary and student-centered approaches to perform effective I4MAT teaching. Despite these prerequisites, at the beginning of the education year, teachers must organize meetings and plan the curriculum with teachers who are working in their own areas of discipline. This situation may have negative effects on the planning and implementation of teaching designs and thereby lead to the emergence of Potpourri and Polarity Problems. Moreover, one of the most important criteria in creating teaching environments for the I4MAT model is that teachers working in different disciplines are not simply brought together in one teaching environment. Rather, these teachers should indicate the relationship of the concept associated with their discipline through dialogue that focuses on the concepts to be taught (Feng, 2012; Max-Neef, 2005). The school culture should be created in this way. Another problem that can be encountered is time constraints, as planning and assessing the process and content require thorough attention to detail, which demands that substantial amounts of time be devoted to doing this. To overcome these problems, interdisciplinary laboratories should be established in schools, and cooperative activities should be focused on time factors rather than on the teaching process to prevent unnecessary delays.

REFERENCES

Ahuja, O. P., & Jahangiri, J. M. (2003). An integrated approach to teaching and learning college mathematics. *Journal of the Korea Society of Mathematical Education Series D: Research in Mathematical Education*, *7*(11-24), 11-24. Retrieved from http://www.mathnet.or.kr/mathnet/kms_tex/980827.pdf

Altun, M. (2006). Matematik öğretiminde gelişmeler. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, *19*(2). Retrieved from http://dergipark.ulakbim.gov.tr/uefad/article/view/5000152340/5000138149

Altun, M. (2007). *Ortaöğretimde Matematik Öğretimi*. Alfa Akademi Publication: İstanbul.

Aşkar, P., & Akkoyunlu, B. (1993). Kolb öğrenme stili envanteri, *Education and Science*, *17*(87), 37-47. Retrieved from http://egitimvebilim.ted.org.tr/index.php/EB/article/view/5854

Ballone, L. M. (2001). Teachers' beliefs about accommodating students' learning styles in science classes. *Electronic Journal of Science Education*, *6*(2), 1-44. Retrieved on 5th Feb 2016 from http://eric.ed.gov/?id=ED463146

Beane, J. A. (2016). Curriculum integration: *Designing the core of democratic education*. Newyork, USA: Teachers College Press.

Becher, A. (1989). *Academic Tribes and Territories: intellectual enquiry and the cultures of disciplines.* Newyork, USA: The Society for Research into Higher Education and Open University Press.

Bıkmaz, F. (2001). Öğrenme biçimlerini (style) okula getirmede 4MAT sistemini kullanma. *Journal of Faculty of Educational Sciences (JFES), 34*(1-2), 105-115. Retrieved from http://dergiler.ankara.edu.tr/dergiler/40/135/942.pdf

Blair, D., & Judah, S. S. (1990). Need a Strong Foundation for an Interdisciplinary Program? Try 4MAT! *Educational Leadership*, *48* (2), 37-38. Retrieved from https://eric.ed.gov/?id=EJ416430

Bloom, B. S. (1998*). İnsan nitelikleri ve okulda öğrenme* (D. A. Özçelik, Trans.). Ankara, Turkey: Milli Eğitim Press.

Boix Mansilla, V. (2005). Assessing student work at disciplinary crossroads. *Change Magazine, 37*(1), 14-21. Retrieved from https://eric.ed.gov/?q=Assessing+student+work+at+disciplinary+crossroads&id=EJ710294

Bonk, C. J., & Zhang, K. (2006). Introducing the R2D2 model: Online learning for the diverse learners of this world. *Distance Education*, *27*(2), 249-264. https://doi.org/10.1080/01587910600789670

Brears, L., MacIntyre, B., & O'Sullivan, G. (2011). Preparing teachers for the 21st century using PBL as an integrating strategy in science and technology education. *Design and Technology Education: An International Journal*, *16*(1), 36-46. Retrieved from https://ojs.lboro.ac.uk/DATE/article/view/1588/1513

Bromme, R. (2000). Beyond one's own perspective: The psychology of cognitive interdisciplinarity. In P. Weingart & N. Stehr (Eds.), *Practising interdisciplinarity* (pp. 115-133). Toronto, Canada: University of Toronto Press.

Capraro, M. M., & Jones, M. (2013). Interdisciplinary STEM project-based learning (Eds: Capraro, Capraro& Morgan). In *STEM Project-Based Learning* (pp. 51-58). USA: Sense Publishers.

Chrysostomou, S. (2004). Interdisciplinary approaches in the new curriculum in Greece: a focus on music education, *Arts Education Policy Review*, *105*(5), 23-29. https://doi.org/10.3200/AEPR.105.5.23-30

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Crow, G. M., & Pounder, D. G. (2000). Interdisciplinary teacher teams: Context, design, and process. *Educational Administration Quarterly*, *36*(2), 216-254. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/0013161X00362004

Czerniak, C. M., & Johnson, C. C. (2014). *Interdisciplinary science teaching education*, Lederman & Abell (Eds.), 537-559. Handbook of Research on Science. Newyork, USA: Routledge.

Davis, S. A., & Knobloch, N. A. (2002). Transforming the curriculum for the 21st century. *The Agricultural Education Magazine*, *75*(3), 14.

Feng, L. (2012). Teacher and student responses to interdisciplinary aspects of sustainability education: what do we really know? *Environmental Education Research*, *18*(1), 31-43. https://doi.org/10.1080/13504622.2011.574209

Gülpinar, M. A. (2005). The principles of brain-based learning and constructivist models in education. *Educational Sciences: Theory & Practice*, *5*(2), 299-306. Retrieved from http://eds.b.ebscohost.com/eds/pdfviewer/pdfviewer?vid=1&sid=4b91a629-03b1-4f03-8c9b-bd8032cb744f%40sessionmgr120

Hotmanoğlu, Ç. (2014). *Sekizinci sınıf öğrencilerinin grafik çizme yorumlama ve grafikleri diğer gösterimlerle ilişkilendirme becerilerinin incelenmesi* (Unpublished Master Thesis). Karadeniz Teknik Üniversitesi, Eğitim Bilimleri Enstitüsü, Trabzon. Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Jacobs, H. H. (Ed.) (1989). *Interdisciplinary curriculum: design and implementation*. Alexandria, VA: Association for Supervision and Curriculum Development.

Jacobs, H. H., & Borland, J. H. (1986). The interdisciplinary concept model: theory and practice. *Gifted Child Quarterly*, *30*(4), 159-163. Retrieved from http://journals.sagepub.com/doi/pdf/10.1177/001698628603000403

Kegan, R. (1982). *The evolving self: problems and process in human development*. Cambridge, MA: Harvard University Press.

Kılıçoğlu, G., & Akhan, N. E. (2014). Sosyal Bilgiler Öğretmen Adaylarının Ekonomi Kavramlarını Anlama Düzeyleri. *Elektronik Sosyal Bilimler Dergisi*, *13*(51), 209-225. https://doi.org/10.17755/esosder.43846

Klein, J. T. (1990). *The Interdisciplinary Process* (Eds: Birnbaum, Rossini & Baldwin). Interdisciplinary Research. International research management: studies in interdisciplinary methods from business, government, and academia, 20-33. Newyork, USA: Oxford University Press.

Klein, J. T. (2002). *Interdisciplinary education in K-12 and college: A foundation for K-16 dialogue*. Newyork, USA: College Board Publications.

Kolb, D. A. (1984). *Experiential learning: experience as the source of learning and development*. NJ: Prentice Hall.

Lafer, S. (1996). *The interdisciplinary teacher's handbook: Integrated teaching across the curriculum*. Portsmouth, NH: Boynton/Cook.

Lattuca, L. R. (2001). *Creativity interdisciplinary: interdisciplinary research and teaching among college and university faculty*. Nashville, USA: Vanderbilt University Press.

Lattuca, L. R. (2006). The constructivist pedagogy we're looking for. *Journal & Mass Communication Educator*, *60*(4), 354-458. https://doi.org/10.1177/107769580506000404

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology*, *28*, 563–575. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.460.9380&rep=rep1&type=pdf

Lee, G. H., & Lee, S. J. (2013). A study on the relationship between learning styles of students and academic achievement in mathematics-Focusing on freshmen enrolled in a college of science and engineering of the medium-sized university. *Communications of Mathematical Education*, *27*(4), 473-486. https://doi.org/10.7468/jksmee.2013.27.4.473

Leinhardt, G., Zaslavsky, O., & Stein, M. K. (1990). Functions, graphs, and graphing: Tasks, learning, and teaching. *Review of educational research*, *60*(1), 1-64. Retrieved from http://journals.sagepub.com/doi/pdf/10.3102/00346543060001001

Max-Neef, M. (2005). Foundations of transdisciplinarity. *Ecological Economics*, *52*(1), 5–16. https://doi.org/10.1016/j.ecolecon.2005.01.014

McCarthy, B. (1987). What 4MAT training teaches us about staff development? *Educational Leadership*, *42*(7), 6I-68. Retrieved from https://eric.ed.gov/?id=EJ319802

McCarthy, B. (2000a). *About Learning*, Chicago, USA: About Teaching, Inc.

McCarthy, B. (2000b). *About teaching: 4MAT in the classroom*. Wauconda, IL: About Teaching, Inc.

McCharthy, B., & McCharthy, D. (2003). *About teaching, companion the 4MAT implementation workbook*. Chicago, USA: About Teaching, Inc.

McGehee, J. J. (2001). Developing interdisciplinary units: A strategy based on problem solving. *School Science and Mathematics*, *101*(7), 380-389. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1949-8594.2001.tb17972.x/epdf

McManus, D. A. (2001). The Two Paradigms of Education and the Peer Review of Teaching. *Journal of Geoscience Education*, *49*, 423-434. Retrieved from https://eric.ed.gov/?id=EJ641994

Merrill, M. D. (2001). Components of instruction toward a theoretical tool for instructional design. *Instructional Science*, *29*(4), 291-310. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.613.4913&rep=rep1&type=pdf

Ministry of National Education. (2015a). *T.C. Millî Eğitim Bakanlığı Talim Terbiye Kurulu Başkanlığı İlkokul Matematik Dersi (1, 2, 3 ve 4. Sınıflar) Öğretim Programı*. Ankara.

Ministry of National Education. (2015b). *İlköğretim Sosyal Bilgiler Dersi 4. Sınıf Öğretim Program ıve Kılavuzu*. Ankara.

National Council for the Social Studies. (2010). National Curriculum Standards for Social Studies: A Framework for Teaching, Learning, and Assessment. Reston VA: National Council for the Social Studies

National Council of Teachers of Mathematics (2000). Principles and standards for school Mathematics, Reston VA: National Council of Teachers of Mathematics.

Nicoll-Senft, J. M., & Seider, S. N. (2009). Assessing the impact of the 4MAT teaching model across multiple disciplines in higher education. *College Teaching*, *58*(1), 19-27. Retrieved from https://eric.ed.gov/?id=EJ872051

Nowacki, A. S. (2011). Using the 4MAT framework to design a problem-based learning biostatistics course. *Journal of Statistics Education*, *19*(3), 1-24. Retrieved from https://eric.ed.gov/?id=EJ961845

Özgen, K. (2013). An analysis of high school students' mathematical literacy self-efficacy beliefs in relation to their learning styles. *The Asia-Pacific Education Researcher*, *22*(1), 91-100. Retrieved from https://link.springer.com/content/pdf/10.1007%2Fs40299-012-0030-4.pdf

Özgen, K., & Alkan, H. (2012). The relationship between secondary school pre-service mathematics teachers' skills in problem solving dimensions and their learning style characteristics. *Educational Sciences: Theory & Practice*, *12*(2), 1173-1181. Retrieved from https://eric.ed.gov/?id=EJ981835

Parker, J. (2002). A New Disciplinarity: communities of knowledge, learning and practice. *Teaching in Higher Education*, 7(4), 373-386. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/135625102760553883

Peker, M. (2003). *Investigate the effects of 4MAT instructional system on students' achievement and their attitudes* (Doctoral dissertation). Ankara: Faculty of Ankara: Faculty of Education University of Gazi. Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/

Pruekpramool, C. (2011). *The development of the science of sound in traditional Thai musical instruments interdisciplinary course for non-science upper secondary school students by using integrated teaching approach* (Doctoral dissertation). Srinakharinwirot University. Retrieved from http://thesis.swu.ac.th/swudis/Sci_Ed/Chaninan_P.pdf

Repko, A. (2007). Integrating interdisciplinarity: How the theories of common ground and cognitive interdisciplinarity are informing the debate on interdisciplinary integration. *Issues in Interdisciplinary Studies*. 25, 1-31. Retrieved from https://our.oakland.edu/handle/10323/4501

Rosenfield, P. L. (1992). The potential of transdisciplinary research for sustaining and extending linkages between the health and social sciences. *Soc Sci Med*, *35*, 1343-1357. https://doi.org/10.1016/0277-9536(92)90038-R

Schoch, E., & Seitz, H. (1997). Interdisziplinärer unterricht-anspruch und wirklichkeit. 25 Jahre IWP. Schule in Wissenschaft, Politik und Praxis, Dubs, R. und Luzi R. (Hrsg.), 633-645, Germany, St. Gallen: İnstitut für Wirthschaftspadagogik.

Tchudi, S., & Lafer, S. (1996). *The interdisciplinary teacher's handbook: Integrated teaching across the curriculum*. Portsmouth, NH: Boyntod Cook.

Thomas, A. M. (2015). *Effectiveness of 4MAT system of instructional design on learning styles, hemispheric preferences and achievement in physics of students at secondary level*. Doctoral dissertation. Kerala: School of Pedagogical Sciences Mahatma Gandhi University Kottayam. Retrieved from http://www.mgutheses.in/page/?q=T%202644&search=&page=&rad=

Veneziano, L., & Hooper, J. (1997). A method for quantifying content validity of health related questionnaires. *American Journal of Health Behavior, 21*(1), 67-70

Yıldırım, A. (1996). Disiplinlerarası öğretim kavramı ve programlar açısından doğurduğu sonuçlar. *Hacettepe University Journal of Education, 12*, 89–94. Retrieved from http://www.efdergi.hacettepe.edu.tr/yonetim/icerik/makaleler/1270-published.pdf

Yurdugül, H. (2005). Davranış bilimlerinde ölçek geliştirme çalışmaları için bazı ayrıntılar. Retrieved from http://s3.amazonaws.com/academia.edu.documents/36401469/FA_OrneklemGenislikleri.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1486641699&Signature=ORyZWokPThORgJUOP2QpAXvAt08%3D&response-content-disposition=inline%3B%20filename%3DFA_Orneklem_Genislikleri.pdf

Yurt, E., Aydin, M., & Sahin, I. (2015). Assessing uses of motivated strategies by middle school students based on their learning styles. *Hrvatskičasopiszaodgojiobrazovanje*, *17*, 117-149. https://doi.org/10.15516/cje.v17i0.1009

ANNEX 1

Table 1. Activities of "Pass the File to the Other Group"

Pictures of File 1

Pictures of File 2

Pictures of File 3

Pictures of File 4

Table 2. The production rates of the hazelnuts grown by the years in Turkey

Year	2010	2011	2012	2013	2014	2015
Ton	600	430	660	550	400	580

Table 3. The consumption rates of the hazelnuts grown by the years in Turkey

Year	2010	2011	2012	2013	2014	2015
Ton	400	250	500	350	280	420

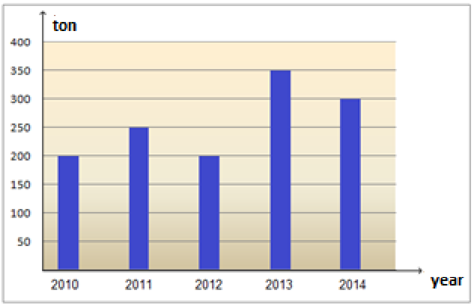
ANNEX 2

Study Worksheet

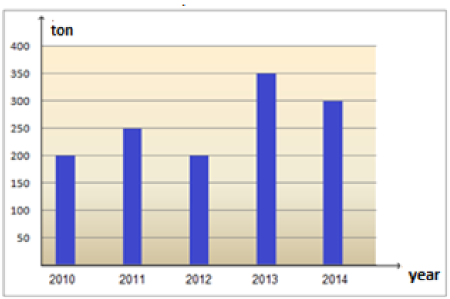
The Mediterranean Region is one of the places where the most amount of corn is grown. The province of Osmaniye in this region is an important production area that contributes to the total production. The municipality of Osmaniye wishes to make the whole country aware of their important contribution to corn production, so they decided to organize a festival. On the poster for the corn festival, they show in graphs the production and consumption rates of the corn grown in Osmaniye in the past five years.

Emre lives in Osmaniye. He saw this poster on the bulletin board in school and thought he could use it in a project called the adventure of corn that he would prepare with his friends about the production, delivery and consumption circle of corn. So he decided to show the graphs on the poster to his friends and prepare questions similar to those his mathematics teacher asked while teaching about bar graphs. Answer Emre's questions with the help of the graphs.

Graphic: the production rates of the corn grown by the years



Graphic the consumption rates of the corn grown by the years



1. In which year was the highest amount of corn grown in Osmaniye? How many tons of corn were produced?
2. In which year or years was the least amount of corn produced in Osmaniye? How many tons of corn were produced in that years?
3. How many tons of corn were produced in Osmaniye in the past five years?
4. In which year was the most amount of corn consumed? How many tons of corn were consumed?
5. In which year was the least amount of corn consumed? How many tons of corn were consumed?
6. How many tons of corn were consumed in the past five years? Then two graphs are compared.
7. In which years were people not able to consume all the corn?
8. In which years was corn production was not sufficient for corn consumption? Why?

http://www.ejmste.com