# An Interdisciplinary Approach to Elementary Astronomy Teaching

**Pınar Başpınar**
**Middle East Technical University**

*Astronomy has become popular and interesting topic since ancient times of the Earth. People tried to discover what they see in sky and then, they had found explanations. Thanks to technological developments, today, it is easier to discover beyond the Earth. In recent years, science education integrates different fields such as mathematics, engineering and art… into K-12 education. Therefore, K-12 astronomy education has also become more interdisciplinary course. Educators integrates different fields into their lessons in many different ways. This article reviewed "Interdisciplinary Astronomy Teaching" in terms of five disciplines which are art, music, mathematics, technology and engineering.*

*Keywords: astronomy education, interdisciplinary astronomy teaching, elementary astronomy*

## INTRODUCTION

People has been interested in sky and beyond since the early ages. From these ages to 21th century, there are many significant explorations and developments. Today, people can imagine space travel from the Earth to other planets. While these innovations are occurred, the education methods and approaches cannot keep away these developments. Also, those developments led to appear a new learning environments and approaches (Brake, Griffiths, Saunders, Thornton, 2004). At that time, Interdisciplinary science teaching has become popular and also, it was enhanced its framework and dimensions such as engineering and technology. Interdisciplinary science teaching means collaboration of disciplines such as math, art and literature with the science programs. The last trend of interdisciplinary science teaching is STEM education which includes science, technology, engineering and math (Czerniak & Johnson, 2014). It was introduced in America and then, spread to nearly whole world. STEM education aims to develop students' skills which are problem solving, critical thinking skills and creativity… In this approach, students become more active while teachers have a role of facilitator or guide (Chang, Chen, Lou, Tseng, 2011). When we looked at the literature about interdisciplinary science teaching, there are little amount of study about interdisciplinary astronomy teaching. Many of research generally focused on engineering-based topics, thanks to STEM education's "E" dimension.

This article focused on an interdisciplinary teaching of astronomy topics. There are reviews of 5 dimensions which based on both elementary astronomy and interdisciplinary science teaching. Each article underwent a research about the effects of different discipline to K-12 astronomy education, with each other. The researchers worked with either students or teachers. Therefore, Reviews are categorized depending on disciplines' types. The reviews are divided into five different disciplines: (1) Art (2) Music (3) Mathematics (4) Technology (5) Engineering. Each subtopic includes description of given discipline, integration of

science lessons and astronomy lessons. Also, related articles are showed and explained in detail to support ideas.

## THE DISCIPLINE OF ART

The discipline of art makes students more creative and imaginative. It provides innovative process to science lessons therefore; students may look contents from new sights. The art makes students more explosive (Connor, Karmokar, Whittington, 2015). In the following paragraphs, reviews about how we can collaborate with art dimension in the astronomy lessons are elaborated.

The Art starts with color and then, saturation, balance… How can we integrate art into the astronomy topics? We should look deeper and more detailed to astronomy concepts. According to Radnofsky, artists improve their eyes' artistic talent such as depth of field, shadows and perspective… She claims that, people can integrate these skills into the astronomical phenomena (Radnofsky,2006). Also, McGinn and Roth (1999) stated that representation with using visuals is the basis of doing and creating something about science. In addition, observation is an important skill for scientist to interpret nature. Radnofsky (2006) argued that there is a relationship between observation and artistic talents. For instance, when people have a nuance which is a ability of perception, they will be do more accurate observations with devices like microscope or telescope. Imaging devices like telescope are important for astronomy because they are our biggest chance to observe beyond the Earth. Ragans (1995) also supported this idea with that, the emphasize of the effects of light on object increased after developments of color had been increased. According to Stavridou and Kakana (as cited in Lee et al., 2019), students who improve visual perception will be better with physical concepts.

Making astronomical models also supported children's astronomical views. Therefore, students can use their artistic talents into their models and finally, they can create 2-D/ 3-D models (Radnofsky,2006). There is a research about the relationship between elementary astronomy and drawing-based models in 2014 supports Radnofsky's claim (Joolingen, Aukes, Gijlers & Bollen, 2014). In this study, researchers underwent an experiment with 247 participant which are nearly same ratio of gender and ages starts with 7 to 15. The study had been lasted for four weekends in the science museum. Museum staff wants participant first to indicate their knowledge about "solar system" and "solar and lunar eclipses" on the questionnaire (as a pre-test) and then, sketch it on the drawing software. Lastly, museum staff put participant to the post-test (Joolingen et. al., 2014). According to results, there is statistically significant relation between drawing-based modelling and astronomy understanding. Also, it is shown that most of the participant do moderately accurate drawings/models.

## THE DISCIPLINE OF MUSIC

Music, generally, has been used as a motivation tool in the classrooms. It is shown that music creates facilitating and engaging environment, therefore students shows better performance in the lessons (as cited in Kim & Yoon, 2017). On the other hand, the music is not used only "the motivation factor" in the lessons. For instance, "The Science Song" study claims when science teachers incorporate with the music discipline, their students can develop their science process skills (Kim & Yoon, 2017). Also, science process skills are essential for most of the science topics, including astronomy (Jirout & Zimmerman, 1970).

From the ancient period to the modern times, people who are interested in astronomy try to relate motion of great bodies and harmony of movement with musical intervals. For example, Levenson (as cited in Radnofsky, 2006) wrote that Aristotle wrote that numeric ratios of regular motion of great bodies have some similarities with musical intervals. Kepler, also, believed that there is a relation between mathematical calculations of orbital motions and harmony in music (Fraknoi, 2002). These attempts to find a connection between music and astronomy may be the starting point of incorporation of them for teaching astronomy. To build beneficial lessons, teachers should help students to discover these relations and research to the students (Radnofsky, 2006).

## THE DISCIPLINE OF MATHEMATICS

The discipline of mathematics may be seen as the closest discipline of science because both of them include formulas and calculations to explain phenomena. Because of this thought, students who are math-phobic can keep away some physics or chemistry subjects in science lessons (Radnofsky, 2006). However, the collaboration of these two disciplines is beyond those formulas and calculations. According to Goldin's (as cited in Herro & Quicqley, 2019) study, students stated that mathematics is the language of science. As opposed to this belief, in real life, mathematics dimension is the weakest area in the interdisciplinary science teaching (Herro & Quiqley, 2019).

In 2011, Chen, Lou, Chang and Tseng (2011) underwent a research about students' attitudes toward some disciplines which are science, math, technology and engineering. They design an interdisciplinary science project for students. Firstly, students were pre-tested to measure their attitudes. After doing project, researchers made a post-test to them. According to results, most of the students have positive attitudes to math discipline but they have least interest to it within the all subjects (both before and after the project) (Chen, Chang, Lou, Tseng, 2011). The reason of students' positive attitude but less interest is previous difficulties of students in their mathematics courses (Chen, et. al., 2011). This study supports why math is the weakest area in interdisciplinary science teaching.

In the astronomy, mathematic is used for creating astronomical models such as evolution process of one astronomical object. To be create a model, people have to do observation some imaging devices such as telescopes. However, observation is not enough for discovery in 21th century. Thanks to mathematical relations, the more complex models can be created. At that point, there should be a framework which astronomers have to be in for making models. This framework consists of rules, theories and facts in chemistry and physics. This collaboration is really important for development of astronomical discoveries (Herro & Quiqley, 2019). Making a model with the help of the mathematics may be difficult for K-12 students. However, at least talking about the connection between two disciplines may help students to understand their relationships.

Math dimension in interdisciplinary science teaching includes in both of math-phobic and logical-math thinkers. In the elementary level, according to Radnofsky (2006), teachers should prepare activities for both math-phobic and logical-math thinkers students. To integrate math dimension to the astronomy lessons, teachers should make students to draw bar graphs, charts, scales to represent their ideas. For instance, to compare size of planets or other great bodies, students can use bar graph (Radnofsky, 2006). Also, students collect data with mathematical tools such as meters, rules and organize them (Herro & Quiqley, 2019).

## THE DISCIPLINE OF TECHNOLOGY

The technology has been developing day to day. Thanks to product of technology, it is the popular subject among students (Noyes & Rees, 2007). Students find technology-related topics interesting. Therefore, integration of technology into the science lessons is not irrelevant. On the other hand, Jenkin (as cited in Noyes &Rees, 2007) stated that technology helps and finds solutions to the many problems related to society, environment or medical issues… The relationship between science and technology still discussed. Some researchers argue that technology is the product of science but some of them thinks that science only supports technological developments, not directly creates (Brooks, 1994).

In educational aspect, one study explained that the quick development of technology requires new skills such as linking information with multiple disciplines (Connor et al., 2019). Interdisciplinary science teaching forces students to improve this skill because it includes more than one disciplines into itself. And now, how we can integrate technology into the astronomy classes?

When looked at researches, technology is used as supplementary discipline. For instance, the research about finding relationship between modeling and elementary astronomy used a software to make students a drawing (Joolingen et al., 2014). Participants firstly, draw a model about on SimSketch (Bollen & Joolingen, 2013) which enables students to draw orbiting and rotating object on computer. Then, they animated their drawings. The elements which are chosen by students move the way that participants

assigned to them. Lastly, the software matches the created models with accurate (correct) models. According to result of the study, using computer software effected students' participation positively. There is another study to support that technology dimension effects positively to astronomy teaching (Beecher, Black, Hayes & Marino, 2010). In USA, researchers underwent a study with 1153 participants from grades 6-8. They implemented technology-enhanced STEM Astronomy curriculum to the students with the help of teachers. When we looked at findings about technology part, technology-enhanced materials help students to enhance their academic achievements and self-efficacy. However, they added that there should be more study about this area (Beecher et al., 2010).

As mentioned before, technology has been developing day to day. Therefore, computer software, simulation or animations cannot get enough (Litvak, Mintz & Yair, 2001). 3-D VR (virtual reality) technologies which enables people to be in an environment such as from space, lab or spacecraft while they are wearing VR glasses. "VR improves learning, when it does, by providing the learners with new, direct experiences of phenomena they could not have experienced before, either in direct interaction with the real world or using other technologies" (Furness, Win & Yu, 1997, para.10 ). Yair et al. (2001) results that using VR in astronomy lessons helps students convert abstract knowledge to concrete because they interact directly with astronomical concepts. Also, they argue that using virtual reality creates deep learning about space and planetary movement contents.

## THE DISCIPLINE OF ENGINEERING

Engineering is an application of science and mathematics to achieve goals and solve problems under given constraints. Engineering utilize multidisciplinary sciences and technologies to model, analyze, design and create solutions to problems (Bennet, Carr & Strobel, 2012).

Studies show that students better understand complex science knowledge when building their own models than when given algebraic and abstract models (Linn, Pea & Songer, 1994). Using concepts and models of science, technology and mathematics, engineering discipline helps students to solve basic problems faced in everyday life. Engineering can simplify and concretize complex and abstract scientific concepts using tangible models created by students. These models are created through analysis, argument and critique thus engineering contextualizes the concepts of math and science (Bennet et. al., 2012). Engineering applications can help learners to approach science and mathematics as subjects relevant to their lives.

Since engineering applications involve science, mathematics and technology, engineering integrates four of STEAM disciplines. This combined educational approach further enhance STEAM education and help students build necessary skills for their college education and career. These skills include problem solving, data collection and analysis, group work, communication about multidisciplinary fields and creative ideas, computer modelling etc.

Qualifications needed in modern engineers can be given as, problem solving, how to perform the ideal solution in a given situation, communicating as a team member in multidisciplinary environments. Providing these elements to learners should be the goal of modern educations systems (Connor, et. al., 2015).

When we looked at researches about astronomy, modern astronomy uses so many fields which include engineering, also. Many types of engineering can work with together to do research about astronomical phenomena, such as physics engineer, chemical engineer and space engineer. In elementary astronomy, teacher may give a problem about the any topic related to astronomy and then want student to find possible solutions. Students can be assigned to any of engineer type and then, they act like an engineer. Mission of being an engineer aims that students gain skills which are mentioned before (Russo, Retrê, & Christensen, 2019).

## CONCLUSION

Overall, this paper aims to show how elementary astronomy lessons can be more interdisciplinary, with supporting researches and studies. Astronomy concepts are generally abstract because the opportunity of observing directly with naked eyes by students is nearly impossible (Radnofsky, 2006). To become more concrete learning, teachers should try different methods in their lessons. Interdisciplinary science teaching is an example of these ways. Interdisciplinary does not means directly integration of one discipline to other discipline (Brake, et al., 2004). It means collaboration of more than one disciplines. In science education, there is a new trend which is STEM education. STEM means collaboration of three disciplines (technology, engineering and mathematics) with science (Czerniak & Johnson, 2014). On the other hand, art, literature or music can be useful to plan a science lesson according to topic. For elementary astronomy teaching, Radnofsky (2006) claimed that art is an important discipline for integration. This article mentioned three factors to explain importance. The first one is art gives students a chance of self-expression and creativeness. Therefore, students gain to broad their perspectives. The second one is about observing something. Radnofsky (2006) mentioned that observation is important skill for astronomy because of most of the astronomical objects are observed by imaging devices. When students develop their artistic talents, they can interpret what they see on these devices. Lastly, we covered a research about effectiveness of making an astronomical model by drawing. According to results, 3D modelling helps students to develop astronomical views. The other discipline is music which is generally used for increasing motivation and focus of students to the lessons. On the other hand, it is revealed that when science works with music discipline, it helps students improve their science process skills. Science process skills are important for students because it forces scientific creativity and also motivation of students toward science. Also, it helps students interpret their environment, conduct an experiment and, meaningful observations (Aktamis & Ergin, 2008). In addition, specifically for astronomy topics, music is always in the mind of astronomers from Aristotle to Kepler (Fraknoi, 2002). They had tried to relate these two concepts with together. However, there is not any recent study which directly conducts to find the relation between understanding of astronomy and music discipline. Therefore, it is not so possible to do good review about efficiency of it. The third dimension which is mentioned in this article is mathematics. According to Herro & Quicley (2019) and Chen et al. (2011), mathematics is not integrated science topics effectively. The reason behind collaboration problem is students' struggle with math class. However, math is not only used for calculations or formulas in the science classes. For instance, to create a 3-D model or comparing volume or size of astronomical objects, students should work with math dimension. In this dimension, teachers should consider students with math phobia in order to reach each student and plan their lessons depending on this situation. In astronomy lessons, the teachers may ask students to draw basic graphs or scales depending on the content (Radnofsky, 2006). The technology is the popular dimension of interdisciplinary science teaching (Noyes & Rees, 2007). Thanks to STEM education, using technology in science classes has been increased day to day. Today, people can easily solve their problems with the help of the technology (Jenkins, 2006). In the fact that it is an important part of our lives and decades, we have to integrate it our classes. Results of the researches shows that technology improve students' academic achievement of astronomy (Beecher, et al., 2010) (Yair et al., 2001). They generally used technological software such as drawing & modelling programs. However, I think that use of virtual reality (VR) for astronomy teaching may be enforced to create more concrete astronomical environment. Yeinz et. al. (2001) also stated that VR use helps students to improve their learning about astronomical phenomena, events and motions. The last aspect which mentioned this article is engineering dimension. Engineering includes many processes into it such as analyzing, problem solving and creating models. Songer et al. (1994) claimed that engineering process forces students understanding about content knowledge. When we looked at astronomical developments, different engineering departments work with together. Therefore, during implementing astronomical content teachers may use engineering process by assigned engineer titles to students.

To conclude, there are many ways to collaborate with different disciplines for specifically astronomy teaching. Mentioned supporting researches showed that interdisciplinary astronomy teaching has positive effects on students learning about astronomical phenomena. However, studies and data about

interdisciplinary astronomy teaching is not enough to make good comparison. I highly recommend increasing number of studies in this area.

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