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THE EFFECT OF ACTIVITIES IN ROBOTIC APPLICATIONS ON STUDENTS' PERCEPTION ON THE NATURE OF SCIENCE AND STUDENTS' METAPHORS RELATED TO THE CONCEPT OF ROBOT

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ABSTRACT

The purpose of this study is to examine students' perceptions of the nature of science and metaphors related to the concept of robot, to determine the differentiation in these perceptions and metaphors resulting from LEGO NXT robot applications, and to share some good examples of education-oriented activities with robots. In this study, a hybrid research method, which is a blend of a qualitative descriptive survey model, pre-test, post-test semi-experimental patterns without controlled group, is utilized. The working groups consist of 48 students, who are volunteers to take part in the research, from 3 different high schools. The data are collected using a "metaphor form" consisting of open-ended questions, utilizing the Scale for Understating Nature of Science. The findings based on our analyses are as follows: The students' perception on the nature of science is generally at medium level and there are no students with low level of perception. Activities with robots contribute considerably to the level of students' perception on the nature of science. A comparison of the results obtained from pre-test and post-test illustrates that prior to the activities, some students suppose that robots are like humans with an ability to think but after the activities none of them consider the robots to have the ability to think.

Key Words: Robots, nature of science metaphor, misconception.

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INTRODUCTION

The nature of science has been an argument of a long-standing discussion among scientists, philosophers and education scientists. The science, apart from being a stand-alone consistent process, is an insight to understand how does this process accomplished and the process itself and to elaborate the attributes of the end-product of this process is termed as "science process skill" or "scientific literacy" (Lederman, 1992). The science literacy is to have an ability to define, to describe and to predict the natural events in which one has some interest. In a similar manner, science literacy is to have an intentional and informed stand against the regional and international scientific topics. A citizen with science literacy should be expected to make comments on the fundamental sources of and on the processes related to the scientific knowledge (NRC 1996; Bell, 2008). For an individual to acquire such knowledge, skill, and attitude and to have consciousness on the science literacy certainly depend on a number of factors. One of those factors is to "understand the nature of science". Despite the fact that this factor is considered to be one of the most important components, researches show that the students lack this understanding (Lederman, 2007).

In order to improve students' understanding on the nature of science, various Science and Technology courses have been introduced in the curriculum of high schools with expectations to provide skills such as observation, questioning, interpreting, experiment setup and research, measurement, description and generalization (Osborne and Simon 1996; Edwards and Talbot, 1997; Goldworthy, 2000). In a similar manner, Information and Communication Technologies (ICT) are expected to have positive effects on improving science and technology education and to provide educational and complementary tools (Marsh, 1994; Walton, 2000). Furthermore, it is shown that the implementation of technology in classroom provides considerable improvements in achieving the objectives of the course, in gaining some science skills, on effective use of the time, and in acquiring critical thinking and creative thinking (Webb, 1997; Goldworthy, 2000). Yalın (2002) describes the computers as highly important multifunctional tools that offer indispensable opportunities in education process.

It is not only computers that should come to mind within the scope of information and communication technologies. Besides computers, in parallel with developments in robotics in recent years, use of robots in teaching and learning environments can be seen. Model robots are beneficial especially in teaching such concepts and processes as computer programs, electronic vision, hearing, feeling, and decision-making that students perceive as too abstract or have difficulty in perceiving. As well, robots can be effective in instilling higher-order thinking skills including critical thinking, quantitative thinking, and creativity. In the literature, studies that employ programmable LEGO and Mindstorm robot family can often be encountered. For example, in a study conducted by Sartatzemi (2005), high school students were given training in basic programming using these robots and it was concluded that robots support learning. Kamada et al. (2008) expressed that high school students like to build and program robots and that the students in the experimental group were significantly better than the control group at comprehending embedded systems. The fact that the use of model robots in teaching programming increases student motivation and helps create a learning environment that is more fun was revealed by a research performed by Pásztor et al. (2010).

Considering the embodiment and motivational contributions that robot applications provide, it can be said that robots can offer significant benefits for educational practices geared towards students to help them understand the nature of science. In this context, sustainable development of a society requires scientific and technological literacy by producing scientific information and direct involvement of society in producing, processing, and utilizing knowledge. This requirement can only be met by a society which acknowledges science and scientific processes, and possesses a high level of scientific and technological literacy. Furthermore, such a society should eliminate the misconception that the science is an action performed by and devoted only to the geniuses or gifted individuals. The misperception about the nature of science and engineering hinders new generation from taking a career in science and engineering, and results in a lack of interest in science and technology among teenagers. This phenomenon is not a problem faced by developing countries only; developed countries also suffer this problem. In literature, some studies show that the younger generations are reluctant to have a carrier in science and technology due mainly to misperception about the nature of science and engineering. In order to clear this misperception, such activities are supported among teenagers that elevate an interest in science and technology and contribute to shaping of individuals who will be exposed to scientific processes and concepts and, through these activities, be encouraged in acquiring careers in science and technology (LoPresti, Manikas and Kohlbeck, 2010; Yilmaz, Jianhong, Custer and Coleman, 2010). The activities provide means to improve the scientific and technological literacy by isolating the preconceptions and contribute to shaping of the information society.

The ever-increasing usage of technology in the daily life requires technological literacy to be a common value in the society and the technological literacy becomes an important part of scientific literacy. However, technology is misinterpreted in the society. For most people, technology is generally considered as computer, electronic gadgets and Internet (Rose, Gallup, Dugger ve Starkweather, 2004), and furthermore, technology is considered simply a direct implementation of science. The lack of understanding on the nature of technology prevents comprehending the interconnection between the scientific knowledge, the process of implementation of scientific knowledge to produce technological products and interaction between science and technology (Cajas, 2001). On the other hand, there are common misperceptions and beliefs in society such as the boys are better than girls in engineering, the engineers are asocial in daily life lacking in writing, speaking and communication skills (Yaşar, Baker, Robinson, Krause ve Roberts, 2006). Such beliefs and misperceptions are the common causes that either discourage young generation from having a career in science and technology or deter them from possessing technological literacy which is a part of scientific literacy. It should be understood that engineering is a social practice and in this profession team working and communication skills are indispensable qualities (Cajas, 1998).

The prejudices and misperceptions in the society may be better understood by investigating the metaphors of the students on the subject. A metaphor is a cognitive structure to define the not-well-known concept by creating analogies with another concept which is known (Kaya, Durmuş, 2010). Palmquist (1996) considers metaphors as cognitive strategies to improve our understanding and to provide additional point of views between concepts and events. (Arslan, Bayrakcı, 2006; Kaya, Durmuş, 2010). Metaphors are common in different spheres of education. These useful structures may also be used for a better insight of technology by the students (Kaya, Durmuş, 2010).

The purpose of this study is to examine students' perceptions of the nature of science and metaphors related to the concept of robot, to group the metaphors under conceptual categories, to determine the misconceptions, to reveal whether these perceptions and metaphors change as a result of applications based on LEGO NXT robot activities, and to share some good examples of education-oriented activities with robots.

Sub-problems in the Research

1. What is the perception of the students towards the nature of science before activities?
2. Does the perception of the students towards the nature of science show any difference between the genders?
3. Does the perception of the students towards the nature of science show any difference due to the type of high school?
4. Does the project affect the perception of the students towards the nature of science?
5. What are students’ metaphors related to robots?
6. Can the metaphors related to robots and kitchen robot be categorized based on their conceptual common features?
7. Is there any variation on the metaphors after the robotic activities with LEGO NXT?
8. What are students’ misperceptions related to robots?

METHOD

Research Model

In this study, a hybrid research method, which is a blend of a descriptive survey model, pre-test, post-test semi-experimental patterns without controlled group, is utilized. It is known that descriptive research defines the subject under investigation. On the other hand, survey models are based on identifying the current situation as it is and with an objective perception. In this study, the aim is to identify the perception of students, who are studying in different types of high schools, on the nature of science and metaphors related to robots. The effect of activities with robots on the students' perception on the nature of science and metaphors related to robots are measured.

Working Group

The working group consists of 48 students, who are volunteers to take part in the research, from 3 different high schools in the city of Konya, namely Dolapoğlu Anatolian High School (Dolapoglu AHS), Fatih Vocational High School (Fatih VHS), and Private Enderun Science High School (Enderun SHS). The gender and the distribution of the students are given in Table 1.

Table 1: Working Group

High School	Girl	Boy	Total
Dolapoğlu AHS	5	16	**21**
Fatih VHS	0	14	**14**
Enderun SHS	2	11	**13**
Total	**7**	**41**	**48**

Data Collection Tools

Scale for Understating Nature of Science

The data is collected using the Scale for Understating Nature of Science. This scale, developed by Can (2008), consists of 35 items which are grouped in three factors. Under the factor "science", there are 12 items aiming to measure the science perception of the students. The inner-consistency of the factor is 0.72. The factor "scientific knowledge" consists of 14 items to measure the students' perception towards scientific knowledge. The inner-consistency of this factor is given as 0.82. Another factor titled "scientist", which is comprised of 9 items, is employed to measure the students' perception towards scientists. The inner-consistency of the factor is found to be 0.69. The scale is a Likert-type scale with the lowest score of 35 and the highest score of 175.

Metaphor Form

The data is collected using a questionnaire consisting of open-ended questions such as "robot is like….. since….." and "kitchen robot is a robot since it is…., "kitchen robot is not a robot since…..". The second question is not a metaphor and is used to detect misperception. An explanation about the metaphors is given to the students before they have written their opinion. It is required from the students to write down their reasoning why robots are like living-beings. In metaphor studies, "a like" statements are used to find the relation between the object which is linked to the other object using the metaphor whereas "because" statements are utilized to uncover the cause and "logical ground" in the students' metaphor (Saban, 2005, Ocak ve Gündüz, 2006).

Activities

In this research the activities designed to integrate technology education with pre-conditions of scientific literacy by focusing on design and engineering exercises to help students develop a positive attitude towards engineering and technology and for elimination of their prejudices and misconceptions can be summarized as follows:

Activity 1 (Two People = One Robot): This is an activity in game format where the primary goal is to carry foam rubber blocks on a platform from one end to the other. Each team consists of 6 students, 3 groups of 2 carry the blocks in order. One student in every group does the carrying with eyes blindfolded and the other member of the group directs the carrier using communication rules that they both agreed upon previously. Detailed activity sheet is given in Appendix-1.

Activity 2 (Color Perception and the Human Eye): This activity aims at providing an understanding of nature of color perception and human vision system. As part of this activity, an experiment is conducted and students brainstorm around questions asked. The final aim is to acquire knowledge about the robotic vision. A brief introduction to human vision system is supplied and the concept of color image perception is introduced by a concise explanation about the rode cells and cone cells in an eye. In addition, a competition is organized using a Color Synthesizing Software developed by the project team where the students are asked to synthesize colors from 3 primary colors. Those students that finish synthesizing colors requested at the shortest time are awarded by surprise presents. Detailed activity sheet is given in Appendix-2.

Activity 3 (Distinguishing Male/Female Voice using Artificial Ear Software): In this activity, students are expected to carry out different experiments about the sound using a sound synthesizer software installed on their computers. Firstly, they are requested to create the sound of every frequency given in a table using the sound synthesizer software and then listen to it. They are then asked to classify those sounds as "bass", "middle" or "treble". In the last experiment, students are required to find out the correct set of parameters in the Artificial Ear software, which is developed by the project team, in order to successfully distinguish female and male voices. The final goal of this activity is to instill an understanding that robots can analyze the speech if they have an ability of processing the sound signal. Successful teams are awarded by some presents. Detailed activity sheet is presented in Appendix-3.

Activity 4 (Lego Mindstorms NXT Robot Assembly): The goal of this activity is to build a programmable robot by putting together different parts and sensors in Lego Mindstorms NXT set. Programming exercises to have the robot perform small tasks are conducted on the robot built. This activity gives first-hand experience to the students that a robotic system could be constructed by using different types of small units and actuators. Lego Mindstorms NXT book set is utilized for this activity.

Activity 5 (Lego Mindstorms NXT Robot Design and Programming Competition): The last activity is designed so that students can apply the knowledge they are expected to have acquired from the previous activities. In this activity, students are required to develop and design a robot which can "see" and "hear". The robots are built from a LEGO Mindstorms NXT sets. Student teams compete for the best program resulting in the best robot show and are judged on various criteria. Detailed activity sheet is presented in Appendix-4.

Data Analyses

On the data collected using the Scale for Understating Nature of Science, some statistical analyses such as the frequency, percentage, Mann–Whitney U, Kruskal-Wallis H, and t-test have been carried out and results are interpreted. The level of meaningfulness for difference and relation is accepted to be $p<0.05$. The raw score for each factor is determined by accumulating the responses on a 5-point Likert-type scale and the raw score is divided by the number of questions and then is multiplied by 20, which results in either the lowest score of 20 or the highest score of 100. The possible highest and lowest values for each factor are constants. The score from the scale is interpreted to classify the students' perception on the nature of science as to be low, medium and high. If the score less than 34, the perception is considered to be low; if it is between the range of 34 to 67, it is accepted to be medium; otherwise, it is regarded as high.

The analysis and interpretation of the metaphors are performed following steps as in Ocak (2005): (1) Firstly, it is determined whether a particular metaphor is presented clearly. (2) It is then determined whether each of the metaphors developed by the students is useful in understanding of the concept of robot. If so, these metaphors are included in the analysis phase. (3) The "logical ground" or "the cause that is expressed to explain the metaphor" is analyzed. (4) The metaphors which have more than one similarities declared by the students are excluded from analysis phase. (5) The metaphors which have common attributes are categorized in the same category. Collected data is then transferred into a computer for quantitative data analysis.

Out of 48 students who declared the metaphors related to the concept of robot in the pre-test, only 34 of them are included in the study based on the analyses in four processes declared above. On the other hand, 37 students' metaphors are included in the post-test. In the final stage, the number of students (f) and their percentage (%) for each metaphor and corresponding categories are calculated, the metaphors are grouped based on their common features, and tables obtained from the pre-test and post-test are created. The questions related to the kitchen robot, which illustrates the misperception of the students, have been asked before project activities and analyzed in order to identify the misperceptions. Furthermore, Pearson Chi-square statistic method is utilized to determine the variation on the students' perception of robots after LEGO NXT robotic activities.

Constraints

The scope of the study is restricted with In the project entitled "Hearing and Seeing with Robots" which is funded by TÜBİTAK and conducted at Mevlana University. The total number of students involved is 48.

FINDINGS

The perception of students on the nature of science has been measured before the project activities in terms of the factors in the scale, namely "science", "scientific knowledge" and "scientist".

The students' perception on the nature of science

Table 2 summarizes the perception of the students involved in the study on the nature of science.

Table 2: Students' perception on the nature of science

Factor	Low Score		Medium Score		High Score	
	f	%	f	%	f	%
Science	0	0	23	47.9	25	52.1
Scientific Knowledge	0	0	43	89.6	5	10.4
Scientist	0	0	41	85.4	7	14.6
Total Score	**0**	**0**	**38**	**79,2**	**10**	**20,8**

As seen from Table 2, the perception of the students who are from different types of high schools is found to be 79.2% medium and 20.8% high. When it is evaluated based on the factors, it is found that the perception of students on "the science" (which is 52.1%) is higher compared to the perception on "scientific knowledge" (which is 10.4) and "scientist" (which is 14.6). Based on these findings, it can be concluded that there is no student with low perception on the nature of science and in general the students' perception is at a medium level.

The difference in the perception of the students on the nature of science with respect to gender before the activities

Table 3 illustrates the findings on whether there is a meaningful difference, with respect to gender, in the perception of the students on the nature of science.

Table 3: Perception on the nature of science with respect to gender (girl N=7, boy N= 41)

Factor		Mean Rank	Sum of Ranks
Science	Girl	26.14	183.00
	Boy	24.22	993.00
Scientific Knowledge	Girl	17.93	125.50
	Boy	25.62	1050.50
Scientist	Girl	21.64	151.50
	Boy	24.99	1024.50
Total Score	Girl	21.29	149.00
	Boy	25.05	1027.00

Test	Science	Scientific Knowledge	Scientist	Total Score
Mann-Whitney U	132.000	97.500	123.500	121.000
Wilcoxon W	993.000	125.500	151.500	149.000
Z	-0.337	-1.348	-0.588	-0.659
Asymp. Sig. (2-tailed)	0.736	0.178	0.557	0.510
Exact Sig. [2*(1-tailed Sig.)]	0.753	0.183	0.567	0.529

It can be concluded from Table 3 that there is no meaningful difference, in terms of total scores and factors, in the students' perception on the nature of science with respect to gender (p>0.05) and that the gender does not have any effects on the perception of the students on the nature of science.

The difference in the perception of the students on the nature of science with respect to the type of high schools before the activities

Table 4 shows the findings on whether there are any differences in the perception of students on the nature of science with respect to the type of high schools, before the project activities.

Tablo 4: Student perception on the nature of science w.r.t. the type of high school

Factor	High School	N	Mean Rank
Science	Fatih VHS	14	25.96
	Dolapoğlu AHS	21	25.24
	Enderun HS	13	21.73
Scientific Knowledge	Fatih VHS	14	26.71
	Dolapoğlu AHS	21	23.24
	Enderun HS	13	24.15
Scientist	Fatih VHS	14	22.32
	Dolapoğlu AHS	21	24.79
	Enderun HS	13	26.38
Total Score	Fatih VHS	14	25.36
	Dolapoğlu AHS	21	23.95
	Enderun HS	13	24.46

Test	Science	Scientific Knowledge	Scientist	Total Score
Chi-Square	0,726	0,533	0,590	0,085
Df	2	2	2	2
Asymp. Sig.	0,696	0,766	0,744	0,958

In the table, it is shown that there is no meaningful difference in the perception of the students with respect to the type of high school (p>0.05). As a result, it can be declared that there is no direct effect of the type of high schools on the students' perception on the nature of science.

The effect of the project activities on the students' perception on the nature of science

In Table 5, the findings related to the effects of the project activities on the students' perception on the nature of science are given.

Table 5: The effects of the project activities on the students' perception

Variables		N	$\overline{X}$	S	t	sd	p
Science	Pre-test	48	67,19	8,39	55,498	47	0,000
	Post-test	48	70,69	8,86			
Scientific Knowledge	Pre-test	48	60,38	5,65	74,26	47	0,000
	Post-test	48	60,89	5,68			
Scientist	Pre-test	48	61,02	8,46	49,94	47	0,000
	Post-test	48	66,80	8,50			
Total Score	Pre-test	48	64,29	5,12	86,99	47	0,000
	Post-test	48	65,57	5,58			

Concluded from Table 5 that the activities in this research do have a direct effect on the students' perception and there is a meaningful increase in the total score related to the students' perception on the nature of science ($t=86.99$, $p<0.001$). A similar effect is observable on the factor scores in that the project activities meaningfully increase the scores of all factors. As a result, it can be claimed that the robotic activities In this research has provided a considerable contribution to improve the students' perception on the nature of science.

Metaphors

34 valid metaphors in the pre-test and 37 valid metaphors are determined as related to the concept of "robot". The metaphors are categorized into four groups. Examples from the categories and the related metaphors are as follows.

The category "human with ability to think" includes the metaphors below:

Student 8: Robot is like a human since it does whatever living creatures can do
Student 21: Robot is like a human since it does whatever a human-being can do
Student 31: Robot is like a human since it decides based on reasoning

The category "robots are unable to think and they are unfeeling" includes the metaphors below:

Student 2: Robot is like a handicapped human since it does only whatever it is asked to do.
Student 24: Robot is like a human since, if it is programmed, it performs tasks using its sensors.
Student 29: Robot is like unfeeling human since it operates based on some commands and the feelings do not have any effect on the commands

The category "machine" includes the metaphors below:

Student 4: Robot is like an advanced machine since it can be controlled with advanced programming techniques.
Student 12: Robot is a useful man-made machine since it can be controlled by human to help human.
Student 19: Robot is like airplane since it helps save time and helps us to do too much in a short time.

The category "others" includes the metaphors below:

Student 22: Robot is like a pet since it follows the commands given.
Student 1: Robot is a garbage bin since it is full but only with invaluable things.
Student 27: Robot is like a stone since it has no feeling, although it helps much.

Table 6 summarizes the metaphors in the corresponding categories.

Table 6: Conceptual Categories obtained from the students' metaphor related to the concept of robots

Conceptual Categories	Pre-test		Post-test	
	N	%	N	%
Human with ability to think	9	26	0	0
Unable to think/unfeeling human	13	38	18	49
Machine/Tool	8	24	15	41
Other	4	12	4	10
Total	**34**	**100**	**37**	**100**

Pearson Chi-square (sd=3)=11.862; p=0.008

It can be realized from the table that the metaphors declared by the students can be categorized into four conceptual categories. In the pre-test, there are 9 metaphors in the "Human with ability to think" category. On the other hand, "Unable to think/unfeeling human" category contains 13, "Machine/Tool" category consists of 8 and "Other" category has 4 metaphors. The post-test, on the other hand, has following distribution: no metaphor in "Human with ability to think" category, 18 metaphors in "Unable to think/unfeeling human", 15 metaphors in "Machine/Tool" category and 4 metaphors in the "Other" category.

The metaphors in pre-test and post-test are investigated and it is found that a considerable amount of students (26%) in the pre-test think that the robots have ability to think like human-beings. On the other hand, none of students in the post-test agree with this metaphor. The reason behind this differentiation could be that students after the project activities have realized that robots are unable to do any task unless they are programmed by a human being.

38% of the students in the pre-test think that robots are unable to think and they are unfeeling. The percentage has increased to 49% after project activities. LEGO NXT robot kit used in the activities is suitable for building different kinds of robots and humanoids. A humanoid LEGO NXT has also been introduced to the students during the activities. The differentiation in this metaphor could be a result of introducing the humanoid which is unable to perform any task without being programmed by human.

24% of the students state that robots are like a machine in the pre-test. However this percentage is increased to 41% after the project activities. The increase can be contributed to the fact that students are exposed to the electro-mechanical systems even if they look like a humanoid robot.

The findings show that the activities have influence on the students' metaphors. In other words, the activities carried out using LEGO NXT robots create differentiation in the students' metaphors related to the concept of robots. This differentiation is statistically meaningful (χ^2=11.862; sd=3; p=0.008). Accordingly, the activities with LEGO NXT robots have affected the students' metaphors meaningfully. Also, if investigated it is realized that the misperceptions on the concept of robots are corrected after the activities.

33 students (69%) give an affirmative response to the question of "is the kitchen robot a robot?" (kitchen robot is called "kitchen robot" in Turkish), while the remaining 15 students (31%) respond negatively. The reasons stated by the students who affirmed are as follows:

- *Because it makes our life easier*
- *Because it helps us*
- *Because it is a machine with a function*
- *Because it saves our time and energy*
- *Because it operates under our control*
- *Because it has motors and tools*

On the other hand the students who disagreed are listed their reasons as follows:

- *Because it could not move*

- *Because it could not perform without human help*
- *Because it does not have arms and legs*
- *Because it is just a machine*
- *Because it is not able to give decision*
- *Because it is very slow*

If both sets of responses are investigated thoroughly, it is found that students perception on the concept of robot are highly diverse and they are unaware of technological issues related to robots such as automatic decision making, sensors for seeing, hearing, sensing, face detection and recognition, artificial intelligence etc. According to students, every machine that helps us to save time and help human could be a robot. Furthermore, according to students, it is necessary for a robot to have an ability to move and to have arms, legs (like a human). Robots should also be quick. Only a few students (N=5) express that the automatic decision making is a criterion for a machine to be considered as a robot. As a result, it can be stated that the students have considerable misperception on the robots and robotic technologies.

CONCLUSIONS

Conclusion on the Nature of Science

The students' perception on the nature of science is generally at medium level and there are no students with low level of perception. This could be a result of the fact that all students were eager to take part in this research activities despite the fact that they were on holiday and all activities were held in the summer. As it is indicated in literature, the interest is a key factor in the understanding the nature of science and science literacy. Based on these findings, it can be recommended that teachers who are responsible for improving science literacy among the students should trigger the interest of students by means of robotic activities. On the other hand, having the middle level of the perception on the nature of science among the students who are involved in this research could be due to their schooling stage. This finding can be interpreted that the science and technology education starting from primary school 4th grade contributes successfully to improve the science literacy among students.

The gender and the type of school do not have crucial effect on the students' perception on the nature of science. This could be a result of having a similar curriculum in all high schools and a result of reduced number of students to an acceptable level in a classroom to improve the education quality in high schools. In a similar manner, the gender factor does not affect the perception, as technologic gadgets and tools have recently became very common in daily life decreasing the effect of gender factor. Therefore, the gender factor might be considered as a trivial factor. However, high level learning environments with enhanced technological infrastructure and skilled teachers are necessary to improve science literacy and the perception on the nature of science.

The robotic activity with in this research contributes considerably to the level of students' perception on the nature of science. All the activities in this research have been performed either as a group work or individually by the students and learning-by-doing was the main strategy. The activities are designed, as much as possible, to be an interactive, clue-based, feed-back providing activities. Therefore, it is naturally expected that all the activities contribute to have a positive effect on the behavioral difference of students, leading to improving the students' understanding on the nature of science.

Conclusion on the Metaphors

After comparing the metaphors in the pre-test and post-test, it is found that some students consider robot to be like a human, with an ability to think, before the project activities. After the project activities on the other hand, no student considers robots to have an ability to think like human. There is great increase, after the project activities, in the percentage that the robots are mechanical tools without ability to think and unfeeling. In other words, the activities carried out using LEGO NXT robots create differentiation in the students' metaphors related to the concept of robots. It is found that this differentiation is statistically meaningful. Accordingly, it is found that the activities with LEGO NXT robots have affected the students' metaphors meaningfully and if investigated it is realized that the misperceptions on the concept of robots are corrected after the activities.

The differentiations in the metaphors could be contributed to the awareness developed during the activities that robots are unable to perform any task without being programmed by a human being. Also students are exposed to the electro-mechanical systems and they have realized that even if these systems look like a humanoid robot, they are electro-mechanical systems at the end.

In order to delve into the misperception on the robots, the question "is a kitchen robot a robot" has been asked to students and responses investigated to find out the requirements which are set by students, for considering a machine as a robot. If both negative and confirmative responses are investigated thoroughly it is found that students' perceptions on the concept of robot are highly diverse and they are unaware of technological issues related to robots such as automatic decision making, sensors for seeing, hearing, sensing, face detection and recognition, artificial intelligence etc. According to the students, every machine which helps us to save time and helps humans could be a robot. Furthermore, according to students, it is necessary for a robot to have an ability to move and to have arms, legs (like a human). Robots should also be quick. Only a few students state that the automatic decision making is a criteria for a machine to be considered as a robot. As a result it can be stated that the students have considerable misperception on the robots and robotic technologies.

The findings show that as Turkish society does not follow the technological developments closely and the level of scientific and technological literacy is not high enough, it seems to be necessary to conduct projects and surveys so as to measure and to improve the scientific and technological literacy. Furthermore, TÜBİTAK Science and Society programs should be promoted in order to contribute to the developments of similar projects.

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Appendix 1:

TWO PEOPLE = ONE ROBOT GAME

Goal: The main goal of this activity is to carry foam blocks from one end of the game platform to the other end at the shortest time possible. Each team consists of 6 students. 3 groups of 2 in each team will perform carrying of blocks in order. One of the group members will be blindfolded and will do the carrying. This member will be directed by the other member using communication rules that they determine beforehand. For example, for "TURN RIGHT" operation, a touch to right shoulder of the carrier might be used. Similar rules of communication should be decided on for other operations such as "HOLD", "CARRY", etc. With instructions from his/her group-mate conveyed by these communication rules, the carrier performs desired moves to carry foam blocks to target location. Here, the carrier should gain experience as to which move he/she needs to do in response to an instruction. In order for the teams to get familiar with rules of the game, they will be given 15-20 min. of time to practice on the platform.

Rules:

- Four teams of six students will compete.
- Each team will have three groups of two students.
- One student in every group will be blindfolded.
- Before the competition starts, members of every group must agree upon how to communicate with each other.
  - Determine which moves are necessary to carry the blocks to the target location. E.g. FORWARD, STOP, BACKUP, RIGHT, LEFT, PICK, DROP.
  - Determine the rules to communicate these moves. For example, touching right shoulder to instruct a turn to right.
- There will be only one group from a team competing on the platform at a given time.
- Foam blocks must be stacked one on another. If a stack gets high, to prevent its collapse, another stack can be started.
- There exists blocks of two different sizes. Each big block counts 10 points; each small block counts 5 points.

Penalties:

- Hitting obstacle blocks on the platform.
- While putting a block on a stack, toppling other blocks.
- Directing the carrier by touching continuously.
- Stopping the carrier by grabbing him/her.
- Giving a voice instruction.

There will be a deduction of 1 point for every penalty from the team's total point.

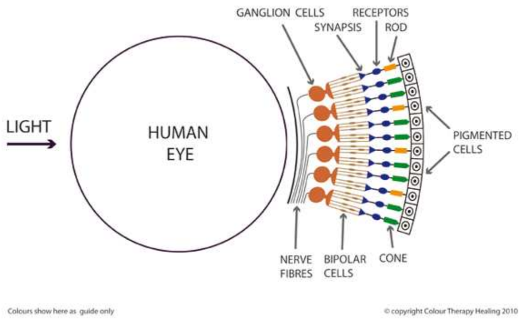
When there is no more foam block to carry, the game ends. The team that obtains the highest carrying score minus penalty points wins.

Appendix 2:

COLOR PERCEPTION and HUMAN EYE

Human Eye: Human eye has special photoreceptor cells called "rod" and "cone" cells. It is estimated that, on the average, there are 125 million rod cells and 6-8 million cone cells in an eye. Rod cells are only sensitive to light and receive images as black & white and levels of gray. Cone cells, on the other hand, possess sensors sensitive to RED, GREEN, and BLUE colors. Each type of color sensor is sensitive to light within a certain range of wavelengths. Human eye cannot sense light waves that are outside the range of wavelengths it is sensitive for. Can you find examples? In humans with color blindness, rod cells do not function normally.

Basic Cross section of the Eye - Showing the Rods and Cones



Experiment: LEDs used in remote control devices of TV and similar electronic equipment emit light in infrared frequency. However, we humans cannot see this light. Why? Try taking a video or a picture of a LED on a remote control device at a moment of operation. What do you see? Please explain.

Question: If our eyes have sensors sensitive to only RED, GREEN, and BLUE colors, how come we can also see colors other than these?

COLOR SYNTHESIS SOFTWARE and COMPETITION

Goal: Analyzing how to obtain colors from three basic colors in a computer environment.

Rules:

- You will be asked to synthesize different colors using the color synthesis software.
- You must show the colors that you synthesize correctly to your team coach. Your team coach will fill out the table below.

The team that finishes synthesizing colors given at the shortest time and shows them to team coach will grab surprise presents!

Name of the Team: ……………………………….………

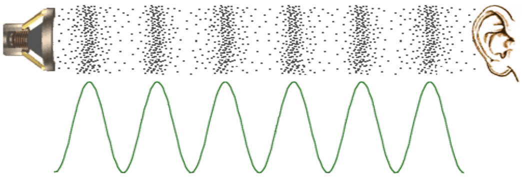
EVALUATION			
Color		Successful	Unsuccessful
1	Color1		
2	Color2		
3	Color3		
4	Color4		
5	Color5		
6	Color6		
7	Color7		
8	Color8		

Appendix 3:

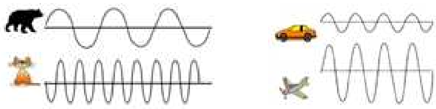
ARTIFICIAL EAR SOFTWARE and CLASSIFICATION of HUMAN VOICE

Goal: To understand sound waves and working principles of Auditory System.

Sound Waves: Sound waves are vibrations that can be propagated via solid, liquid or gas objects filling the space.

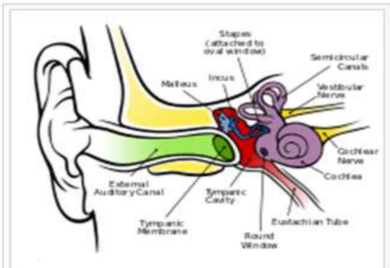


There are two important parameters of the sound: one is "frequency" value, the other is "amplitude" value. Knowing these two values of a sound signal provides us important information about that signal. The frequency of sound does not change with distance to the source of sound whereas its amplitude increases or decreases while getting closer to or farther away from the source.



The unit of frequency for sound signals is called Hertz. The number of oscillations or vibrations of a sound signal in a second gives us its frequency as "Hertz" (Hz). In addition, to measure the amplitude of sound the unit "decibel" (dB) is used. Within human ear's hearing thresholds, high frequency sound signals are named as "treble" sounds and low frequency sound signals "bass" sounds.

Auditory System: Sound can be defined as vibrations of air molecules. These vibrations create sound waves detected by human ear. Sound waves detected by the ear, in turn, are converted to signals interpreted by the brain. Auditory system is composed of four main components: outer ear, middle ear, inner ear, and the nerves going to the brain.



The components of auditory system can hear sound waves of between 20 and 22000 vibrations, meaning sound signals of frequency between 20 Hz and 22 KHz. Each species detects the sound signals of different frequency ranges. For example, bats, dogs and dolphins can hear sounds of frequencies outside the range that human ear can detect. Also, as a human gets older, his/her ear has more difficulty in perceiving high-frequency sounds.

CLASSIFICATION of SOUNDS USING ARTIFICIAL EAR SOFTWARE

Experiment: Using the sound synthesizer software that is installed on the computer and wearing your headphones, please test how comfortably you can hear sound signals of different frequencies. Create the sound of every frequency given in below table using the sound synthesizer software and then listen to it. Mark on the table those sounds that you perceive as "bass", "middle" or "treble".

Name of the Team: ……………………………………..………

Frequency		Bass Sound	Middle Sound	Treble Sound
1	150 Hz			
2	10000 Hz			
3	5000 Hz			
4	1400 Hz			
5	800 Hz			

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CLASSIFICATION of FEMALE/MALE VOICES USING ARTIFICIAL EAR SOFTWARE

Goal: To distinguish female and male voices using artificial ear software providing appropriate parameters.

Rules:

- The audio files listed in below table and located in the specified folder on your computer should be played and "pitch frequency" values determined should be written in the table.
- In order for the artificial ear software to classify voices correctly, an appropriate “threshold frequency” value should be determined resulting from pitch frequency values above.
- Once the correct threshold frequency is set, you should replay each audio file and write down on the table (third column) whether the software thinks that file pertains to a male voice or a female voice.
- “Evaluation Trials” column of the table will be filled out by your team coach according to the result of classification for each audio file.

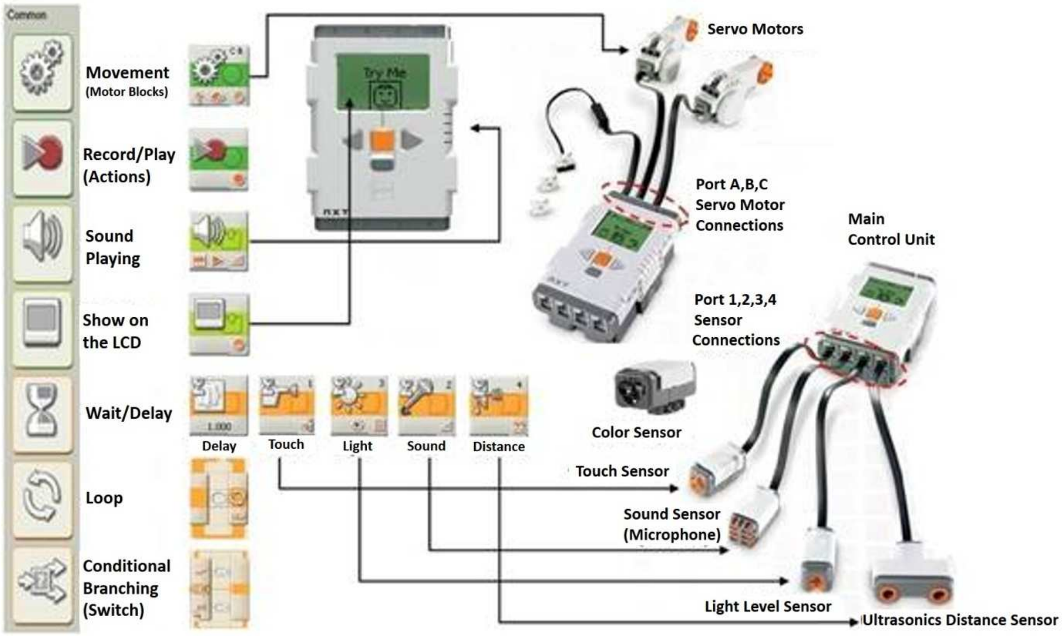
The team that finishes the correct classification of audio files given in below table first will be rewarded.

Name of the Team: ………………………………………

Audio File Name		Pitch Frequency	Classification by the Software (Male / Female)	Evaluation Trials (True / False)					
1	Audio01								
2	Audio02								
3	Audio03								
4	Audio04								
5	Audio05								
Threshold Frequency determined =>									

Appendix 4:

LEGO MINDSTORMS NXT ROBOT
DESIGN and PROGRAMMING COMPETITION



Goal: To design and implement an original program on a robot to put forth the best robot show.

Rules:

- As the first step, discuss and determine a design with your group for 15 min. For the design you come up with, write down on a paper:
  - Its goal (what does it accomplish?)
  - Graphical representation of what the robot will do

  and give the paper to your team coach.
- At the second step, you will program your robot according to your design for the show. You will be given a total of 45 minutes to complete your implementation and tests.
- The criteria to be used for evaluation of the design are as follows:
  - Functionality
  - Originality
  - Complexity
  - Group Dynamics

  At the end of competition, the group receiving the highest evaluation score will win the grand prize!