Osmangazi Journal of Educational Research **Volume 9(1), Spring 2022**

RESEARCH Open Access

Suggested Citation: Keklik, A., & Öztürk, A. (2022). Effectiveness of creative drama as a method in problems requiring mathematical modeling. *Osmangazi Journal of Educational Research, 9*(1), 1-26.

Submitted: 30/05/2021 **Revised:** 12/12/2021 **Accepted:** 26/12/2021

Effectiveness of Creative Drama as a Method in Problems Requiring Mathematical Modeling

***Akın KEKLİK, **Ali ÖZTÜRK**

Abstract. In this study, it was aimed to investigate the effect of creative drama processes in solving mathematical modeling questions of students. The research was handled in a quantitative design and an experimental design with control group was used. A total of 38 eighth grade students, 19 in the experimental group and 19 in the control group, participated in the research. Before the process, the experimental and the control groups took the preliminary test, the post-test and lastly the permanence test three weeks later. As a result of these tests, it was observed that creative drama workshops increased the success of the students. According to the results of the permanence test, it was concluded that that the success continued. In the light of the findings, it was discovered that the creative drama method and its approaches have positive effects on both success and permanence in the mathematical modeling process.

Keywords. Creative drama, mathematics, mathematical modelling, mantle of the expert, life.

***(Responsible Author)** Mathematics Teacher, Ministry of National Education, Tepebaşı Şehit Mutlu Yıldırım Secondary School, Eskişehir, Türkiye

e-mail: akinkeklik@gmail.com

** Prof. Dr., Eskişehir Anadolu University, Faculty of Education, Eskişehir, Türkiye

e-mail: alio@anadolu.edu.tr

Note: This article is derived from of the same name of Akın Keklik's Master's Thesis.

The importance of the term "Mathematical Literacy" has started to increase with the recent exams such as PISA and TIMMS. Mathematical literacy should be considered not only as a structure in which Mathematics is used but also as processes in which all the details of life exist and are used. Mathematical literacy is a life-oriented, interdisciplinary way of thinking that does not adhere to mathematical operations and rules. It is an understanding of how and in which way students can transfer and apply their knowledge to real-life situations and prove it, instead of simply proving their knowledge in the exams. According to Aydogdu Iskenderoglu and Baki (2011, p. 289), mathematical literacy is:

"It is a way to use and comprehend mathematics in our individual lives, when faced with the need to be constructive, engaged, and thoughtful as citizens, as well as to make well-founded defenses and use the individual capacity to diagnose and understand the role mathematics plays in the world."

In international exams, including the PISA exam held in 2018, it has been reported that students from Türkiye failed the exam in general. In the exam, students are expected not only to solve four basic arithmetic operations and practice problems but also to interpret mathematics in daily life problems and make some inferences about it. The Ministry of Education (MoE) also took steps in line with its expectations in a similar direction, and in 2018, it went through a renewal for the "Mathematics Curriculum". MoE listed the first three items under the title of the special objectives of the guide as follows.

"1. Students will be able to develop and effectively use mathematical literacy skills.

2. Students will be able to understand mathematical concepts and use these concepts in daily life.

3. Students will be able to easily express their thoughts and reasoning in the problem-solving process, and will be able to see the deficiencies or gaps in the mathematical reasoning of others (MoE, 2018)."

It is thought that the MoE signals that it will make changes and updates that will support mathematical literacy through its new approaches. It is accepted that the MoE has given the educators the idea that in the next period, it will take mathematics out of the impression of a memorized lesson and bring it to a more life-oriented line that allows for different methods. With the increasing importance of mathematical literacy, it will become a necessity for teachers, who need to serve this purpose, to seek alternative presentation methods. It is also thought that the importance of problem-solving will increase in this direction.

According to Altun (2010, p. 79), the problem-solving ability is perhaps the most basic skill required for the survival of humanity. Mathematics is almost as old as human history and problem-solving forms the basis of it. Problem-solving creates internal conflicts in mathematics and sows the seeds of many important inventions and developments. It is also a detail that should be kept in mind that mathematical literacy and its problems come from life, thus they can help students to adapt to real-world experiences and to have a kind of rehearsal for life. This approach will pave the way for raising students who can interpret and synthesize daily life with mathematics. In this way, mathematical thinking will be fed from all areas of life and supported by experiences and permanent learning will be provided. In this direction, the problems prepared in contexts that are close to the students or in which they can create experiences will increase the focus and interest of the students.

It will be possible for students to be inspired by the problem or to make comments based on experience with contexts close to them. In this way, students will be able to include other disciplines and enter the discovery process on the subjects they have an opinion on. With having this aspect, having contexts close to students' own lives will turn their prejudices towards problems into positive ones. Context problems are mathematical problems in which real-life situations that children witness or situations that they can imagine are presented in a wide framework (Yağcı & Arseven, 2010, p. 266). It is considered that especially students' exposure to questions prepared in contexts specific to the geographical regions they interact with, or exposure to problems prepared in contexts that are generally valid for all people, will also affect their problem-solving performance.

The primary purposes of problem-solving education are understanding mathematical expressions, increasing the processing ability and creating appropriate visuals such as shapes, tables etc. according to the problem. In general, the purposes can be listed as improving the ability to solve a problem situation and to transfer it to other situations. It is not a requirement to present these purposes when solving problems. In other words, there is no specific way or method of problem-solving processes. However, Polya showed an understanding, which is the most accepted understanding, that problem-solving processes can be put in an order as follows:

1) Understanding the problem

2) Choosing the appropriate strategy for solution (Planning)

3) Performing the strategy (Executing the plan)

4) Evaluation of the solution (Altun, 2010, p. 81)

Adhering to Polya's process sequence does not mean that it will always succeed and the problem will be solved. It is accepted that trying to solve the problem with such a discipline can be more effective in understanding the problem's details and the process steps. The linear progression of this gradual structure does not always seem possible. One of the problem types that does not comply with this gradual structure and where mathematical literacy is important is "Mathematical Modeling" problems.

Mathematical Modeling

Different definitions can be found in the field of mathematical modelling. Some of these definitions are given below.

- Mathematical modelling is the process of overcoming real-life problems (Keskin, 2018, p. 10).
- Mathematical modelling consists of transforming real-world problems into mathematical problems, solving mathematical problems and translating these solutions into the real-world language (Kapur, 2005, p. 5).
- In the most general terms, mathematical modelling is the process of analyzing a real-life situation using mathematical methods (Erbaş et al., 2014, p. 1608).
- Mathematical modelling is the process of expressing a real-life situation mathematically (Kertil, 2008, p. 1).

As can be understood from the definitions, mathematical modelling processes have a direct relationship with "real life". Due to this connection, the person who is exposed to these problems should adopt an interdisciplinary way of thinking. For the solutions of the problems, a logical relationship must inevitably be established not only with mathematics but also with every discipline related to real life. In the mathematical modelling process, the fact that there is not just one solution and result between the given and the desired of the problem is the point that separates the mathematical modelling from the problem-solving process (Türker Biber & Yetkin Özdemir, 2015, p. 48). The difference in modeling type problems is that the process both checks past learning and feeds on life experiences. The process is very close to the structure called “Metaxis” in the theatre that lives between the fictional world and the real world. In this way, it is thought that it will be easier for students to make sense of the question by pretending to be. Since students who will be persuaded to believe in this structure with the creation of enabling environments will not have limits in the questions to be solved with this structure, and knowing that this is fiction will lead them to think

freely and unlimitedly. By providing new learning syntheses in the mind, it is thought that permanent learning will take place, as students will create an experience for the solution of the problem as a result of these syntheses. In the literature, the most accepted problem solving step is by Altun (2010, p. 81), which belongs to Polya, is in a linear structure, which is expressed as follows:

1) Understanding the problem

2) Choosing the strategy for the solution (Making a plan)

3) Implementation of the chosen strategy (Implementation of the plan)

4) Evaluation of the solution

The solution of mathematical modeling problems may not comply with this structure and may show differences. Solutions of modeling type questions are not a linear process like the sequence put forward by Polya. Kapur (2005, p. 5) explained the process with a metaphor that we can catch the real-world problem with our teeth and dive into the ocean of mathematics, swim there for a while and come to the surface with the solution of the real-world problem. Alternatively, Kapur explained the process with another metaphor: "We can say that we ascend into the mathematical atmosphere with the problem, we fly there for a while and descend to the world with the solution". Based on these metaphors, the process is considered to be transitive and dynamic. This shows that mathematical processes do not have a static or constant structure. In fact, they are very dynamic processes with intense mental processes. According to Berry and Houston (1995, p. 24), the process basically has three stages; We formulate the mathematical model by describing mathematical structures (such as graphs, equations, inequalities, rigorously examining the assumptions we make) in terms of mathematical structures, or by representing the real world. Lesh and Doerr, one of the main works written on mathematical modelling, tabulated this structure as follows. The table shows the variables of this structure.

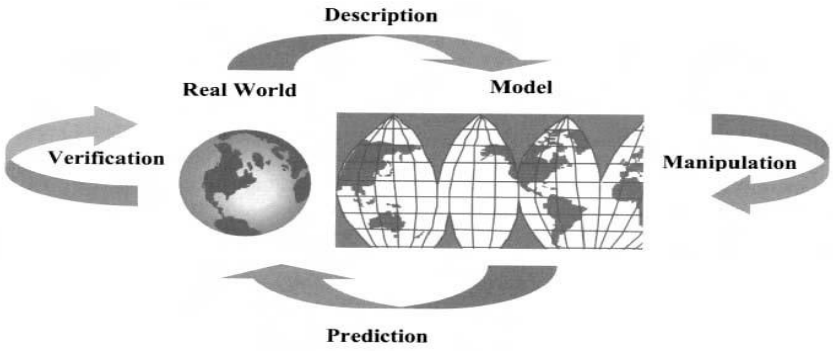


Figure 1. The Mathematical Modeling Cycle (Lesh & Doerr, 2003, p. 17).

To explain the concepts in the loop;

a) Description: Description that creates a mapping from the real (or imagined) world to the model world.

b) Manipulation: Manipulation of the model to produce predictions or actions related to the original problem-solving situation.

c) Prediction: Transferring results about the transformed (or predicted) to the real (or imagined) world.

d) Verification: Verification of the usefulness of actions and predictions.(Lesh & Doerr, 2003, p. 17)They have detailed this structure in the book prepared by Lesh and others with a more interconnected table as follows.

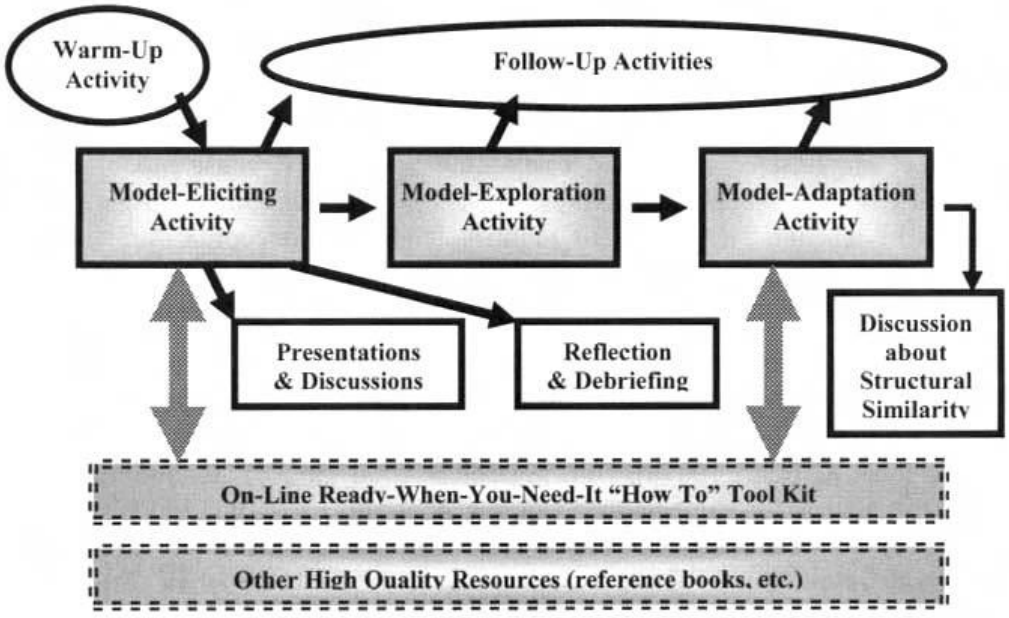


Figure 2. Standard Organizational Chart of the Model Development Sequence (Lesh & Doerr, 2003, p. 45).

In order to get the highest efficiency from the organization, it was put forward by Lesh (2003, p. 35-58) by utilizing the principle of "Dienes' Multiple Arrangement". It is thought that the aim is to create a map about how more meaningful and effective learning can progress in solving problems involving real-life situations. The beginning steps of the process are preparation, warm-up and model creation. However, the rest of the process is very complex and does not have to be linear. Due to the prominence of these intense intellectual processes, it is accepted that it is important for students to adopt the problem and try to combine it with their own lives.

Creative Drama

Creative drama is an another method and discipline in which intense intellectual processes are experienced and a solution to the conflict (problem situations) is sought by feeding on experiences, as in mathematical modelling. In this respect, it is thought that the "Creative drama" method, which feeds on life and removes the teacher from being an authority, will increase the desire of the student to internalize and to participate in the process. In addition, although creative drama processes don't have to be entertaining, they can be. It is thought that the processes structured in this direction by an experienced leader or trainer can be used in mathematical modelling processes.

Creative drama sessions are planned as "Preparation/Warm-Up, Improvisation/Roleplay, Evaluation". Creative drama can also progress with various approaches that do not adhere to this structure. To give an example of these approaches, especially Dorothy Heathcote's "Mantle of the Expert" and "Processual Drama" approaches are frequently used in drama processes. In this study, it was seen that the approach and planning were efficient, especially when the evaluation was made on the outputs. As mentioned in this study, the "Adiguzel Approach (Metinnam, 2019, p. 227)" or other approaches of creative drama were adhered to. In the sessions, examples that are close to the context of the students were chosen and it was ensured that they created experiences and benefited from each other's experiences. In this way, it was thought that the students would take steps to solve the problem by using their own or their friends' experiences. As a result of that, the efficiency of the process and the student's desire thought to be increased. In addition, as a result of the implemented workshops, it is thought that the ability to solve mathematical modelling questions and to create a model will create a life experience and that experience can be positively transferred to other questions. Another point is that creative drama workshops can also allow digital access. With this aspect, creative drama can structure a strong side according to the planner's preference. The fact that students can play certain roles through digital access is considered to be another very important aspect of the method in the process. When all these are put together, the "Creative Drama" method acts like a "Catalyst", which accelerates the reaction of the experiment and shortens the process for getting results and is effective in revealing the product. One of the reasons for this is that it can contain games. Although there is no game in every session, the presence of game-like processes is thought to be a motivational factor for these solutions. In the configuration, the game was used by the researcher to make the problem situation felt and to determine the variables. Among the approaches, the tool used in the "mantle of the expert" and expressed as "client letter" was used to transfer the problems. In addition, a letter with a similar function to this tool is used in the mathematical modelling process. While planning a usual

workshop, writing dramatic situations or problem statements, the problem situations are constructed by giving the components of dramatic structure such as role, focus, time, place, dramatic tension, movement, atmosphere, language, symbol, dramatic meaning and conflict situations. It is thought that these concepts increase the students' perseverance towards internalizing the questions and solving them.

Throughout the research process, the effect of creative drama workshops on the solution of mathematical modelling questions was investigated. In addition, the effect of the study on permanence was also investigated in this research.

To summarize briefly the techniques and layouts used in the process;

Role Playing: It is role playing in a game and requires sincerity. It is one of the main techniques of drama, which is one of the techniques of the theater and is used for students to take part and to see a flow from their own life and through the eyes of the person who will have a problem in the pretext of the problem situation.

Improvisation: It takes place spontaneously, freely, little designed or not predetermined, and exists with people (Adiguzel, p. 321). It is to act in accordance with the role and situation after a short preparation about a subject. It is used to assimilate the behavior and situation appropriate to the subtexts of the problems.

The Role of the Teacher: According to Adiguzel (2015, p. 332), the trainer can direct the process both as an external trainer and by taking a fictional role. This kind of selection is called the role of the teacher. In addition, in this way, it is ensured that the students do not deviate from the problem situation, which is the focus, and it provides both an eye looking from the outside to the inside and an eye that can observe the inside from the inside. It is ensured that the focus does not shift.

Meeting Order: In creative drama studies, it is carried out in the form of taking action for purposes such as group members making decisions together or developing suggestions, hearing and sharing any information, finding the source and solution of a problem, and making a plan together (Adiguzel, p. 362). In this study, this technique was used to make students evaluate their own answers and to create an environment for discussion within the role.

Frozen Image: According to Adiguzel (2015, p. 357), it is the creation of silent, wordless, still images by the members of the group with their own bodies individually or in small groups.

Gossip Ring: It occurs in the form of gossiping or whispering about the behavior of the main character that constitutes the problem or her/his general behaviors during the process, in the role played by the students in the process or in another environment but in an absolute role (Adıguzel, p. 360). This technique was used to allow students to freely express different perspectives and variables.

Dream Order: When using this order, animations are exhibited like a dream of any person, without a timeline, irregular, changeable independently of time and space, and not providing a unity. Sometimes, it was used for students to adopt the role, and sometimes to fill the subtext of the fiction about the problem situation. In some workshops, it provided the role analysis of the main character in different periods.

Small Group Improvisation: Before the animations, it was ensured that the students had discussions and decisions were made with smaller groups rather than with the whole group. Thus, dominant or very successful students were prevented from carrying out the process alone. In this way, fair groups were formed where all students could express their thoughts. Cycles were also provided between these groups, which changed each time.

Method

In this research, an experimental design based on the quantitative approach was used. In this design, pre-tests and post-tests were used, experimental and control groups were included, and the sample was randomly selected. Experimental researches are studies to test the effect of the differences created by the researcher on the dependent variable. The main purpose of the experimental design is to test the cause-effect relationship between the variables (Büyüköztürk et al., 2016, p. 195). The trials with the highest scientific value are constructed with real trial models (Karasar, 2016, p. 131). For this reason, it was deemed appropriate to conduct the research with an experimental design to determine the effect of the creative drama method on the process of solving problems in the type of mathematical modelling. At the beginning and end of the process, mathematical modelling questions were given to the students and the results were evaluated with the SPSS 22 software. All of the mathematical modeling questions selected for the pre-test, post-test, and workshops were taken from "Turkish Academy of Sciences (TÜBA)- Daily Life Modeling Questions for High School Mathematics Subjects" and "Mathematical Modeling in Mathematics Education - For Researchers, Educators and Students - Edt. Esra Bukova Guzel". Selected questions were shared with three mathematics field experts and their approval was obtained. The same questions were used at the beginning and end of the process.

In this study, the effect of plans applied with creative drama on the process of solving mathematical modelling problems of eighth-grade students was investigated. The study was carried out in the form of three-hour workshops outside the school. After the pre-test exam, the plans prepared for the students were applied and then the students were tested again with the pre-test exam. Finally, at the end of three weeks, at the beginning of the fourth week, a permanence test was given. None of the questions asked in the pre-test-post-test-permanence exams was handled in the practice workshops. At the beginning of the workshops, independent workshops were conducted to provide the students with ideas about improvisation and role-playing and to stimulate their integration with the role. In these workshops, workshops with communication, interaction, harmony, trust, animation rules, role playing and improvisation learning outcomes were applied.

Working Group

The research was conducted with eighth-grade students of a public school in the spring semester of the 2017-2018 academic year. The reason for the selection of these students is that the PISA exam is also applied in this age category and the success is low. Students were randomly selected from those who wanted to participate, especially with their own will. The practice was carried out during out-of-school hours when volunteers could attend the study. Thirty-eight students, seventeen male and twenty-one female, participated in the study. After the announcement was made to the students, volunteer participants were invited to the research. With the announcement, a total of thirty-eight students from two different classes applied to participate in the workshops and all of their applications were accepted. Nineteen of the invited students were classified as the experimental group and nineteen as the control group. Some time after the start of the workshops, two of the students left the experimental group for various reasons. Nineteen students, who stated their schedule and courses they were continuing at the beginning of the studies, agreed to be the control group voluntarily. The researcher first evaluated the academic levels of the group through the "8. Grade / … class, 4th, 5th, 6th and 7th Grade Year-End Weighted Grade Point Averages" certificate obtained through the Ministry of National Education's "e-School Student Information Evaluation System" and determined that there were no big differences between the groups.

Data Collection

A test was prepared to collect data. The prepared test was examined by one creative drama, three mathematics, one Turkish field, two education program experts and was used after their approval. In addition, feedback on the questions was received from a teacher who is not in the same

city and from the students whom this teacher thought to be at a high academic level, regarding whether the assessments for the problems and the test would be appropriate. Questions were sent to the aforementioned students via e-mail and they were asked to answer the questions. In addition, the same questions were evaluated by the teacher of those students and the teacher's approval was obtained. This test was also used as both the post-test and permanence test. With the three determined questions, the change in the success of the students in the modelling type questions was observed as a result of the creative drama workshops. During the application process, two sample workshops were given to students who did not have a creative drama background in order to provide information about the process. Then, five different modelling questions were handled in workshops organized with the creative drama method.

Data Analysis

In order to collect data, a written exam consisting of three questions was prepared for the students. Approval for the validity of this exam was obtained from one creative drama, three mathematics, one Turkish field experts and two education program field specialists. The prepared test was given to the experimental and control groups, both before and after the process. An answer key was prepared for the results of the prepared tests. The answer key was sent to three mathematicians and their approval was obtained. The tests given with this approval were evaluated by adhering to this answer key. In terms of reliability, the answers were re-read by another field expert and a third expert read the conflicting test papers. In this direction, safety calculations were made among the encoders. For the reliability calculation between encoders, the formula "(Agreement / (Agreement + Disagreement))x100" (Miles & Huberman, 1994, p. 84) was used. After the evaluation between the pre-test and post-test encoders, the reliability was calculated as approximately 95%. In other words, the results were evaluated as almost the same with each other. However, papers with different results were evaluated by a third expert. As a result, the answers were discussed and agreed in favour of the researcher. After these evaluations, using the SPSS 22 software, a significant difference was sought between the pretest-post test-permanence tests to see if there was a difference between the groups. It was investigated between which tests the significant difference occurred.

Results

In this study, non-parametric tests were applied because the number of students in the groups was below 30 and did not show a normal distribution.

Comparison of Experimental and Control Groups

There are many examples of experimental studies on the difference that emerged, starting with two groups that are at equal levels in research. In this study, the researcher first examined the existence of any significant difference between the groups that he would determine as the experimental and control groups. As a result of the evaluation of the two groups, there was no significant difference according to the Mann-Whitney U test (U=150.000; p>.05).

Table 1.

Preliminary Test Results of Experimental - Control Groups

Groups	N	X(AVG)	SS	Mann- Whitney U	Z	P
Experimental	17	2.0000	1.60078	150.000		.712
Control	19	1.8421	1.39496		- 369	

In this context, it can be said that the students in the experimental and control groups are equivalent at the beginning of the process according to the results of the mathematical modelling pre-test of the groups. With this evaluation, related workshops for the experimental group were started to be planned.

Comparison of Pre-Test-Post-Test-Permanence Test Results of the Experimental Group

As a result of the creative drama workshops, the data were collected by interviewing the students, collecting the data in writing, and then giving the "Post Test". The post-test was given to both the experimental and control groups at the same time. Three weeks later, the "Permanence Test" was given only to the experimental group students. The permanence test was conducted three weeks after the post-test and one week after the closure of the schools so that the students would not be in a hurry for the exam and could focus easily. Friedman test was used to determine whether there was a significant difference between the “Pre-Test-Post-Test-Permanence Test”.

Table 2.

Experimental Group Pre-Test - Post-Test- Permanence Tests Comparison

GROUPS	N	Mean	Std. Deviation	Chi-Square	P
Pre Test	17	2.00	1.60		
Post Test	17	9.17	3.82		.000*
Permanence	17	9.20	5.49	21.42	

**p<0.05*.

The Friedman test is a non-parametric test and reveals whether there is a significant difference in the relations of more than two data groups with each other. As a result of the analysis, a significant difference (chi-square = 21.429 and p <.05) was found between the pre-test, post-test and permanence test scores of the students. Then, an evaluation was made about which evaluations these significant differences were between.

Comparison of Pre-Test/Post-Test and Post-Test/Permanence Tests of the Experimental Group

The researcher revealed a significant difference with the Friedman test and used the Wilcoxon test to find out which two tests this significant difference was between. While using the Wilcoxon test, the researcher performed the tests between "Pre-test/Post-test" and "Post-test/Permanence Test". There was no need for questioning between the "pre-test and permanence test" because it is not considered to be an appropriate questioning for the purposes of the researcher.

Table 3.

Comparison of Pre Test/Post Test and Post Test/ Permanence Test

Groups	N	Average	Ss	Sıra Avg	Sıra Total	Z	P
Pre Test	17	2.0000	1.60078				
Post Test	17	9.1765	3.82811	9.00	153.00	-3.624[b]	.00*

*p<0.05.

It was observed that there was a significant difference between the pre-test and post-test scores of the students in the experimental group (p <.05). In this context, it was determined that the students'

post-test scores (X=9.1765) were higher than their pre-test scores (X=2.00). This was a finding that supports significant differentiation.

Comparison of Post-Test-Permanence Test

It was checked whether there was a significant difference in the evaluation made between the post-test and permanence tests.

Table 4.

Comparison of Post-Test/Permanence Test

Groups	N	Average	SS	Z	P
Post	17	9.1765	3.82811	-.126[b]	.900
Perm	17	9,2059	5.49164		

It was determined that the values (Z= -.126bp >.05) found as a result of the Wilcoxon test performed between the post-test and the permanence tests did not reveal a significant difference. In this context, it was observed that the success level of the students did not change after three weeks. It can be said that the level of success of the education that the students received in the experimental group did not change within the specified time. This shows that they are permanent in answering the mathematical modelling questions taught with the creative drama method.

Comparison of the Pre-Test/Post-Test Results of the Control Group

The researcher then evaluated the data of the control group and evaluated the pre-test and post-test results. The aim of this evaluation is to question whether there is a difference between the students who do not attend any creative drama workshop and continue their education with the MoE curriculum, which is also called the traditional method.

Table 5.

Control Group Pre-Test/Post-Test Comparison

Control Group	N	Average	SS	Sum of Rank	Z	P
Pre Test	19	1.84	1.39	33.50		
Post Test	19	2.05	1.35	57.50	-.885[b]	.376

As a result of the Mann Whitney-U test performed between the pre-test and post-test of the control group, it was revealed that there was no significant difference based on the values obtained

between the groups (Z=,885b and p=,376>,05). This means that the traditional method does not affect learning. From this point of view, it is thought that the MoE curriculum has no effect on the "Mathematical Modelling" skill. When the results obtained by the researcher were examined, it was determined that the small change seen in the average was because the students who were good in their group slightly increased their scores in the first exam.

Comparison of Post-Test Results of Experimental and Control Groups

The researcher made a double evaluation to make an evaluation between the post-tests of the experimental and control groups and noticed that there was a significant difference.

Table 6.

Experimental and control groups post-test comparison

Groups Post Test	N	Average	SS	Sum Of Rank	U	Z	P
Experiment	17	9.1765	3.82811	463.50			
Control	19	2.0526	1.35293	202.50	12.500	-4.752	.000*

*p<0.05.

For this evaluation, the researcher used the Mann-Whitney U test and it was determined that there was a significant difference since the resulting values were (U=12.500 and p <.05). It was determined that the score obtained from the post-test of the experimental group (X=9.18) was higher than the scores of the students in the control group (X=2.0526). This significant difference also proves the success of the method. In this context, it can be said that the creative drama method used in teaching mathematical modelling questions is more effective than the traditional method.

Conclusion, Discussion, Suggestions

In this research, eighth-grade students were faced with mathematical modelling questions and solutions were expected from them. As a result of the tests conducted at the beginning and at the end, it was determined that the effects of the creative drama workshops, which were determined as a method, were positive. It has been observed that the method gives successful results in mathematical modelling problems. Based on these results, it is thought that it will make an important contribution to the fields of mathematics education and creative drama. In the light of the findings, the following conclusions were reached.

- With the increase in the variables that the students could not display in the pre-test questions at the beginning of the process, it was concluded that they showed improvement in mathematical thinking.
- The advantages that creative drama provides to problems through storytelling (indirectly creating experiences) (life experience desek nasıl olur) are considered to be the ability to reveal more variables than normal and the success of the applied post-test. In particular, the fact that the students completed the post-test exam in a much shorter time than the pre-test exam and were more successful was evaluated as a kind of "catalyst" effect of the method on solving the questions correctly and on success.
- It has been concluded that creative drama will be effective by integrating the components of dramatic structure into mathematical problems.
- It has been determined that creative drama sessions increase the efficiency of mathematical modelling workshops and also have a significant effect on permanence.
- It has been concluded that creative drama workshops have an effect on permanence through the experiences they create.
- It was seen that enriching the problem with the components of the dramatic structure in the problem preparation process within the creative drama method had a positive effect on the process and the students did not break away from the process.

In the light of these evaluations, the fact that no classroom management problems were encountered during the process and the continuity of the students were interpreted both for the correct management of the process and for the willingness of the students. In this respect, as Korkmaz (2011, p. 206) mentioned, it has been seen as an aspect of creative drama for problems that can be beneficial in mathematic processes. The existence of students with an increase in academic achievement, averages obtained and students who improved in grades showed that the creative drama method was successful like other positive studies in the field. In this direction, a different example of a method in transferring questions to students in the field of mathematics has been put forward, with the method giving them a way they would be willing to do during the transfer of the problem to the students. In the process, processes such as “Metaxis”, “Role Playing”, “Improvisation” ensured students' permanence of learning by creating an experience. The results of the permanence test also showed that the students developed skills in revealing the variables and were able to transfer this. Considering the duration of the pre-test and the duration of the post-test, it was seen that the students finished the post-test earlier. In this case, it is thought that the creative drama method accelerates the process of

interpretation of the question and making a solution proposal. It is thought that this shows that the steps of understanding and strategy development are passed faster in problem solving, as Polya stated. It is thought that starting the creative drama workshops without any preparation and feeding from each other's lives increase the students' desire to explore. In this way, it has been accepted that creative drama is effective in revealing the variables with their reasons while creating an experience. This situation has been accepted as a strong aspect of creative drama.

- In this study, plans based on the "Adiguzel Approach" in the literature were applied. In the light of the evaluations and results discussed, it is recommended to evaluate the workshops structured with the "Mantle of the Expert" approach. In addition, it is recommended to conduct in-service training activities for teachers.
- In the study, no data were collected in the direction of gender-achievement and academic success - modelling question solving skills. This aspect is recommended to be studied in another study.
- It is suggested that more studies should be carried out on the "Mantle of the Expert" approach of creative drama and training should be planned to bring it together with teachers.
- For creative drama education to be used in mathematics lessons, it is recommended to be taught as a lesson along with its approaches, especially in the department of mathematics teaching in faculties of education.

About Authors

The First Author: Akın Keklik is a teacher at an secondary school in Eskişehir. He is a Maths teacher. He is interested in Maths, creative drama.

The Second Author: Ali Öztürk is an instructor at Anadolu University, Faculty of Education, Department of Fine Arts Education. He is interested in Creative Drama, Orff-Schulwerk, Music Teaching Methods, Theater.

Conflict of Interest

There is no conflict of interest between the authors.

Funding

No financial support was received.

Ethical Standards

Ethical and legal principles were followed in this research.

ORCID

Akın Keklik http://orcid.org/0000-0003-4733-4086

Ali Öztürk http://orcid.org/0000-0002-5160-1063

References

Altun, M. (2010). *İlköğretim 2. Kademe (6, 7, 8. Sınıflarda) Matematik Öğretimi* (7. baskı). Bursa: Alfa Aktüel Akademi Bas. Yay. Dağ. Ltd. Şti.

Aydoğdu İskenderoğlu, T. ve Baki, A. (2011). *İlköğretim 8. Sınıf Matematik Ders Kitabındaki Soruların PISA Matematik Yeterlilik Düzelerine Göre Sınıflandırılması.* Eğitim Bilim, 36(161), 287-301.

Berry, J. and Houston K. (1995). *Mathematical Modeling*. Oxford: Elsevier

Büyüköztürk, Ş., Kılıç Çakmak, E., Erkan Akgün, Ö., Demirel, F. (2016). *Bilimsel Araştırma Yöntemleri.* Ankara: PegemA Yayıncılık.

Erbaş, A. K., Kerkil, M., Çetinkaya, B., Çakıroğlu, E., Alacacı, C. Ve Baş, S. (2014). Matematik eğitiminde matematiksel modelleme: Temel kavramlar ve farklı yaklaşımlar. *Kuram ve Uygulamada Eğitim Bilimleri*, 14(4), 1607-1627.

Kapur, J.N. (2005). *Mathematical modeling* (Reprint). New Delhi: New Age International (P) Limited, Publisher.

Karasar, N. (2016). *Bilimsel araştırma yöntemi: Kavramlar ilkeler teknikler*. Ankara: Nobel Akademik Yayıncılık Eğitim Danışmanlık Tic. Ltd. Şti.

Keskin, Ö.Ö. (2008). *Ortaöğretim matematik öğretmen adaylarının matematiksel modelleme yapabilme becerilerinin geliştirilmesi üzerine bir araştırma.* Yayınlanmamış Doktora Tezi. Ankara: Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü.

Kertil, M. (2008). *Matematik öğretmen adaylarının problem çözme becerilerinin modelleme sürecinde incelenmesi.* Yayınlanmamış Yüksek Lisans Tezi. İstanbul: Marmara Üniversitesi.

Korkmaz, E. (2010). *İlköğretim matematik ve sınıf öğretmeni adaylarının matematiksel modellemeye yönelik görüşleri ve matematiksel modelleme yeterlilikleri.* Yayınlanmamış Doktora Tezi. Balıkesir: Balıkesir üniversitesi

Lesh, R., Cramer, K., Doerr, M.H., Post, T., Zawojewski, S.J. (2003). Model development sequences. R. Lesh and H.M. Doerr (Yay. Haz..), *Beyond Constructivism Models and Modeling Perspectives on Mathematics Problem Solving, Learning and Teaching* içinde (s.35-58). Londra: Lawrence Erlbaum Associates, Publishers.

Lesh, R. & Doerr,H.M. (2003). Foundation of a models and modeling perspective on mathematic steaching, learning, and problem solving. R. Lesh and H.M. Doerr (Yay. Haz.), *Beyond Constructivism Models and Modeling Perspectives on 170 Mathematics Problem Solving, Learning, and Teaching* içinde (3-33). Londra: Lawrence Erlbaum Associates Publishers.

MEB. (2018). *Matematik Dersi Öğretim Programı (İlkokul ve Ortaokul 1., 2., 3., 4., 5., 6., 7. ve 8. Sınıflar).* http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=329 adresinden erişilmiştir.

Metinnam, İ. (2019). Sınıf öğretmenliği adaylarının yaratıcı drama oturumu planlama sürecinde yaşadıkları sorunların incelenmesi. *Yaratıcı Drama Dergisi*, 14 (2), 219-242. Retrieved from http://www.yader.org/index.php/yader/issue/view/C14S2

Miles, M. B. ve Huberman, A. M. (1994). *Qualitative data analysis: An expanded source book*. Sage.

Yağcı, E. ve Arseven, A. (2010). *Gerçekçi matematik öğretimi yaklaşımı. International Conference on New Trends in Education and Their Implications'da sunulan*

bildiri. Antalya-Türkiye. s. 265-268. ISBN: 978 605 364 104 9. http://www.iconte.org/FileUpload/ks59689/File/55.pdf.

Appendix

Appendix-1

Workshop 7

Course : Mathematics

Subject : Mathematical Modeling

Grade/Duration: 8th Grade (20 people) / 3 hours

Place: Mutlu Drama Classroom

Methods and Techniques: Creative Drama (Mantle of Expert – The role of the leader, Meeting Technique)

Tools and Materials: Paper, pencil, ruler, meter, paper prepared for clue paper and photo.

Learning Outcomes:

- Creates the variables for mathematical modeling problems by using proportional thinking.
- Makes transformations of variables from each other's type.
- Develops a strategy for the solution of the problem
- Creates a mathematical model

Preparatıon /Warm-Up

Activity 1

The instructor divides the group into two and tells them to act out a murder they designed.

Animation

Activity 2

The instructor comes into the small meeting room next to the participants in the role of inspector, wearing a leather jacket. Then he says,

"Friends, we will earn a lot of money from this business, anyway, we have done this business for years. We were the most famous police investigators in the community. Our history is full of successes. I'm sure we will show everyone what detective work is with this company. We have only a few shortcomings left and we have to decide on them together."

Then, by creating groups in the class, giving a piece of paper to everyone:

"First of all, we should have a name, just as every company. In addition, we must report this to the police chief so that they can recognize and know us in everywhere, but we must decide on this together. If you want, everyone can come up with a name proposal first, then we can talk about the proposals"

Activity 3

The instructor gives the participants some time and finally tells them to speak individually. Afterwards, the trainer states that he will inform the relevant authorities about the name discussed and adopted and leaves the room.

Activity 4

Then the instructor states that she/he received a fax in the same role and starts reading.

"*TO THE _____ DETECTIVE OFFICE,*

Late yesterday, we learned that our daughter Professor Doctor Ayse YALDIZ, a world-famous botanist scientist, was the victim of a murder. The event took place on the island of Arkhe, which is a well-known natural protection area within the borders of our country. Due to the failure of the sent teams, we decided to contact you, our esteemed and experienced inspectors. As the Yaldiz family, we request your valuable inspectors' help in this regard, as we believe that the security forces are not working enough on this issue. We request that the crime be clarified as soon as possible and that the guilty or perpetrators are held accountable to justice. We want you to know that your hard work will be rewarded no matter what."

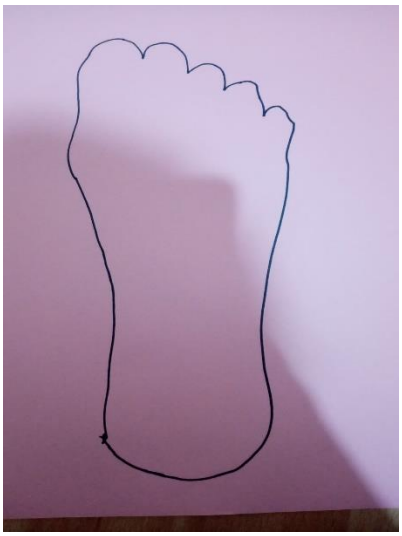
After reading the fax, the instructor turns to her/his friends;

"Friends, the only clue that belongs to the crime scene and is given to us is a footprint, and a photocopy of it in its original size has been sent. Also, this is the only clue in the whole area, all the suspects are in custody and it is very difficult to enter and exit the island, and no one can enter the island at the moment. In addition, UNESCO does not allow electronic devices to enter the island in any way, since it threatens natural life and is the first habitat in the world. In any case, transportation is done by ship until 1 km to the island, and then only by boats. As you can see, we have to solve this research with this clue at hand, because the transportation to the island takes a week, and when we get there, the clue will already be lost. Because the island is located in an area that receives heavy rainfall. Therefore, please let's get started right away, do you think we can reach a conclusion?"

Evaluation

Activity 5

The experiences of the whole group and why they apply the procedures and steps are listened to.



Appendix-2

Pre-Test / Protest / Permanence Test Questions

Question 1: Pricing For the Magazine

The sales price of Mathematical Thought magazine, which is published quarterly and each issue sells approximately 25,000, is 5.5 TL. However, due to the increase in the production cost, it became inevitable to increase the sales price of the magazine.

To better understand the negative impact of the increase on magazine sales.

In order to understand, a research was made among the readers. Accordingly, it is predicted that every 50 Krs. increase in the price will cause 1250 people to give up buying the magazine. If you were the managers of the magazine, how much would you set the new sales price?

Question 2. Ancient Age Residents

During the construction of a road, bones thought to belong to ancient people were found. Although not all of the skeletons were found, it was understood from their location that they belonged to two separate people. The lengths of the bones found are in Table 1; bones in the human body locations are shown in Figure 1.

First Skeleton Second

Skeleton -1

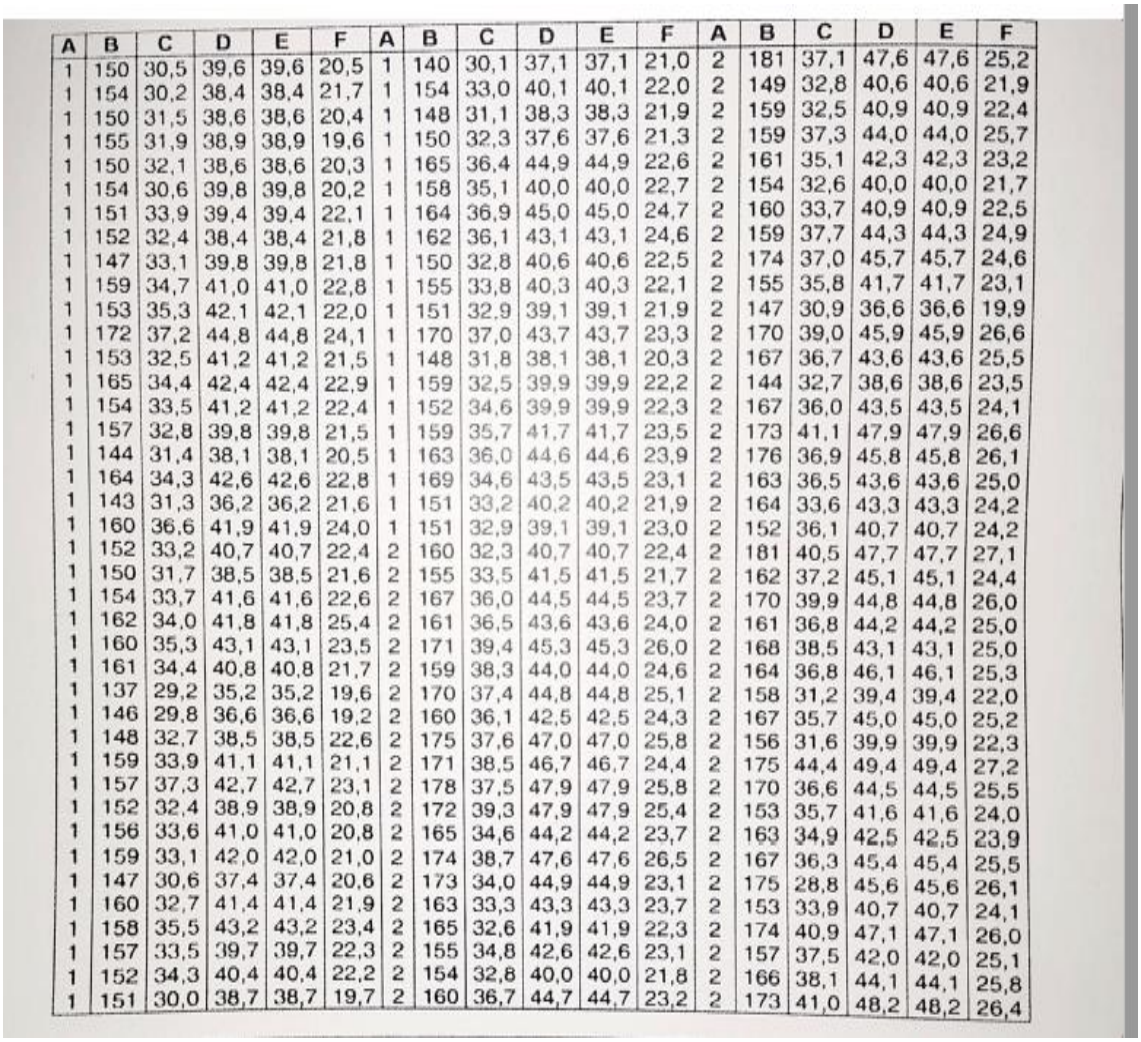
Biceps: 47.5 cm, 47.6 cm. Forearm bone: 25.8 cm

Skeleton -2

Biceps: 34.7 cm Forearm bone: 20.5 cm

It is important for historians to determine the physical characteristics of people who lived many years ago. In this regard, historians ask you (mathematicians like you) for help. Of course, your methods must be scientific and reliable. The statistical information obtained from the database of the Turkish Forensic Medicine Data Center (TFMDC), which may be of use to you in this regard, is given in figure 2. In this table, bone measurements compiled from people of different ages and genders are given.

Calculate the height of the persons to whom the first and second skeletons belong. State which models you prefer and why. (Mathematical models using the statistical relationships of bones to human height)



A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
1	150	30,5	39,6	39,6	20,5	1	140	30,1	37,1	37,1	21,0	2	181	37,1	47,6	47,6	25,2
1	154	30,2	38,4	38,4	21,7	1	154	33,0	40,1	40,1	22,0	2	149	32,8	40,6	40,6	21,9
1	150	31,5	38,6	38,6	20,4	1	148	31,1	38,3	38,3	21,9	2	159	32,5	40,9	40,9	22,4
1	155	31,9	38,9	38,9	19,6	1	150	32,3	37,6	37,6	21,3	2	159	37,3	44,0	44,0	25,7
1	150	32,1	38,6	38,6	20,3	1	165	36,4	44,9	44,9	22,6	2	161	35,1	42,3	42,3	23,2
1	154	30,6	39,8	39,8	20,2	1	158	35,1	40,0	40,0	22,7	2	154	32,6	40,0	40,0	21,7
1	151	33,9	39,4	39,4	22,1	1	164	36,9	45,0	45,0	24,7	2	160	33,7	40,9	40,9	22,5
1	152	32,4	38,4	38,4	21,8	1	162	36,1	43,1	43,1	24,6	2	159	37,7	44,3	44,3	24,9
1	147	33,1	39,8	39,8	21,8	1	150	32,8	40,6	40,6	22,5	2	174	37,0	45,7	45,7	24,6
1	159	34,7	41,0	41,0	22,8	1	155	33,8	40,3	40,3	22,1	2	155	35,8	41,7	41,7	23,1
1	153	35,3	42,1	42,1	22,0	1	151	32,9	39,1	39,1	21,9	2	147	30,9	36,6	36,6	19,9
1	172	37,2	44,8	44,8	24,1	1	170	37,0	43,7	43,7	23,3	2	170	39,0	45,9	45,9	26,6
1	153	32,5	41,2	41,2	21,5	1	148	31,8	38,1	38,1	20,3	2	167	36,7	43,6	43,6	25,5
1	165	34,4	42,4	42,4	22,9	1	159	32,5	39,9	39,9	22,2	2	144	32,7	38,6	38,6	23,5
1	154	33,5	41,2	41,2	22,4	1	152	34,6	39,9	39,9	22,3	2	167	36,0	43,5	43,5	24,1
1	157	32,8	39,8	39,8	21,5	1	159	35,7	41,7	41,7	23,5	2	173	41,1	47,9	47,9	26,6
1	144	31,4	38,1	38,1	20,5	1	163	36,0	44,6	44,6	23,9	2	176	36,9	45,8	45,8	26,1
1	164	34,3	42,6	42,6	22,8	1	169	34,6	43,5	43,5	23,1	2	163	36,5	43,6	43,6	25,0
1	143	31,3	36,2	36,2	21,6	1	151	33,2	40,2	40,2	21,9	2	164	33,6	43,3	43,3	24,2
1	160	36,6	41,9	41,9	24,0	1	151	32,9	39,1	39,1	23,0	2	152	36,1	40,7	40,7	24,2
1	152	33,2	40,7	40,7	22,4	2	160	32,3	40,7	40,7	22,4	2	181	40,5	47,7	47,7	27,1
1	150	31,7	38,5	38,5	21,6	2	155	33,5	41,5	41,5	21,7	2	162	37,2	45,1	45,1	24,4
1	154	33,7	41,6	41,6	22,6	2	167	36,0	44,5	44,5	23,7	2	170	39,9	44,8	44,8	26,0
1	162	34,0	41,8	41,8	25,4	2	161	36,5	43,6	43,6	24,0	2	161	36,8	44,2	44,2	25,0
1	160	35,3	43,1	43,1	23,5	2	171	39,4	45,3	45,3	26,0	2	168	38,5	43,1	43,1	25,0
1	161	34,4	40,8	40,8	21,7	2	159	38,3	44,0	44,0	24,6	2	164	36,8	46,1	46,1	25,3
1	137	29,2	35,2	35,2	19,6	2	170	37,4	44,8	44,8	25,1	2	158	31,2	39,4	39,4	22,0
1	146	29,8	36,6	36,6	19,2	2	160	36,1	42,5	42,5	24,3	2	167	35,7	45,0	45,0	25,2
1	148	32,7	38,5	38,5	22,6	2	175	37,6	47,0	47,0	25,8	2	156	31,6	39,9	39,9	22,3
1	159	33,9	41,1	41,1	21,1	2	171	38,5	46,7	46,7	24,4	2	175	44,4	49,4	49,4	27,2
1	157	37,3	42,7	42,7	23,1	2	178	37,5	47,9	47,9	25,8	2	170	36,6	44,5	44,5	25,5
1	152	32,4	38,9	38,9	20,8	2	172	39,3	47,9	47,9	25,4	2	153	35,7	41,6	41,6	24,0
1	156	33,6	41,0	41,0	20,8	2	165	34,6	44,2	44,2	23,7	2	163	34,9	42,5	42,5	23,9
1	159	33,1	42,0	42,0	21,0	2	174	38,7	47,6	47,6	26,5	2	167	36,3	45,4	45,4	25,5
1	147	30,6	37,4	37,4	20,6	2	173	34,0	44,9	44,9	23,1	2	175	28,8	45,6	45,6	26,1
1	160	32,7	41,4	41,4	21,9	2	163	33,3	43,3	43,3	23,7	2	153	33,9	40,7	40,7	24,1
1	158	35,5	43,2	43,2	23,4	2	165	32,6	41,9	41,9	22,3	2	174	40,9	47,1	47,1	26,0
1	157	33,5	39,7	39,7	22,3	2	155	34,8	42,6	42,6	23,1	2	157	37,5	42,0	42,0	25,1
1	152	34,3	40,4	40,4	22,2	2	154	32,8	40,0	40,0	21,8	2	166	38,1	44,1	44,1	25,8
1	151	30,0	38,7	38,7	19,7	2	160	36,7	44,7	44,7	23,2	2	173	41,0	48,2	48,2	26,4

Figure 2. Türkiye Forensic Medicine Data Center (TFMDC) Database (Key, A column 1: Male, 2 Female, B column height (cm), C column shin (cm), D column thigh bone (cm), E column biceps bone (cm), F-pillar forearm bone (cm)

Data Source: "http://web.utk.edu/-auerbach/GOLD.html" and "Auerbach, B.M., & Ruff, C.B.(2004). Human body mass estimation: A comprasion of "morphometic" and "mechanical" methods. American Journal of Physical Anthropology, 125, 331-342."

Question 3: Hay Bale Problem

In the figure below, there are 5 straw bales in the bottom row. When moving to the next row, one straw bale decreases each time, that is, 5, 4, 3, 2, 1 straw bales are arranged from the bottom to the top. Calculate the approximate height of the entire stack accordingly.