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HOW IS A SCIENCE LESSON DEVELOPED AND IMPLEMENTED BASED ON MULTIPLE INTELLIGENCES THEORY?

ÇOKLU ZEKA KURAMINA DAYALI BİR FEN BİLGİSİ DERSİ NASIL GELİŞTİRİLİR VE UYGULANIR?

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ABSTRACT: The purpose of this study is to present the whole process step-by-step of how a science lesson can be planned and implemented based on Multiple Intelligences (MI) theory. First, it provides the potential of the MI theory for science teaching and learning. Then an MI science lesson that was developed based on a modified model in the literature and implemented in an 8th grade classroom is given as a concrete example in order to help preservice and inservice science teachers to create bridges from the theoretical framework of the MI theory into classroom practice. This study uncovers that there are four important factors affecting how MI science lessons are planned and carried out. They are: (1) identifying individual students' multiple intelligences or strengths via a reliable and valid tool, (2) paying attention to the literature findings related to students' difficulties in learning the relevant science topic, (3) considering the nature of the knowledge structure that students are supposed to learn with respect to the MI, and (4) examining teacher's ability to manage the MI activity.
Keywords: multiple intelligences theory, science education, multiple intelligences science lesson.

ÖZET: Bu çalışmanın amacı, Çoklu Zeka Kuramına dayalı bir fen bilgisi dersinin nasıl planlanabileceği ve uygulanabileceğiyle ilgili tüm süreci adım adım sunmaktır. Çalışmada, öncelikle Çoklu Zeka Kuramının fen öğretimi ve öğrenimi açısından sahip olduğu potansiyel sunulmaktadır. Daha sonra, literatüre dayalı geliştirilmiş ve ilköğretim 8. sınıfta uygulanmış Çoklu Zeka Kuramına dayalı bir fen bilgisi dersi, fen bilgisi öğretmen adayı ve öğretmenlerine Çoklu Zeka Kuramını teoriden sınıf içi pratiğe dönüştürmede yardımcı olmak amacıyla somut bir örnek olarak verilmektedir. Bu çalışma, çoklu zeka fen bilgisi derslerinin nasıl planlanacağı ve uygulanacağı ile ilgili dört önemli faktör açığa çıkarmıştır. Bu faktörler, (1) güvenilir ve geçerli bir ölçme aracı ile öğrencierin çoklu zekalarını belirlemek, (2) ilgili fen konusunda literatürde bulunan öğrencilerin öğrenme sorunlarına dikkat etmek, (3) öğrencilerin öğrenmesi amaçlanan bilgi yapısını çoklu zekalar açısından dikkate almak, ve (4) öğretmenin çoklu zeka aktivitesini sınıf içinde uygulama kabiliyetini sınamasıdır.
Anahtar sözcükler: çoklu zeka kuramı, fen eğitimi, çoklu zeka fen bilgisi dersi

1. INTRODUCTION

Gardner, through his research, offers a different viewpoint on the nature of intelligence. To arrive at the Multiple Intelligences theory, Gardner studied stroke victims suffering from aphasia at the Boston University Aphasia Research Center and worked with children at Harvard's Project Zero, a laboratory designed to study the cognitive development of children (Gardner, 1999a). Working with the two groups of children in two different contexts led Gardner to believe "that the human mind is better thought of as a series of relatively separate faculties, with only loose and nonpredictable relations with one another, than as a single, all-purpose machine that performs steadily at a certain horsepower, independent of content and context" (p.32). This succinct statement embodies the theory of Multiple Intelligences. This means individual faculties or frames within the human mind can be associated with a particular intelligence, the verbal-linguistic, logical-mathematical, musical, spatial-visual, bodily-kinesthetic, interpersonal, intrapersonal, and naturalistic. Without stripping cultural values, Gardner examined the individual's growth and developmental patterns for each intelligence. He connected multiple intelligences to the works of Jean Piaget (logical-mathematical and spatial-visual intelligences), Erik Erikson (development of personal intelligences), and Lev Vygotsky (developmental models of linguistic intelligence and interpersonal intelligence). Thus, to understand multiple intelligences, Gardner synthesized the extant literature from multidisciplines. MI theory is derived from the biological or neurosciences (brain development and organization), evolution, logical analysis, developmental psychology, experimental psychology, and psychometrics. Since Gardner's

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book of *Frames of Mind: The Theory of Multiple Intelligences,* Gardner's view of intelligence is rapidly being incorporated in many school curricula to redesign the way it educates students around the world. Many educators have become interested in the theory, the numerous journal articles (Campbell, 1997; Checkley, 1997; Daniel, 1997; Eisner, 2004; Gardner, 1997; Hoerr, 2004; Goodnough, 2001a,b) and books have been published about the theory (Armstrong, 1994, 2000; Campbell, Campbell, & Dickinson, 1996; Gardner, 1983, 1985, 1993, Lazear, 1992; Talu, 1999).

The MI popularity blows one's mind! However, the literature findings reveal the following questions: Where does MI stand in connection with science education research? and Why such a popular theory has not gained much ground in science education research? because there have been only two science education MI research studies (i.e., Goodnough, 2001a,b) that have been published in international journals of science education so far. The editors of the *School Science and Mathematics* that has been published continuously since 1901 shed light on this issue (Flick & Lederman, 2003). Flick and Lederman (2003) highlighted why the MI theory garner so much attention in education. They state "Teachers we encounter in workshops and master's courses are more likely to recognize references to 'multiple intelligences' than they are to recognize references to 'learning cycle' in science education or 'cognitively guided instruction' in math education." (p. 117). According to Flick and Lederman (2003), the most important educational problem that is particularly serious in teaching science and math is how science and mathematics can be taught based on individual students' abilities or multiple intelligences. The editors also observe that the discussion and application of the MI theory by teachers are at best superficial. For instance, some followers use the term MI but do not understand the fundamental principles of the theory. There are some teachers who know the principles of the theory, but do not know how the principles and the associated empirical evidence resolve a particular educational problem in classrooms. Flick and Lederman (2003) described the MI theory as a popular theory but unpopular research as shown in the title of their editorial letter: "Popular Theories-Unpopular Research". They also argue that we as researchers must learn to help teachers to strike a balance and develop educational theories that teachers consider important.

MI research in science education is just beginning to emerge, and active research should be pursued by teachers, educators and researchers. To achieve this goal, teachers of science should first understand how a specific objective of science can be taught using the MI theory. Therefore, this study is timely an example to show science classroom teachers, educators and researchers how an MI science lesson can be planned and implemented in a middle school classroom involving the topic of particulate nature of matter.

1.1. The Potential of Multiple Intelligences Theory for Science Teaching and Learning

MI theory is derived from the biological or neurosciences (brain development and organization), evolution, logical analysis, developmental psychology, experimental psychology, and psychometrics (Gardner, 1983). Thus, the MI theory has the potential to make science accessible to all students because it acknowledges each student's unique cognitive profile (Gardner, 1995). Recent calls in the current science education reform documents (e.g., American Association for the Advancement of Science, 1993; National Research Council [NRC], 1996) either implicitly or explicitly emphasized the need for science to be accessible to all students, and personalized or individualized learning experiences are vital for this goal. Thus, if the aim is to improve science learning through the learning experiences for all learners, the MI teaching approach can be used to meet this goal by matching teaching to the ways students can learn science because it offers teachers a framework with which to make pedagogical decisions that can foster individualized learning in science using students' multiple intelligences or abilities. Moreover, if we believe in the concept of "science for every child", then we need to decide on teaching approaches focusing on the individual abilities, needs and interests of the learner.

A wide variety of MI teaching strategies are matched with abilities of students so that they are engaged in science (Akamca & Hamurcu, 2005; Goodnough, 2001a,b). For example, learning activities such as role plays, drawings, science stories, singing a song, individual investigations, and writing essays, not common to science education, enable students to contextualize learning in terms of their own strengths or multiple intelligences. Within these learning activities, students are able to freely speak out their ideas, do hands-on laboratory experiments, make strong positive relationships with classmates in both small and large groups, do exciting homework assignments, and use their individual MI portfolios for feedback on their learning (Armstrong, 1994, 2000; Azar et al., 2005; Campbell et al., 1996; Daniel, 1997; Ebenezer & Haggerty, 1999; Goodnough, 2001a,b; Kaya, 2006; Kaya & Ebenezer, 2003, 2006; Kaya et al., 2007; Tuğrul & Duran, 2003). Such qualities of teaching and learning couched in MI theory no doubt will improve students' conceptual understanding and achievement, and affective dispositions (e.g., attitudes toward science) in science and contrast sharply with traditional teaching. In the traditional science classroom, teaching "scientific facts" and accompanying problems from textbooks taps into the verbal and mathematical intelligences. Unfortunately, students who are weak in verbal-linguistic and logical-mathematical intelligences are disadvantaged in school when the focus is on teacher lectures and notes, and questions on the assigned readings or handouts in school. Many studies suggest that traditional teaching practices do not promote achievement in and attitudes toward science of even those students who are strong in verbal-linguistic and logical-mathematical intelligences (Ebenezer & Zoller, 1993a). In comparison, the MI teaching approach that combines intelligences in creative ways to address the uniqueness of individual learners (Armstrong, 1994, 2000), may promote students' achievement and affective dispositions in science.

2. METHODS

2.1. Sample and Procedure

Participants were from 8th grade in a public elementary school in Ankara, the capital city of Turkey. There are three 8th grade classes in the school, and one of these classes was randomly selected for this study. Participating group of students consisted of 25 students (13 boys and 12 girls), The population of students (ages 13 – 14) was from low and middle socio-economic status homes. They generally learned science with traditional teaching methods before this study.

A science teacher who held a master's degree in science education and had 6 years of experience teaching the subject taught the class. Listening to the lecture on the theoretical and practical orientations of the MI theory given by the researcher, a science teacher in the audience showed keen interest in practicing a science lesson designed based on the MI theory. The appeal for MI theory is captured in his own comments, "*MI teaching approach is very different from the teaching way that I have been using in my classes. We need to individually consider each student's intelligences profile to be able to teach science them better. The traditional teaching style leaves most children intellectually malnourished thus depriving children from having equal opportunities to participate in high quality science education. Through the MI theory, I believe that I can find many ways to teach science my students...*" The teacher participating in this study was trained for 12 hours by the researcher to standardize the administrative procedures and the implementation of the treatment. In these training sessions, it was focused on the following topics: (1) the story of development of MI theory, (2) theoretical background about the theory, (2) change in education through the MI theory, (3) designing a science lesson based on the MI theory, and (4) implementing a science lesson based on the MI theory. The selected science unit was matter and energy. The teacher wanted to start teaching the science unit to his students starting from atomic structure and properties. Other science topics that the students learned were chemical and physical changes in matter, chemical reactions, and acids and bases. This study was over an 8-week period during the 2004-2005 academic year, and the science class were held three times each week according to the school timetable.

In this research, a case study, how a science lesson was planned and practiced in an 8th grade classroom was qualitatively explained. Immediately during and/or after MI science lessons, the researcher, who is the author of this article, jotted in his daily log his observations and reflections of student actions, teacher-student and student-student interactions, and specific experiences in the MI science class. These thoughtful entries, obtained from the research-based classroom, illuminated how the MI science lessons can be developed and implemented.

2.1.1. Instrument

In order to determine each student's intelligences profile, Multiple Intelligences Development Assessment Scales (MIDAS) (Shearer, 1994) was used in this study. This survey[1] was translated and adapted into Turkish by the researcher, accompanied by six experienced elementary teachers and one expert on Turkish language. All teachers had expert knowledge and experience on the implementation of MI theory in their classrooms. After the translation of the survey into Turkish was completed, these teachers teaching students in grades 2 to 8 individually examined the survey items and choices. The researcher obtained very useful comments and feedback from the teachers on the survey. The seven experts were asked to write their notes as narrative to make the survey items and related choices more understandable by regarding the level of their students' reading comprehension. All of the teachers stated how to make the items that they criticize better. These comments and feedback of the teachers on the survey items, including the related corrections, were distributed to all of them. As a result, the final survey incorporated the necessary revisions that the teachers pointed out in their narratives. This survey consists of 93 items. Cronbach's alpha reliability coefficient of the MIDAS was found 0.81.

One example of the MIDAS survey from each intelligence area is below.

Musical-Rhythmic Intelligence
3. Do you think you could be a really good musician or singer if you tried?
A) I don't think so, probably not
B) Maybe a little bit
C) I could be fairly good
D) I could be a good musician
E) I could be a great musician
F) I don't know

Bodily-Kinesthetic Intelligence
16. How well can you use your hands to sew, cut with scissors, or put small things together?
A) Not very well or just fair
B) Well
C) Very well
D) Excellent
E) The best
F) I don't know

Logical-Mathematical Intelligence
27. Do you often try to figure out why and how things work?
A) Every once in a while
B) Sometimes
C) Many times
D) Almost all the time
E) All the time
F) I don't know

Visual-Spatial Intelligence
31. Do you like to decorate your room with pictures or posters, drawings, etc.?
A) Not very much
B) Sometimes
C) Many times
D) Almost all the time
E) All the time
F) I don't know or I haven't had the chance

Verbal-Linguistic Intelligence
51. How well can you write a note or letter to someone?
A) Not very well
B) Fairly well
C) Well
D) Very well
E) Excellent
F) I don't know

Interpersonal Intelligence
54. Do you ever offer to help people around the house or in school?
A) Every once in a while
B) Sometimes
C) Many times
D) Almost all the time
E) All the time
F) I don't know

Intrapersonal Intelligence
72. Do you work well on your own?
A) Not very well
B) Fairly
C) Well
D) Very well
E) Excellent
F) I don't know

Naturalist Intelligence
86. Are you ever curious about nature and look for animals in the woods, collect plants, bugs or other things?
A) Never or rarely
B) Every once in a while
C) Sometimes
D) Often
E) Almost all of the time
F) I don't know

[1] The survey may be obtained, upon request, by writing to the author.

2.2. Developing and Implementing an MI Science Lesson

In many publications, the MI initiatives mostly provide examples of the lesson plans in various school subjects such as science, mathematics and social studies rather than presenting the process of how an MI lesson can be planned and conducted. However, in the literature, there are three models about how an MI lesson can be developed and implemented. These models, proposed by Armstrong (1994, 2000), Campbell, Campbell and Dickinson (1996) and Lazear (1992), help teachers to create bridges from the theoretical framework of the MI theory into classroom practice, making the theory easily understandable and applicable to classroom teachers at the practical level. The Armstrong's model focuses on how a specific educational objective can be taught using the MI theory, while two other models deal with how a whole unit or lesson can be taught using the MI theory.

In this study, a modified version of the Armstrong's (1994, 2000) seven-step procedure was used for creating the MI lesson sequence because of the reasons described below. This seven-step procedure consists of (1) focusing on a specific objective, (2) asking key MI questions, (3) considering possibilities, (4) brainstorming, (5) selecting appropriate activities, (6) setting up a sequential plan, and (7) implementing the plan (Armstrong, 1994). The first six steps consist of designing a lesson plan and the seventh step focuses on implementing the plan. The development and the implementation of the MI lesson plan using the chemical objective, determining the size of an atom will be illustrated.

2.2.1. The First Effort in the MI Class

For many educators, "Multiple intelligences" means how a teacher can arrange learning activities regarding the individual abilities of all students in a classroom. Thus, there is a need to know differences and similarities among abilities, needs, and interests of individual students in the same classroom (Haley, 2004). Accordingly, in this study, the first attempt was to identify each student's intelligence profile using Multiple Intelligences Development Assessment Scales (MIDAS) (Shearer, 1994) before the research began. The MIDAS, providing a rich and descriptive understanding of a person's multiple intelligences profile, is a research based self-report measure of intellectual disposition for people of all ages. In this study, the MIDAS for KIDS**:** All About Me (for students in grades 4-8, or ages 10-14) was used. The MIDAS is different from most MI tests. It is a research based self-report with a proven track record of producing a valid and reliable profile that can inspire, motivate and maximize achievement. According to Gardner, the MIDAS represents the first effort to measure the Multiple Intelligences, which have been developed according to standard psychometric procedures (Shearer, 2007).

The critical information of each student's abilities obtained from the MIDAS was efficiently used for not only developing but also implementing MI teaching activities in this study. For example, a student who was strong in spatial-visual, interpersonal and logical-mathematical intelligences was mostly engaged in spatial-visual, interpersonal and logical-mathematical activities during MI science lessons. However, the same student who was weak in bodily-kinesthetic and verbal-linguistic intelligences was also encouraged to participate in bodily-kinesthetic and verbal-linguistic activities. In other words, students learned the unit of particulate nature of matter using their strengths, while they were also involved in MI activities in which they are weak in order to strengthen their intelligences.

2.2.2. Focusing on a Specific Objective

The objective related to the determination of the size of an atom was to teach students to think about measuring the space in which the electrons move relatively to the nucleus of atom.

2.2.3. Asking Key MI Questions

Asking key MI questions based on the determination of the size of the atom helped the researcher look at the possibilities for involving as many intelligences as possible: What follows is a description of each intelligence, and the related key MI questions. This thinking procedure was followed to consider possible activities and to select the most useful one.

Verbal-linguistic intelligence is the ability to use language effectively to express one self, both written and oral. How can we use the spoken or written word?

Logical-mathematical intelligence is the ability to think conceptually and abstractly and capacity to discern logical or numerical patterns. How can we use numbers, calculations, and logic games?

Spatial-visual intelligence is the ability to perceive and visualize the spatial-visual world accurately and using the images to solve problems. How can we use graphs, figures, 3-D drawings and visual awareness activities?

Bodily-kinesthetic intelligence is the ability to use both the whole body and the hands to manipulate objects and materials and to express ideas and emotions. How can we involve the whole body or hands-on experiences?

Musical-rhythmic intelligence is the ability to interpret, discriminate, and express musical forms. How can we use singing, and rhythms?

Interpersonal intelligence is the ability to detect and respond appropriately to the needs emotions and desires of others. How can we engage students in peer sharing and cooperative learning?

Intrapersonal intelligence is the ability to be aware of realistic knowledge of one's feelings, values, beliefs, needs and thinking processes along with capacity for self-discipline. How can we use individual projects, and writings related to personal feelings?

Naturalist intelligence is the ability to readily recognize and categorize plants, animals, and other objects in nature, and using analogies from nature to envision problems and solutions. How can we use the characteristics of the natural world?

2.2.4. Considering Possibilities

Eight possible MI activities described below that can be used to help students understand how to determine the size of the atom. It should be noted that more than one activity in each intelligence can be developed.

Verbal-linguistic intelligence, Write a paragraph describing how the size of atoms may be determined. Students may revise their initial writing after peer sharing and carrying out interpretive discussion.

Logical-mathematical intelligence, Calculate the size of several atoms by using the ratio of the diameter of the nucleus and the diameter of atom. For the hydrogen atom, the ratio of nuclear diameter to atomic diameter is approximately $1:10^5$.

Spatial-visual intelligence, Compare a marble with the schoolyard, a tennis ball with the school district, and a soccer ball with the city. In this activity, the marble, tennis ball, and soccer ball represent the nucleus of different atoms. The schoolyard, school district, and city represent the space in which the electrons move.

Bodily-kinesthetic intelligence, Swirl the tennis balls around your head to illustrate how the electrons move in space around the nucleus. The tennis balls illustrate the electrons and the head represents the nucleus.

Musical-rhythmic intelligence, Compose a song to express your understanding about the determination of the size of atoms:

Protons and neutrons in nucleus

Electrons move around nucleus

Nucleus is too small

Space of movement of electrons is too large

So, imagine or think the space of movement of electrons.

Interpersonal intelligence, Prepare posters in the small groups (3-4) with scientific questions, writings, and drawings concerning the determination of the size of atoms. Display your posters on the class wall and present your understandings to your peers.

Intrapersonal intelligence, Prepare and present an individual speech concerning the determination of the size of atoms. Then write down important notes from each speech as feedback. Respond in writing to the feedback by your peer.

Naturalist intelligence, Draw an analogy to find the ratio between the seed (nucleus) and the fruit (space of movement of the electrons), which contains one seed.

2.2.5. Brainstorming

An MI planning activity sheet containing the foregoing MI activities was first prepared. This activity sheet was shared with MI theory and science education experts who had first the MIDAS results of the students in the science classroom. Based on the possible activities cited on the worksheet, the experts then brainstormed for the most suitable activity for teaching students to determine of the size of an atom. The same procedure was carried out for all of the learning objectives involving the particulate nature of matter for the remaining science lessons.

2.2.6. Selecting Appropriate Activities

All five colleagues (one MI experts, two science teachers, two professors of science education) gave the researcher fruitful feedback about the appropriateness of all MI activities involving the particulate nature of matter, including the determination of the size of an atom. For example, most of them said that because this objective was on the size of an atom based on the spatial perception, a spatial-visual activity was better than the other MI activities. As a result, the focus was on how the spatial-visual activity was designed to demonstrate how to imaginatively determine the size of the atom.

In this activity, importance was given to student-centered learning, which consisted of active participation, identifying students' preconceptions and the reasons of their conceptions. The reasons for selecting the spatial-visual activity as opposed to all other MI activities are as follows:

- The MIDAS results showed that more than half of the students (N=14) in the class are strong in the spatial-visual intelligence, and the remaining students (8) who are strong in verbal-linguistic and logical-mathematical intelligences can be engaged in this activity when they express their ideas and discuss with their classmates.
- Students can be taken to the schoolyard so that they will be able to imagine the vastness of the space between the nucleus (marble) and the immediate surrounding.
- Students' writings, posters, swirling the tennis balls around his/her head to illustrate how the electrons move in space around the nucleus, students' songs, individual speeches and writings, calculation of the size of several atoms by using numbers have some limits with respect to the realistic estimation of the ratio between the diameter of the nucleus and the diameter of space in which the electrons move. For example, when a student shows the nucleus as a point (1 mm diameter), the students must have a very big paper (100 m diameter) for representing the realistic estimation. And when students swirl the tennis balls in their hands around the head to illustrate how the electrons move in space around the nucleus, the space in which their arms swirl is only 1-2 m. Also, understanding and imagining the ratio ($1: 10^5$) between the diameter of the nucleus and atomic diameter by means of calculations is very difficult at this age level.
- Also, many textbook drawings and models of atoms give rise to alternative conceptions related to the size of atoms. And drawing a proper scale for the size of an atom in the science books is impossible. Because, for a hydrogen atom, the ratio of nucleus

diameter to atomic diameter is approximately $1:10^5$. For a nucleus 2 cm in diameter in the science book, electrons should extend to about 2000 m. This is a conflict even for high school science students (e.g., Harrison & Treagust, 1996).

- The teacher also thought that he could manage better the spatial-visual activity than other MI activities to teach his students determining the size of an atom.

2.2.7. Setting up a Sequential Plan

The first six lessons were devoted to the introduction of matter, properties of matter, compound, mixture, element, and introduction of the atom. Subsequent lessons were devoted to specific subtopics related to the atoms such as atomic structure, size of atoms, weight of atoms, motions of atoms, and space among atoms during phase changes. Each lesson had a sequence of 3-4 knowledge structures. For example, in the lesson devoted to the size of atoms, the knowledge structures consisted of the following:

- An individual atom is incredibly small. It cannot be seen even under the most powerful microscope.
- The size of an atom is determined primarily by the space in which the electrons move relatively to its nucleus.
- Different kinds of atoms have different size.

2.2.8. Implementing the Lesson Plan

For revealing students' preconceptions and reasons related to determining the size of an atom, the diagnostic questions were prepared. Keeping these questions in mind, the following activity was done to explore students' ideas and then to teach the objective concerning the determining the size of an atom. Students were taken to the schoolyard. The marble was rolled. Students were asked: If an atomic nucleus was as large as this marble (0.5 cm diameter), what do you think about the size of atom? Ninety-two percent of the students expressed that the size of the atom with the nucleus, which is the marble is 3-5 cm. Next the tennis ball was rolled. Students were asked: If an atomic nucleus was as large as this tennis ball (5 cm diameter), what do you think about the size of atom? Eighty-eight percent of the students pointed out that the size of the atom with the nucleus, which is the tennis ball, is 25-50 cm. The soccer ball was rolled. Students were asked: If an atomic nucleus was as large as this soccer ball (25 cm diameter), what do you think about the size of atom? Ninety-six percent of the students said that the size of the atom with the nucleus, which is the soccer ball, is 150-300 cm. No student provided a realistic estimation of the size of the atom to the nucleus with respect to the marble, tennis ball, and soccer ball.

The teacher also wanted to know "What determines the size of an atom?" eighty percent of the students said that proton, neutron, and electron determine the atomic size. Curious to know which one of these particles determined the atomic size, students were asked: "Which particle(s) is the most important for deciding the atomic size?" Forty percent (n=10) of the students (n=25) answered the foregoing question correctly by stating that the number of electrons is the most important criterion for the atomic size. Forty-eight percent (n=12) of the students (n=25) said that the proton determined the atomic size. Of the 12 students who answered that the proton determines the atomic size, 83% offered an explanation: "Because of its positive charge we must know the number of protons for deciding the atomic size." Twelve percent (n=3) of the students (n=25) did not answer. Because students did not focus on the neutron they were asked: "Why the neutron is not important for deciding the atomic size?" Sixty-four percent (n=16) of the students (n=25) expressed that the atomic size does not depend on the number of neutrons because they do not have any charge.

Students who subscribed to the notion of the number of electrons were asked: "Why do you think that the number of electrons is the most important for the atomic size?" seventy percent (n=7) of the 10 students said that the size of objects was dependent on the area covering the space. The nucleus of the atom is in the center of the atom, but their electrons move around the nucleus, and so, the space in which the electrons move is the most important for determining the size of an atom. The students were also asked: "What do you think about your classmates' responses?" Many students agreed with the last idea described above.

After students explained their ideas of the atomic size, students were given the example of the marble (0.5 cm diameter) and the space (500 m) in which the electrons move around. The size (500 m) is nearly the size of schoolyard. According to this example, they were asked to imagine the ratio between the size of nucleus and the space in which the electrons move. Afterwards, they estimated the relative size of the atoms using the tennis ball and soccer ball as nucleus. Many students estimated a realistic size for the atoms. For example, their estimates were: the size of atom that has a nucleus (the tennis ball) is nearly the size of school district. The size of atom that has a nucleus (the soccer ball) is nearly the size of city (Ankara) where they lived. Lastly, students were asked to reveal a principle relating to the size of an atom. Many students collaboratively constructed that "the size of an atom is determined by the space in which the electrons move, and relative to the size of its nucleus."

The above activity portrays spatial-visual intelligence. Verbal-linguistic intelligence was evident because of the students' talk based on their own ideas. Logical-mathematical intelligence activity was also observed because students were able to discuss the size of atoms.

2.3. Incorporating Students' Preconceptions in Armstrong's Seven-Step Model

"If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" (Ausubel, 1968). Ausubel's quote from 1968 gives a frame for a main research focus in science education of the last three decades: Students' preconceptions in numerous various science topics were investigated in the 1970s and 80s. In the following years several models of a constructivist approach in science teaching and learning were developed. In all of these theories the integration of students' preconceptions plays a key role. Nowadays, most of the science educators have agreed that an understanding of the concepts students hold prior to instruction is of paramount importance for effective teaching of science (Morrison & Lederman, 2003). There was an important difference between MI lesson plans of this study and Armstrong's seven-step model in developing and implementing MI lesson plans. That is, Armstrong's procedure does not stress the importance of incorporating students' prior conceptions and their reasons for a specific topic. The MI teaching activities in this study formally and informally identified students' intuitive conceptions, partial understanding, and the reasons for their conceptions of particulate nature of matter and incorporate these into lesson sequence. For example, in the spatial-visual awareness activity above, the teacher firstly focused on identifying students' preconceptions and the reasons by means of diagnostic questions and then teaching the objective relating to the determination of the size of atoms through the spatial-visual activity. As a result, this step, promoting the conceptual change, includes not only students' awareness concerning their own conceptions and reasons, but also their teacher's awareness.

3. SUMMARY AND CONCLUSIONS

The aim of the study is to help especially preservice and inservice science teachers how to develop and implement an MI science lesson. The results of this study, obtained from a research-based classroom, showed that there were four important factors when an MI science lesson is planned and carried out. They are: (1) identifying individual students' multiple intelligences or strengths via a reliable and valid tool such as the MIDAS, (2) paying attention to the literature findings related to students' difficulties in learning the relevant science topic, (3) considering the nature of the knowledge structure that students are supposed to learn with respect to the MI, and (4) examining teacher's ability to manage the MI activity.

It should be noted that the spatial-visual activity related to teaching what determines the atomic size may be more appropriate to teach the students in the current study, because the MIDAS results indicated that there were 14 students, strong in the spatial-visual intelligence, and thus many students can use their strengths when learning science, while the remaining students strengthen their underutilized spatial-visual intelligence. Other MI activities in the phase of considering possibilities (see p. 5) for the same learning objective may be more suitable for different students because of the possible differences of the students' multiple intelligences or strengths. The MI initiatives already defend that every student or classroom has its unique cognitive profiles. For example, if a class (N=25) that have 3 or 4 students who strong in the spatial-visual intelligence, and 10-15 students who strong in bodily-kinesthetic intelligence, the bodily-kinesthetic intelligence given in the phase of the considering possibilities (see p. 5) seems more reasonable to teach the students what determines the atomic size. Selecting the best MI activity also depends on the literature findings related to students' difficulties in learning the relevant science topic. For example, the findings of science education literature (e.g., Harrison & Treagust, 1996) indicate that other activities, except for the spatial-visual activity, may have important limitations to teach students the determination of the atomic size. The third factor is the nature of the knowledge structure with respect to the MI. For example, the nature of the learning objective "the determination of the atomic size" requires students to imagine the atomic structure and mentally compare the ratio of nuclear diameter to atomic diameter. It is clear that students need to use their spatial-visual intelligence to be able to learn this objective. The last important factor is whether or not the teacher can efficiently manage the MI activity. This criterion is completely depending on multiple intelligences or strengths of teachers. In this study, the teacher also reported that he would be able to conduct the spatial-visual activity. Of course, there are many other factors that affect selecting the best MI activity to teach students science such as physical classroom environment.

A common misconception among teachers is that each learning objective or knowledge structure should be taught through all multiple intelligences (Kaya, 2006). However, there is no need to address all MI in every objective or lesson, but each lesson should be reasonably allotted to implement different intelligences (N=3-5). For example, a lesson consisting of 3 objectives may be carried out through spatial-visual, bodily-kinesthetic and logical mathematical intelligences or musical-rhythmic, spatial-visual and interpersonal intelligences. It is also obvious that trying to teach a knowledge structure in science using all of the eight intelligences is nearly impossible and unnecessary. Gardner (1995), in fact, cautions against "going in the bandwagon" in an effort to include all eight intelligences in every lesson or in each teaching activity. Gardner (1997) also states, "MI is not a quick fix. But educators who thoughtfully use the theory to support their larger educational goals find that it is a worthy partner in creating schools of excellence" (p. 20). In this connection, one doubts a rose in my mind prior to the study that lessons based on multiple intelligences theory would take more time compared to traditional teaching. Moreover, the classroom observations revealed that even if the selected topic is abstract and students do not have experience on MI activities, the time was not an issue in the context of the MI science lessons because students can readily understand and adapt the MI activities after the first few lessons.

In this study, identifying students' preconceptions and the reasons for these through MI activities added to Armstrong's seven-step model for creating and implementing MI lesson plans, which incorporated was very useful to provide the students' awareness and their teacher's awareness concerning preconceptions and the reasons of their conceptions. Thus, this study implies that the MI activities should first focus on identifying students' preconceptions and the reasons for these preconceptions. During the activities, students can become aware of the changes in their own cognitive structures. Therefore, the MI activities ties in with a constructivist view of learning which emphasizes that students must be active in their own construction of knowledge, depending on what they already know. Meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with old ideas.

Overall, this study helps science teachers the MI theory as teaching and learning approach in their classroom; however, they can use their own unique ways to create and implement the MI science lesson sequence. The aim of science teachers should be to develop a repertoire of teaching activities that emphasize multiple intelligences and to help students use combination of intelligences, consisting of not only stronger but also weak intelligences, to be successful in school to help them learn whatever they want to learn as well as what the teachers and society believe they need to learn in science.

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GENIŞLETILMIŞ ÖZET

Bireyin zekasını daha çok problem çözme, mantığını kullanma ve eleştirel düşünme yeteneklerine bağlı olarak değerlendiren geleneksel yaklaşıma karşı çıkan Harvard Üniversitesi profesörlerinden Howard Gardner (1983), ilk olarak insan oğlunun yedi farklı zekaya sahip olduğunu belirtmiştir. Gardner Çoklu Zeka Kuramını (ÇZK) geliştirirken Boston Üniversitesi Dil ve Konuşma Bozuklukları (Aphasia) Araştırma Merkezinde tedavi gören kişilerden ve çocukların bilişsel gelişimi üzerinde araştırma yapmak için dizayn edilen Harvard Project Zero adlı proje kapsamındaki bir laboratuvardan elde ettiği verileri kullanmıştır. Gardner, zekanın sadece dilsel/sözel ve mantıksal-matematiksel zekalara bağlı olmadığını daha sonra eklediği doğa zekasıyla beraber sekiz yönünün olduğunu savunarak, sadece matematik ve dilde başarılı olanların değil, müzikte, sporda, dansta, iletişimde, resimde başarılı olan ve aynı zamanda kendini iyi tanıyan kişilerin de zeki olduğunu belirtmektedir

Gardner'ın ÇZK'yi ilk olarak sunduğu "Zihnin Çerçeveleri: Çoklu Zeka Kuramı" adlı kitabının ardından farklı ülkelerden (Örneğin, Arjantin, Avustralya, Çin, Danimarka, Kolombiya, Kore, Norveç, Japonya, Romanya, Tayvan, Türkiye) çok sayıda eğitim bilimci, öğretmen ve okul yöneticisi kuramla ilgilenmeye başlamıştır. Birçok eğitim bilimci, ÇZK'nin eğitim ve öğretime yansımalarının şaşılacak boyutta ve hızda olduğu konusunda hemfikirdir Özellikle son 10 yıl içerisinde kuramın birçok ülkenin eğitim sistemi üzerindeki etkileri hissedilir oranda artmıştır. Günümüzde "Çoklu Zeka Okulu" veya "Çoklu Zeka Öğretmeni" gibi terimlere sıkça rastlanmakta ve bu ve benzeri sözler daha çağdaş bir okul veya öğretmeni işaret eder hale gelmiştir. Kuramla ilgili bu tarz olumlu gelişmelerin tersine, Gardner'ın farklı ülkelerdeki Çoklu Zeka okullarında yaptığı gözlemler ve kuramla ilgili diğer araştırmalar (Örneğin, Flick ve Lederman, 2003, Kaya ve Ebenezer, 2006) öğretmenlerin kuramla ilgili hem teorik bilgi hem de uygulama becerisinde önemli sorunlar olduğunu ortaya koymuştur. Örneğin, Flick ve Lederman (2003) ÇZK'nin Amerikan fen ve matematik öğretmenleri arasında çok yaygın bir kavram olduğunu, fakat kuramın birçok öğretmen tarafından yeterince anlaşılmadığını gözlemlemişlerdir. En önemli sorunların başında, sınıflarda daha etkin bir öğretim için öğrencilerin bireysel farklılıkları, ilgi ve ihtiyaçlarının veya başka bir deyişle çoklu zekalarının nasıl dikkate alınması gerektiği gelmektedir. ÇZK tabanlı bir öğretimin nasıl planlanıp uygulanacağı birçok fen eğitimcisi, öğretmeni ve araştırmacısının da odakladığı önemli bir problemdir.

Bu çalışmanın amacı, ÇZK'ye dayalı bir fen bilgisi dersinin nasıl planlanabileceği ve uygulanabileceğiyle ilgili tüm süreci adım adım sunmaktır. Çalışmada, öncelikle ÇZK'nin fen öğretimi ve öğrenimi açısından sahip olduğu potansiyel sunulmaktadır. Daha sonra, literatüre dayalı geliştirilmiş ve ilköğretim 8. sınıfta uygulanmış ÇZK'ye dayalı bir fen bilgisi dersi, fen bilgisi öğretmen adayı ve öğretmenlerine ÇZK'yi teoriden sınıf içi uygulamaya dönüştürmede yardımcı olmak amacıyla somut bir örnek olarak verilmektedir. Araştırma Ankara ilindeki bir ilk öğretim okulundan rasgele seçilen 25 (13 erkek ve 12 kız) 8. sınıf öğrencisinin bulunduğu bir sınıfta yürütülmüştür. Öğrencilerin ailelerinin sosyo-ekonomik seviyeleri genellikle orta ve zayıf seviyedendir. Araştırma öncesinde öğrenciler fen bilgisi derslerini mantıksal-matematiksel ve dilsel-sözel zeka etkinliklerinin yer aldığı, öğretmen merkezli geleneksel öğretim yoluyla işlemişlerdir. Çalışmaya 6 yıllık deneyime sahip ve yüksek lisans eğitimini tamamlamış bir fen bilgisi öğretmeni katılmıştır. Öğretmenin çalışmaya katılması, ÇZK'nin sınıf içi uygulamalara nasıl dönüştürülebileceği, sınıflarda yaşanacak muhtemel sorunlar ve çözüm yolları üzerine araştırmacı tarafından verilen bir seminer vasıtasıyla olmuştur. Öğretmenin seçiminde kuramla ilgili yorumları "Çoklu Zeka tabanlı öğretim benim şu anda sınıflarda kullandığım yoldan oldukça farklı. Öğrencilere fen kavramlarını ve bu kavramlar arası ilişkileri daha iyi öğretebilmek için onların sahip oldukları çoklu zekaları veya zeka profillerini belirlemeli ve ona göre bir öğretim uygulamalıyız. Geleneksel öğretim birçok öğrenciyi görmezlikten gelmemize ve onları sınıf içi ekinlikler dışında tutmamıza neden oluyor. Çoklu Zeka Kuramına dayalı öğretimle sınıflarımdaki öğrencilerin hepsine ulaşabileceğimi ve onlara fen bilgisini öğrenmelerinde mutlaka bir yol sunabileceğimi düşünüyorum" etkili olmuştur. Öğretmen araştırmacının verdiği toplam 12 saatlik bir eğitim-öğretim programında sonra, ÇZK tabanlı derslere başlamıştır. Bu ilk hazırlık programı devresinde odaklanılan konular; (1) ÇZK'nin geliştirilme süreci, (2) ÇZK ilgili teorik bilgi, (2) ÇZK'nin eğitim-öğretim ortamına getirdiği değişiklikler, (3) ÇZK'ye dayalı bir fen bilgisi dersini tasarlama ve (4) ÇZK tabanlı bir fen bilgisi dersini uygulamadır. 8 hafta süren ve 2004-2005 eğitim-öğretim yılında yürütülen araştırmada, seçilen fen bilgisi dersi ünitesi madde ve enerjidir. Nitel bir araştırma olan bu çalışmada, araştırmacı ÇZK tabanlı fen bilgisi derslerine gözlemci olarak katılarak sınıfta meydana gelen öğrenci-öğrenci, öğrenci-öğretmen arasındaki ilişkileri ve öğrencilerin ÇZK etkinlikleri boyunca sınıf içi katılımlarını not almıştır. Bu veriler ÇZK tabanlı fen bilgisi derslerinin nasıl geliştirilebileceği ve uygulanabileceğini değerlendirmek açısından analiz edilmiştir. Verilerin analizi, çoklu zeka tabanlı fen bilgisi dersleri ile ilgili dört önemli faktör açığa çıkarmıştır. Bu faktörler, (1) güvenilir ve geçerli bir ölçme aracı ile öğrencilerin çoklu zekalarını belirlemek, (2) ilgili fen konusunda literatürde bulunan öğrencilerin öğrenme sorunlarına dikkat etmek, (3) öğrencilerin öğrenmesi amaçlanan bilgi yapısını çoklu zekalar açısından dikkate almak ve (4) öğretmenin çoklu zeka aktivitesini sınıf içinde uygulama kabiliyetini sınamasıdır. Bu çalışmanın sonuçları, Gardner'ın (1995) ÇZK sınıflarındaki gözlemlerine dayalı işaret ettiği yanlış uygulamalara da açıklık getirmiştir. Örneğin, yaklaşık 40 dakikalık bir ders saati içerisinde kazandırılması amaçlanan hedef davranışların 8 zeka alanının hepsi kullanılarak öğretilmesinin gereksiz olduğudur. Bu noktada önemli olan etkenler yukarıda sunulmuştur. Bu faktörlerin dikkate alındığı ÇZK tabanlı bir öğretim, öğrenmenin yapılandırmacı bakış açısıyla da uyum içerisinde olacaktır.