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Middle School Students' Views on Mathematical Modeling Applications in the BİSTEK: Intelligence Cube Project[1]

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Abstract

The aim of this study is to determine the views of middle school students on mathematical modeling applications in the "BISTEK: Intelligence Cube 2" project. Many different disciplines (such as astronomy, mathematics, physics, design, painting, music, theater and engineering) are involved in this project, which is realized with disadvantaged middle school students living in rural areas. Mathematics lessons in this project included mathematical modeling problems in which the relationship between mathematics and daily life was emphasized. To achieve the purpose of the study, interviews were held with 12 middle school students after the mathematical modeling applications in the BİSTEK: Intelligence Cube Project 2 was carried out within the scope of TÜBİTAK 4004 Nature Education and Science Schools Support Program. The analysis of the data has been conducted by content analysis. As a result of the study, it was seen that the students had positive approaches towards the mathematical modeling applications in this project and they wanted to include modeling activities in math lessons. In this study, middle school students living in rural areas had the opportunity to realize the importance of mathematics in daily life. Mathematical modeling applications should be included more in the projects in order to enable students to meet with modeling problems.

Keywords: Mathematical modeling, Middle school students, TÜBITAK 4004 - nature education and science schools

INTRODUCTION

Although math is at the center of many areas of daily life in science, technology and economics, the real-life importance of math is often set aside due to the fact that math lessons are mostly content-oriented (Hattebuhr & Frank, 2019). It is very important to integrate daily practical situations in-class teaching situations in order to show students the practical applicability of math (Tong, Loc, Uyen & Giang, 2019). From this point of view, mathematical modeling helps to show the applicability of math in daily life. Because, in mathematical modeling activities, information transfer is provided between school math and daily life by

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doing those mathematical topics are presented in relation to daily life situations (Doruk, 2010). Mathematical modeling is essentially the process of facilitating students to learn and explore real-life situations using mathematical tools such as shapes, tables, and functions (Tong, Loc, Uyen & Giang, 2019). The open-ended nature of modeling problems encourages reasoning, problem solving, and exposure to unclear or open problems can help children become comfortable with their helpful and informative solutions (Garfunkel & Montgomery, 2016). The mathematical modeling process does not only describe a static structure or concept, but also refers to the problem-solving process, which is often open-ended, not complex, routine, and should be evaluated in the context of real-life (Bukova Güzel, 2016). There are different modeling processes in the literature. For example, when the modeling cycle structured by Blum and Borromeo Ferri (2009) is analyzed from a cognitive perspective, in the first stage of this cycle, the problem situation must be understood in order to set up a mental representation of the situation. Then, the situation needs to be simplified, structured and made more specific, taken to a real model of the situation. In the mathematization phase, the real model is converted into a mathematical model consisting of certain equations. In the mathematical working phase, the models are solved and the mathematical results are revealed. In the interpretation phase, mathematical results are interpreted in the context of a real-life situation. In the verification phase of these results, the accuracy of the solutions reached and their compatibility with real-life are checked. As Erbaş et al. (2016) stated, these steps are not linear and can be repeated. It is aimed that individuals gain modeling competence in all mathematical modeling cycles despite the differences in the mathematical modeling processes (Duran, Doruk & Kaplan, 2016). Mathematical modeling competence is closely related to the modeling process (Bukova Güzel, 2016). While working on modeling problems, metacognitive modeling competencies are important as well as cognitive modeling competencies (Bukova Güzel, 2016; Stillman, 2011).

It is aimed for individuals to gain modeling competence in all mathematical modeling cycles despite the differences in the mathematical modeling processes (Duran, Doruk & Kaplan, 2016). Mathematical modeling competence is closely related to the modeling process (Bukova Güzel, 2016). While working on modeling problems, metacognitive modeling competencies are important as well as cognitive modeling competencies (Bukova Güzel, 2016; Stillman, 2011). Modeling activities are not only carried out as in-class applications, but out-of-class application alternatives may also arise in accordance with the nature of mathematical modeling (Özer & Bukova Guzel, 2020). From this point of view, the fact that TÜBİTAK 4004-Nature Education and Science Schools Support Program includes in-class and out-of-class applications makes it meaningful that mathematical modeling applications are also included in these projects.

Scientific and Technological Research Council of Turkey [TÜBİTAK] 4004 Nature Education and Science Schools Support Program aims to introduce and disseminate information to society, and to gain information in an understandable way through interactive applications by visualizing it as much as possible. In the projects within the scope of the program, it is aimed to encourage the participants' sense of curiosity, their desire to research, question and learn by making them realize scientific facts (TÜBİTAK, 2019). In these projects, it is aimed to transfer information in a more understandable way with applied activities, to

make people realize how much and important the relationship between scientific concepts and daily life is, and to show that dealing with science can be enjoyable and fun (Sezer Evcan et al., 2020). For this purpose, "Science, Art and Technology Camp, BİSTEK: Intelligence Cube Project 2", which includes active teaching methods such as STEM education, mathematical modeling, art applications and technology-design studies, for middle school students living in rural areas was carried out within Muş Alparslan University. In this article, it is aimed to determine the views of middle school students on mathematical modeling applications after participating in the "BISTEK: Intelligence Cube 2" project.

METHOD

In this research, phenomenology design, which is one of the qualitative research methods, was used to reveal the views of the 7th grade students participating in the Bistek intelligence cube-2 project supported by the TUBITAK Nature Education program on the mathematical modeling applications.

Participants

The sample of the research consisted of 12 middle school 7th grade students who participated in the Bistek intelligence cube-2 project supported by the TUBITAK Nature Education program. The students participating in this project are the children of families who live in rural areas and whose economic situation is not good. This middle school students participating in these applications did not have previous experience with modeling. The students participating in the research were coded as S1, S2, … , S12 and their names were not included in the study.

Data Collection Tools and Data Collection

Mathematical modeling applications were included in the Bistek Intelligence Cube-2 project supported by the TÜBİTAK Nature Education program. Many different disciplines (such as astronomy, mathematics, physics, design, painting, music, theater and engineering) were included in this project. Mathematical modeling practices that positively improve students' mathematical thinking, communication skills and self-confidence were included in the mathematics lessons within the scope of the project. In this project, Apple Pie Problem (Tekin Dede, 2015), Bigfoot Problem, Big Horse Racing Game Problem and Long Jump Problem (Doruk, 2010) selected from the literature were applied. Students tried to solve mathematical modeling problems with group work. The researcher avoided interfering with the students during the application. After each activity, students shared their solutions on the board. Thus, it was ensured that the students saw that there were different solutions to mathematical modeling questions, that they could establish mathematical communication and work in collaboration. Considering that students encountered mathematical modeling for the first time, it was requested to determine their thoughts about modeling applications. For this purpose, interviews were held with students at the end of this application. A semi-structured interview form was prepared as a data collection tool developed by the researcher in order to determine the students' views on the modeling problems, they encountered for the first time. This interview questions are as follows:

1. What similarities/differences have you noticed between the problems you are trying to solve and the problems you have encountered so far?

2. How much did group work affect you during your work with activities?

3. How did these activities affect your views on the usefulness of mathematics in your life? Is it positive or negative?

4. What do you think about including such activities in your lessons from now on? Should such activities be included in your lessons?

Data Analysis

Content analysis was used in the analysis of the data in order to analyze the students' views on mathematical modeling applications. Because content analysis is defined as a systematic, repeatable technique in which some words of a text are summarized with smaller content categories with encodings based on certain rules (Büyüköztürk et al., 2008).

FINDINGS

Table 1. *Comparison of mathematical modeling activities and math questions encountered in lessons*

Category	Code	Frequency
There were similarities	Calculation	1
There were differences	Having multiple results	5
	Multidimensional thinking	3
	Group work	2
	Long paragraph	1
	Difficult	2

When the middle school students participating in the project were asked to compare the mathematical problems, they learned at school with the modeling problems they encountered in the project, the answers given by the students were analyzed and the categories of "*there were similarities*" and "*there were differences*" emerged. While *calculation* code was under the category of "*there were similarities*"; "*having multiple results, multi-dimensional thinking, group work, long paragraph"* and "*difficult"* codes were in the category of "*there were differences*".

S2 stated that the problems they encounter in math lessons and modeling problems are similar because they contain operations as follows:

> *"Both of them had operation"*

S8 who thinks that mathematical modeling problems are different because they contain more than one result, stated the following:

> *"The questions in the math class at school have one result, but there can be 2-3 results here."*

S3 who thinks that modeling problems are different because they involve multidimensional thinking, stated the following:

"These questions require multidimensional thinking."

S5 who thinks that mathematical modeling problems are different in the direction of group work, stated the following:

"We were working individually in the previous questions, but it is easier to find the right answer because we were more than one in this one."

S4, who thinks that the students' modeling problems are different because they contain long paragraphs, stated the following:

"Normally, there were not many tables in the lessons at school, but here the paragraphs are long, and the tables are many."

S1, who thinks that the students' modeling problems were different from the problems in math lessons because they were difficult, stated the following:

"These questions are harder."

Table 2. *The effect of group work in the mathematical modeling process*

Category	Codes	Frequency
Positive	Simplifies the process	4
	Exchange of ideas	4
	Seeing different views	3
	Correcting mistakes	3

When the middle school students who participated in the project were asked about the effect of group work in the mathematical modeling process, the answers given by the students were examined and the codes were included under the category of "*positive*" and the codes of "*simplifies the process*, *exchange of ideas*, *seeing different views"* and "*correcting mistakes"* in this category.

S5, who thinks that group work facilitates the process in the mathematical modeling process, stated the following:

"It worked well, we can have difficulties in the questions when we work individually, but now it is easier to find the answers to the questions because there is more than one thought."

S8, who thinks that group work enabled the Exchange of Ideas in the mathematical modeling process, stated the following:

"It made us trust ourselves, we consulted each other when we were unsure, and we did it better."

S11, who thinks that group work among students in the mathematical modeling process helped to see different views, stated the following:

"When we work individually, we find one result, when we work in groups, we can get multiple results."

S7, who thinks that group work helped students correct mistakes in the mathematical modeling process, stated the following:

"When we do it individually, we make mistakes, but when we do it as a group, our friends correct them, we see our mistakes and correct them."

Table 3. *Views on the usefulness of mathematical modeling activities in math*

Category	Code	Frequency
Positive	Seeing different solutions	5
	Has proven that math is used everywhere	4
	Self-confidence	2
Negative	Failure to reach consensus	1

When the middle school students participating in the project were asked about the usefulness of mathematical modeling activities, their answers were analyzed, and "*positive*" and "*negative*" categories were formed. Seeing different solutions in the "*Positive*" category, "*has proven that math is used everywhere"*, "*self-confidence"* codes are included. In the "*Negative*" category, there is the code of "*failure to reach "consensus"*.

S3 who thinks that mathematical modeling activities enable to see different solutions, stated the following:

"On the contrary, there is more than one result, and it is very easy to find out as a group."

S4 who thinks that mathematical modeling activities provide proof that math is used everywhere, stated the following:

"*We learned that there is a golden ratio in the human body and we use math in it."*

S5, who thinks that mathematical modeling activities provide self-confidence, stated the following:

"As we find the right answers, our confidence grows so we can better educate ourselves."

T1, who thinks negatively because they could not reach a consensus on mathematical modeling activities, stated the following:

"There is only one result when we are individuals, but it is difficult to reach the one result as a group."

Table 4. *Including mathematical modeling activities in math lessons*

Category	Code	Frequency
Let it be	More free thinking	4
	Reaching multiple results	4
	Group work	2
Don't let it be	Difficult	1
	Multidimensional thinking is required	1

When middle school students participating in the project were asked about their views on the inclusion of mathematical modeling activities in math classes, the answers given by the students were examined and the categories of "*let it be*" and "*don't let it be*" were formed. While there are codes of "*more free thinking",* "r*eaching multiple results"* and "*group work"* in the category of "*may*", there are codes of "*difficult"* and "*multi-dimensional thinking is required"* in the category of "*Negative*".

S11, who wants mathematical modeling activities to be included in math lessons because it enables more free thinking, stated the following:

> *"Because it improves us when we find it here in our own way, but if it goes through the formula, it limits our thinking."*

S9, who wants mathematical modeling activities to be included in math lessons because they provide different results, stated the following:

> *"Because we can find more than one result".*

S5, who wants mathematical modeling activities to be included in math lessons because they provide group work, stated the following:

> *"It should be given as a group work so that it increases our unity."*

S1, who wants mathematical modeling activities not to be included in math lessons because they were difficult, stated the following:

> *"For me it's better not to include it because everyone may have different views, don't let mine be because those are difficult and more boring."*

S12, who wanted mathematical modeling activities not to be included in math lessons because they require multidimensional thinking, also stated the following:

> *"No, because we need to think multidimensional in these questions."*

CONCLUSIONS and DISCUSSION

In this study, middle school students living in rural areas had the opportunity to encounter a different type of mathematics than traditional mathematics, and by seeing the daily life-mathematical relationship with the help of mathematical modeling, they realized the importance of mathematics in daily life. The students who participated in the project thought that the modeling problems were different from the normal mathematical problems because the mathematical modeling activities had multiple results and enabled multi-dimensional thinking.

Indeed, the modeling problems allows for multiple approaches and responses (Blum & Borromeo Ferri, 2009; Fisher, 2020; Lingefjärd 2006). In addition, some students stated that modeling problems, different from mathematical problems, included long paragraphs and were difficult. Studies have shown that the majority of students at all levels have difficulties not only in reading and understanding the modeling task, but also in remembering the mathematical information necessary to solve problems and have difficulty in moving from the real world to the mathematical world (Sol, Giménez & Rosich, 2011; Zulkarnaen, 2018). The reason why students find modeling problems difficult is that until they encounter modeling activities in the project, they encountered problems in mathematics lessons that are disconnected from real life, in which procedural skills come to the fore.

The students who participated in the project stated that the modeling studies carried out with group work facilitated the modeling process, provided different views, had the opportunity to correct mistakes and exchanged ideas, and they found it positive. These results reinforced the idea that group work is important as it facilitates the modeling process of students as stated by Warwick (2007). This result also shows parallelism with the results found by Deniz and Akgün (2014), which in their study with secondary school students, that the students exchanged information among themselves about group work and realized the existence of different ideas.

It is seen that the views of the students participating in the project on the usefulness of mathematics in modeling activities are generally positive. Students stated that they could see different solutions with modeling, they could see that mathematics is used everywhere in daily life, and their self-confidence increased. According to Hernández, et. al. (2016) mathematical modeling isn't just for science - it transcends disciplines and provides tools for students to engage with real problems in society. Therefore, it is seen that these students who encounter modeling for the first time can realize the relationship between daily life and mathematics. Looking at the studies conducted in middle school, Doruk and Umay (2010) found that middle school students dealing with modeling problems were successful in transferring mathematics to daily life. In also Deniz and Akgün's (2014) study, secondary school students stated that they understood where mathematics is used in daily life. This result shows that mathematical modeling applications have an important role in changing the thought that mathematics is only about operations or that it is an abstract course. Despite these positive comments in this study, it is seen that there is a student who thinks that it has a negative effect on the usefulness of mathematics because they could not reach a consensus while solving mathematical modeling problems. This result coincides with the results of Delice and Taşova's (2011) study. In this study of the researchers, it was seen that although the students try to create a common mathematical meaning by combining the ideas they have about the problem with group work in the modeling process, sometimes the dominant role of one or two people in the groups can cause other individuals to hold back.

When the students' views about the use of real-life modeling in lessons are examined, it is seen that they generally express positive views. In generally. modeling problems are initially uncertain (Kaiser &Schwarz, 2006) and this allows students to look at the problem from different perspectives. Therefore, the modeling process allows students to feel that they are competent to complete the given problems (Stillman, Brown & Galbraith, 2013). In this study, the majority of students also want to include modeling activities in math lessons because it enables them to realize different solutions and to think more freely. Regarding this, it is also

seen in the study conducted by Deniz and Akgün (2014) with high school students that the students want mathematical modeling problems to be included in math lessons because they are thought-provoking. Despite these positive thoughts, some students did not want modeling activities to be included in math lessons due to the difficulty of modeling problems.

Recommendations

*Especially, students living in rural areas were able to both participate in group work outside of school and find the opportunity to realize the real-life relationship between mathematics and mathematics. Therefore, mathematical modeling applications should be included more in the projects in order to enable students to meet with modeling problems.

*In addition to mathematical modeling applications, activities such as STEM activities, which allow interdisciplinary work (Yıldırım, 2021), can be included in other projects to show the relationship between mathematics and daily life.

* Students stated that they were able to establish a relationship between mathematics and daily life thanks to modeling problems and that there could be different solutions. Real life problems should also be included in the mathematics lessons taught in middle schools and different solutions to these problems should be discussed in class.

*Moreover, modeling activities should be included in math lessons at all levels of math education. Regarding this, Garfunkel and Montgomery (2016) stated in their studies that modeling applications from kindergarten to 8th grade are a way to develop and maintain students' positive tendencies towards math.

* Group working in modeling processes enables students to express themselves and to take different ideas into account. In this way, students can gain multidimensional thinking skills when they encounter different opinions. In this study, even if there is no problem in group work in general, more group work should be done for the differences of opinion to have a positive effect on reaching a solution.

REFERENCES

Blum, W., & Borromeo Ferri, R. (2009). Mathematical modelling: Can it be taught and learnt?. *Journal of Mathematical Modelling and Application, 1* (1), 45-58.

Bukova Güzel, E. (Eds.) (2016). *Matematik eğitiminde matematiksel modelleme: araştırmacılar, eğitimciler ve öğrenciler için [Mathematical modeling in math education: for researchers, educators and students].* Pegem Akademi.

Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö.E., Karadeniz, Ş., & Demirel, F. (2008). *Bilimsel araştırma yöntemleri [Scientific research methods].* Pegem Akademi Publications.

Delice, A., & Taşova, H. (2011). Influence of individual and group work on the process of and performance in modeling activities. *Marmara Üniversitesi Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi [Marmara University Atatürk Education Faculty Journal of Educational Sciences]. 34* (34), 71-97.

Deniz, D. & Akgün, L. (2014). Secondary school students' views on the in-class application of mathematical modeling method [Ortaöğretim öğrencilerinin matematiksel modelleme

yönteminin sınıf içi uygulamalarına yönelik görüşleri*]*. *Trakya University Journal of Education Faculty, 4* (1), 103-116.

Doruk, B. K. (2010). *Matematiği günlük yaşama transfer etmede matematiksel modellemenin etkisi [The effect of mathematical modeling on transferring math to daily life] Unpublished PhD Dissertation.* Hacettepe University Institute of Social Sciences.

Doruk, B. K., & A, Umay (2010). Matematiği günlük yaşama transfer etmede matematiksel modellemenin etkisi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi [Hacettepe University Journal of Education], 41* (41), 124-135.

Duran, M., Doruk, M., & Kaplan, A. (2016). Mathematical modeling processes of pre-service math teachers: an example of the paradox of Achilles and the tortoise. *Cumhuriyet International Journal of Education, 5* (4), 55-71.

Erbaş, A. K., Çetinkaya, B., Alacacı, C., Çakıroğlu, E., Aydoğan-Yenmez, A., Şen-Zeytun, A., Korkmaz, H., Kertil, M., Didiş, M. G., Baş, S. & Şahin, Z. (2016). *Lise matematik konuları için günlük hayattan modelleme soruları [Daily life modeling questions for high school math subjects]*. Turkish Academy of Sciences.

Fisher, D. M. (2020). Algebra Students Build Stock/Flow Models to Study Non-linear, Dynamic Feedback System Problems. *Mathematical Modelling Education and Sense-making*, 505-514. https://doi.org/10.1007/978-3-030-37673-4_43

Garfunkel, S., & Montgomery, M. (Eds). (2016). *GAIMME: Guideline for assessment and instruction in mathematical modeling education.* Philadelphia: Consortium for mathematics and its applications (COMAP) & Society for Industrial and Applied Mathematics (SIAM).

Hattebuhr, M., & Frank, M. (2019, February). *Complex modeling: Does climate change really exist?–Perspectives of a project day with high school students.* In Eleventh Congress of the European Society for Research in Mathematics Education (No. 9). Freudenthal Group; Freudenthal Institute; ERME.

Hernández, M. L., Levy, R., Felton-Koestler, M. D., & Zbiek, R. M. (2016). Mathematical modeling in the high school curriculum. *The Mathematics Teacher, 110* (5), 336-342.

Kaiser, G., & Schwarz, B. (2006). Mathematical modelling as bridge between school and university. *ZDM, 38* (2), 196–208.

Lingefjärd, T. (2006). Faces of mathematical modeling. *ZDM Mathematics Education, 38* (2), 96–112.

Özer, A. Ö. & Bukova Guzel, E. (2020). In and out of class application of Bisim mathematical modeling activity. *International Journal of Educational Studies in Mathematics, 7* (4), 289-308. https://doi.org/10.17278/ijesim.837316

Sezer Evcan, S., Adilov, G., Zeynep, E. K. E. N., Barut, S., Kemali, S., & Tınaztepe, G. (2020) Evaluation of the "Math in our lives: Agriculture" project for 7th grade students within the scope of TÜBİTAK 4004-Nature Education and Science Schools. *International Journal of Educational Researchers, 3* (1), 28-41.

Sol, M., Giménez, J., & Rosich, N. (2011). Project modelling routes in 12–16-year-old pupils. *Trends in Teaching and Learning of Mathematical Modelling*, 231-240. Springer

Stillman, G. (2011). Applying metacognitive knowledge and strategies in applications and modelling tasks at secondary school. In G. Kaiser, W. Blum, R. B. Ferri, & G. Stillman (Eds.), *Trends in teaching and learning of mathematical modelling ICTMA 14* (pp.165-180). Springer.

Stillman, G. A., Brown, J. P., & Galbraith, P. (2013). Challenges in modelling challenges: Intents and purposes. In *Teaching mathematical modelling: Connecting to research and practice* (pp. 217-227). Springer.

Tekin Dede, A. (2015). *Developing students' modelling competencies in mathematics lessons: An action research study* [Unpublished PhD Dissertation]. Dokuz Eylül University.

Tong, D. H., Loc, N. P., Uyen, B. P., & Giang, L. T. (2019). Developing the competency of mathematical modelling: A case study of teaching the cosine and sine theorems. *International Journal of Learning, Teaching and Educational Research, 18* (11), 18-37.

The Scientific and Technological Research Council of Turkey (2019). *The text of call for TÜBİTAK 4004-nature education and science schools support program 2019.* https://www.tubitak.gov.tr/tr/destekler/bilim-ve-toplum/ulusal-destek-programlari/icerik-4004-doga-egitimi-ve-bilim-okullari

Warwick, J. (2007). Some reflections on the teaching of mathematical modeling. *The Mathematics Educator*, 17 (1), 32-41.

Yıldırım, B. (2021). Integration of STEM into Environmental Education: Preservice Teachers' Opinions. *Journal of STEM Teacher Institutes, 1* (1), 50-57.

Zulkarnaen, R. (2018, October). *Why is mathematical modeling so difficult for students?*. In AIP Conference Proceedings (Vol. 2021, No. 1, p. 060026). AIP Publishing LLC.