The effect of scientific process skills education on students' scientific creativity, science attitudes and academic achievements

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Received 23 Apr., 2008
Revised 24 Jun., 2008

Contents

Abstract

The aim of this study is to investigate the effects of teaching scientific process skills education to students to promote their scientific creativity, attitudes towards science, and achievements in science. The research includes a pre-test post-test research model with a control group. The subjects of the research consist of 40 students reading at 7th grade of an elementary school existing in Buca District of Izmir Province, Turkey. The data collection tools for the research include the "Combination of Force and Motion- the Energy" Chapter Achievement Scale the Science Attitude Scale and the Scientific Creativity Scale. (Hu & Adey, 2002).

As a result of the research, it was determined that the scientific process skills education increased the students' achievements and scientific creativities, however, no meaningful progress was made on their attitudes towards science when compared to the teacher-centered method.

Key words: scientific process skills, scientific creativity, science attitude

Introduction

The purpose of science education is to enable individuals to use scientific process skills; in other words, to be able to define the problems around them, to observe, to analyze, to hypothesize, to experiment, to conclude, to generalize, and to apply the information they have with the necessary skills. Scientific process skills (SPS) include skills that every individual could use in each step of his/her daily life by being scientifically literate and increasing the quality and standard of life by comprehending the nature of science. Therefore, these skills affect the personal, social, and global lifes of individuals. The SPS are a necessary tool to produce and use scientific information, to perform scientific research, and to solve problems. These skills can be gained by students through certain science education activities (Harlen, 1999; Huppert, Lomask & Lazarorcitz, 2002). For example, the purpose of learning by using a research study is to help teach the scientific processes. The students undertaking a scientific research study can learn the processes of science (Dhillon, 1996).

Scientists use their creativity in every stage of scientific research (Abd-el Khalick & Lederman, 2000). So the creativity has a supplementary role in many scientific processes. It is used especially in introducing problems and hypotheses and designing experiments. That's why science is a process containing the creativity components affecting each step of life, in addition to being a product (Saxena, 1994). Individuals need to think creatively and to be able to use their scientific process skills in order to develop a fundamental scientific understanding. And creative scientists are required to find useful and new solutions for the problems existing in daily life. Creative scientists are much more sensitive regarding problems. Every educated individual may not be a scientist, but it is important for each person to begin his or her educational life by applying creative thinking. All individuals who learned to think creatively while dealing with the scientific work can also apply these skills in other areas (Meador, 2003). Although creativity is accepted as a problem solving skill in research literature, it requires creative performance, recognizing the problem, thinking differently, and finding solutions. Recognizing the problem plays an extremely important role in the creative process (Erdener, 2003).

The best definition of creativity related to the science was done by Torrance; the definition is that, "The creativity is recognizing the gaps in the problem or the information, creating ideas or hypotheses, testing and developing these hypotheses, and transmitting the data" (Torrance, 1995 in Dass, 2004). When we examine this definition, it's seen that the definition of SPS and creativity look similar. Both are resulting from the necessity of eliminating a problem in daily life. Hypotheses are introduced in order to show how to eliminate this problem, and to test these hypotheses, experiments are done. As a result of these experiments, application can find whether the problem has been eliminated. These results are shared with society and correlated to other results (Dass, 2004).

In this context, it can be accepted that the creativity is an important aspect of scientific skill. The problem solving, creating hypotheses, designing experiments, and technical innovation require a special type of scientific creativity. The human being is creative in a special field. For instance, while an individual is creative in chemistry, he or she may not be creative in painting (Liang, 2002). Therefore, it is generally necessary to separate the scientific creativity from creativity (Lin et al., 2003).

Scientific creativity (creativity in science) can be considered to help achieve new and original steps in performing the targets of science. Moravcsik (1981:222) defined the scientific creativity by saying, "it can explain itself in comprehending the new ideas and concepts added to scientific knowledge, in formulating new theories in science, finding new experiments presenting the natural laws, in recognizing new regulatory properties of scientific research and the scientific group, in giving the scientific activity plans and projects originality, and many other areas".

Creative thinking is necessary to search for solutions to all kinds of problems that are encountered in daily life and to make new products. According to scientific studies, creativity takes a complementary role in many scientific processes. The individuals who use creativity can make their science education functional, and therefore, the scientific information can be the basis for producing a valuable product instead of just amassing information. Therefore, for students to gain the creative thinking skills that they will need as adults, s each stage of their education, beginning in elementary school, must be one of the most important purposes of science education (Koray, 2003).

Science educators recognized the importance of creativity in science education, and started to work on methods and techniques which can improve creativity (Hu & Adey, 2002; Liang, 2002; Meador, 2003; Roberts, 2003). However there are not many studies presenting creativity improvement and supporting methods for science students (Liang, 2002). And the studies have generally used cognitive aspects to determine the scientific creativity of students. For example, certain studies have used finding the problem and formulating the hypotheses skills as criteria to evaluate the scientific creativity (Hoover, 1992; Hoover & Feldhusen, 1990). Finding the problem and formulating the hypotheses are important in improving the scientific creativity, and at the same time, they are the components of SPS. Therefore, it is believed that the scientific creativity of individuals who use SPS was better (Hoover, 1994; Innamorato, 1998; Roberts, 2003; Meador, 2003; Liang, 2002; Hu & Adey, 2002; Cheng, 2004).

When the national science education standards (NRC, 1996) are examined, it is seen that SPSs and creativity had important roles in science education. However, in the school education, the problem and materials are given to the students, and this prevents improvement of thinking skills. Moreover, scientific knowledges and theories are directly told to the students in their textbooks, and they are not allowed to think for themselves. While the teacher teaches a lesson at the classroom, first he/she tells about the concept, and then makes the students do experiments to understand the concept. This type of education does not exactly represent the scientific exploring process.

If during this study some evidence related to improving SPS scientific creativity could be provided, and then science teachers could consider scientific creativity as an educable skill rather than as a comprehension endowment or an extra-ordinary skill. The results of the study can help teachers to understand the factors affecting the scientific creativity of the students.

Therefore, teachers can use SPSs to increase the scientific creativity of the students. Although creativity has been studied by psychologists and researchers for many years, there are very few studies about scientific creativity and scientists' creative processes (Mansfield & Buse, 1981 in Liang, 2002).

For all these reasons, SPS are a subject needed to be emphasized. Also, knowing how much the students gained SPS can improve their scientific creativity.

The attitude towards science contains the attitudes towards scientists, scientific attitudes, and the attitudes towards scientific careers, science teaching methods, interests related to scientific knowledge, and the content of the science. Determining the students' attitudes towards science and scientists takes a key role in determining their scientific creativities (Haladyna & Shaughnessy, 1982).

Although a study presenting scientific creativity and the effects of SPS on scientific creativity has not been encountered in the field literature, it is thought that this study would bring a new point of view for elementary school science and technology education and the related studies.

Aim

The aim of this study is to investigate the effects of the scientific process skills taught to 7th grade elementary school students on their scientific creativities, attitudes towards science, and academic achievement.

The following questions were asked:

1. Is there any significant difference between the academic achievements of the students who got and did not get the SPS (scientific process skills) training according to their pre-test and post-test results?

2. Is there any significant difference between the attitudes towards science of the students who got and did not get the SPS training according to their pre-test and post-test results?

3. Is there any significant difference between the scientific creativities of the students who got and did not get the SPS training according to their pre-test and post-test results?

Method

The pre-test post-test experimental model with control group was used in the research. When random assignments cannot be made, true experimental research cannot be done. In its place, quasi-experimental research is used, which embodies the characteristics of experimental research, except for random selection and assignment of participants (Charles, 1998:308). Therefore, the semi-experimental model was used since the students' score averages were used in creating the control and experimental groups. While teaching the concepts to the students at the experimental group science course, the training was performed using supportive activities which made them use scientific process skills and to develop their scientific creativities (by means of open-ended experiments based on problem solving in addition to general experiments). This research has two limitations. One is that the training in the study was not just for measuring the students' science process skills; otherwise, it is for measuring academic achievement, attitudes and scienitifc creativity. Another limitation was that the study had a small sample size which causes a significant impact on the the direct findings and their interactive effects.

The research subjects consist of the students in a control group (N=20) and in an experimental group (N=20) who are reading at 7th grade level of an elementary school existing in Buca District of Izmir Province.

Data Collection Tools

"Combination of Force and Motion-the Energy" Chapter Achievement Scale

While developing the scale, chapter analysis was performed, and targets and behaviours were determined according to the science course curriculum. The science course book resources were reviewed, and a multiple-choice scale containing 45 questions was prepared. Experts were consulted about the prepared questions, and after performing the necessary corrections and arrangement of the questions, the scale was applied on 192 randomly selected students reading at 8th grade level in four different elementary schools.

After the application, the discrimination indices, difficulty of the items, and the reliability coefficient of the scale were calculated. At the end of the calculations, the questions having a discrimination index below 0.20 were removed from the scale. The chapter achievement scale containing 22 multiple-choice items was created. The Reliability Coefficient (KR–20) of the achieved scale was 0.71.

The Attitude Scale Towards Science Course

In order to develop a scale related to the attitude towards the science course, the field literature was reviewed (Demirci, 2004; Baser, 1996; Chen, 2001; Geban et al., 1994), and then a scale containing 34 items was created. The scale was developed according to the five-point Likert type grading system, and "exactly agree", "agree", "undecided", "disagree", and "totally disagree" choices were used for the expression of each attitude. Three lecturers and two science teacher provided the content validity of the scale. After the scale was arranged according to the ideas of the experts, it was applied randomly on 200 students reading at 8th grade of four different elementary schools.

The reliability coefficient of the attitude scale towards the science course was calculated as $\alpha=0.88$. And it became $\alpha=0.90$ after removing the items whose total item correlation was below 0.30.

Scientific Creativity (SC) Scale

The items at the scientific creativity scale measure characteristics such as uncommon usages, finding the problem, product development, scientific imagination, problem solving, performing scientific experiments, and product design. Scoring rules for continuity, flexibility, and originality were evaluated.

Hu and Adey originally developed the scale (2002). The Cronbach's alpha coefficient for the inner consistency was 0.893and the result of the reliability study done with 160 students in

England. The reliability between the scores ranged between 0.793 and 0.913, and the average was 0.875. Principal components factor analysis was performed for the data obtained from the scale, and the scale was founded as a one-factor model. This showed the good structure validity of the scale. For the validity, the researchers consulted expert science education researchers and science teachers,and the ideas in favour of the scale were generally high.

The Scientific Creativity Scale developed by Hu and Adey (2002) was translated into Turkish, and the items inadaptable to Turkish culture were replaced. A scale containing 6 items was prepared. The scale items were evaluated for continuity, flexibility, and originality that determine scientific creativity levels. The pilot study of the scale was applied randomly on 79 students reading at 7th grade of three different elementary schools in different socioeconomical level.

In order to determine the reliability of the scale applied, two scientists separately evaluated the answers given by the students. Additionally, the Pearson (product-moment correlation) correlation coefficient was found, and the correlation among the scale items were examined ($r=0.94$). The correlation coefficient between 0.70–1.00 shows that there was a high level correlation (Charles, 1998). In order to determine the face validity, the scale was examined by 15 scientists and science teachers. All of the experts expressed a positive opinion proving that the scale had high face validity.

Preparation of the Worksheets Used at the Application

Since the students sampled were in the secondary stage of their education, the aim was to gain high level of scientific process skills. The SPS parallel with this purpose are :

1. Defining The Problem

2. Hypothesizing/ Estimating

3. Determining The Variables

4. Fair testing

5. Collecting Data

    A) Observation

    B) Measuring

6. Presenting Data

    A) Table drawing

    B) Graph drawing

7. Explaining The Results

First, researchers tried to comprehend what skills are to the experimental group by using the activities out of the subject of the lesson for two weeks, and then worksheets were prepared to correlate with the chapter, and finally these skills were reinforced. The examples given on the work sheets prepared for teaching SPS contained examples related to science subjects and examples not containing science content from daily life so that the students could see that they could also use these skills with other problems encountered in their daily lives.

Students' work sheets regarding the gains defined in Science Education Program (MNE, 2000) for the chapter "Combination of Force and Motion - The Energy", 28 worksheets containing each gain and also directed to gain (confusing) SPS were prepared. The first 9 worksheets contained closed-ended scientific process steps, the next 9 were prepared as semi open-ended, and the final 10 worksheets were open-ended to contain SPS only where the problem sentence was given (App).

Performing The Application

During the application, the researcher participated in the experimental and control groups as an observer, and co-instructed the lecture with the teacher when he/she considered it necessary. The allocated time for the chapter is 12 weeks. The first half of this time is allocated for the force and motion subject, and the second half is allocated for the work-energy, simple machines subject. Therefore, in the first half, activities were done by giving closed-ended and semi open-ended work sheets and tests related to SPS; and in the second half, activities were done by using open-ended worksheets and tests to measure and improve the scientific process skills of the students. The brainstorm and question-answer methods were also used during the lecture. The chapter was taught to the control group using the traditional method. In the same semester, the teacher taught both the experimental group and the control group.

The closed-ended, semi open-ended and open-ended worksheets and tests developed during the application were given to the students. The application was done in a three month period as determined by the annual plan. As much as possible, an environment where the students could study freely and use their creativity was encouraged.

After a two-week training on the definition and usage of SPS, "The combination of Force and Motion – Energy" Chapter was taughtusing the prepared worksheets. Groups worked together to compleate the first 9 and second 9 worksheets. Four groups containing six people in each group were generated in accordance with the request of the students. During the teaching done involving the first 9 closed-ended work sheets, the worksheets were read together by the students, and they tried to hypothesize or estimate by brainstorming. Then, in groups, they tried to determine the variables by estimating or making hypotheses given on the worksheet. Finally, students completed the worksheets by reading the experiment design with their group members and they determined the necessary materials needed. For the next 9 semi openended worksheets, some parts wereleft blank, and the students were to complete this part by working together in a group. In the meantime, the teacher conducted the students' lesson. During the final 10 worksheets, the students individually filled out the parts related to the given problem sentence on the work sheets. Again, here, the teacher conducted the students' lesson. During the previous lecture, the next taught subject title was given to the students, and they were to come to the lecture informed about this subject. Each student designed his/her experiment by means of his/her foreknowledge and they asked for help from their friends when they had a problem during the application of the experiment.

In the control group, the instructions were given without using any teaching material. The lecture was conducted by the teaching asking introductory questions to introduce the subject at the beginning of the lecture, and ended with the teacher solving example problems related to the subject. This method was teacher centered.

Analysis of Data

At the analysis of data, the answers given to the scales by the students were evaluated by means of the statistical techniques such as mean, Standard deviation, Independent Samples t-test, and Paired sample t-test by SPSS 11.0 statistical program.

Findings and Comments

1. First sub-problem : Is there any significant difference between the academic achievements of the students who got and did not get the SPS (scientific process skills) training according to their pre-test and post-test results?

The averages of pre-test and post-test achievement scores of the groups were compared by the t-test analysis.

Table I. Achievement Scale Pre-Tests of Experimental and Control Groups

	Number (N)	Mean (the highest score: 22)	Standard Deviation	t	p	Significance Level
Pre-test (experimental)	20	9.00	4.70	1.83	0.075	$p > 0.05$ Not significant
Pre-test (control)	20	6.90	2.04			
* $p<0.05$						

According to the results given in Table I, there is no significant difference between the achievement levels of the experimental and control groups before the application. The achievement levels of both groups were close to each other before the application.

Table II. Achievement Scale Post-Tests of Experimental and Control Groups

	Number (N)	Mean (the highest score: 22)	Standard Deviation	t	p	Significance Level
Pre-test (experimental)	20	12.90	5.15	3.83	0.001	$p < 0.05$ Significant
Pre-test (control)	20	8.30	3.08			

* p<0.05

When Table II is examined, it is seen that there was a significant difference between the achievement scores of the experimental and control groups after the application. And when the averages of both groups were examined in order to determine is the difference, it is seen that there was a significant difference in favour of experimental group.

2. Second sub-problem : Is there any significant difference between the attitudes towards science of the students who got and did not get the SPS training according to their pre-test and post-test results?

The averages of pre-test and post-test attitude scores of the groups were compared using the t-test analysis.

Table III. Attitude Scale Pre-Tests of Experimental and Control Groups

	Number (N)	Mean (the lowest score: 0, the highest score: 90)	Standard Deviation	t	p	Significance Level
Pre-test (experimental)	20	65.05	8.38	-0.49	0.627	p > 0.05 Not significant
Pre-test (control)	20	66.50	10.26			
* p<0.05						

According to the results given in Table III, there is no significant difference between the attitude levels of the experimental and control groups before the application. This result shows that the attitude levels of both groups were close to each other before the application.

The results of the attitude scale scores obtained after applying the scale again after the application are given in Table IV.

Table IV. Attitude Scale Post-Tests of Experimental and Control Groups

	Number (N)	Mean (the lowest score: 0, the highest score: 90)	Standard Deviation	t	p	Significance Level
Pre-test (experimental)	20	72.45	7.16	0.76	0.454	p > 0.05 Not significant

Pre-test (control)	20	70.75	7.06			
* p<0.05						

When the Table IV is examined, it is shown that there was no statistically significant difference between the attitude scores of the experimental and control groups after the application according to the significance level of a = 0.05. The attitudes towards science for both group is close to each other. However when we look at the averages of attitude scores of both groups before and after the application, there was an increase in both groups and the increase in the experimental group was higher. However this increase is not so great as to make a significant difference.

3. Third sub-problem: Is there any significant difference between the scientific creativities of the students who got and did not get the SPS training according to their pre-test and post-test results?

The averages of pre-test and post-test scientific creativity scores of the groups were compared by using t-test analysis. The results of pre-test SC scores obtained from the control and experimental group before the application are given in table V.

Table V. *Scientific Creativity Scale Pre-Tests of Experimental and Control Groups*

	Number (N)	Mean	Standard Deviation	t	p	Significance Level
Pre-test (experimental)	20	17.30	4.99	1.00	0.321	p > 0.05 Not significant
Pre-test (control)	20	15.65	5.38			
* p<0.05						

According to the results given in Table V, there is no significant difference between the SC levels of the experimental and control groups before the application. This result shows that the SC levels of both groups were close to each other before the application. The results of SC scale scores obtained after applying the scale again after the application are given in table VI.

Table VI. *Scientific Creativity Scale Post-Tests of Experimental and Control Groups*

	Number (N)	Mean	Standard Deviation	t	p	Significance Level
Pre-test (experimental)	20	21.85	4.88	5.11	0.000	p < 0.05 Significant
Pre-test (control)	20	14.30	4.45			
* p<0.05						

As seen in Table VI, there is a significant difference between total SC scores of the experimental and control groups after the application according to the significance level of a = 0.05. Looking at the averages to determine what the difference is, it is seen that there was a significant difference in favour of experimental group.

Conclusion and Discussion

After the study was completed, the effects of the scientific process skills training on the students' scientific creativity, achievement and attitude were investigated. The results obtained for each sub-problem are as follows:

1. The students who had SPS training succeeded more than the students had traditional training. This result shows that giving scientific process skills training increased the academic achievements of the students. Similar results show that there was an increaseon the achievement levels of the students at the end of the SPS training done in science courses by Ardaç and Mugaloglu (2002), laboratory and computer-aided training done based on SPS training at chemistry courses by Geban (1990), and the training done based on the activity by Turpin (2000).

2. There was an increase in both groups attitudes; however, there was no significant difference between them. When the post-test results of the two groups were compared, there was no statistically significant difference between both groups, although the average of the group that had SPS training was slightly higher. Jaus (1975) found that SPS training did not affect the attitudes of the students towards science. Similar results were obtained at the other studies done related to attitudes such as the study of Çaliskan, Selçuk and Erol (2005) where the attitudes towards physics was investigated, the study of Altiparmak and Nakipoglu (2002) related to attitudes towards biology, and the study of Ünal and Ergin (2006) where the effects of the science education using the discovery teaching strategy on the students' attitudes towards science were investigated. When the studies were investigated, the duration of the applications varied from four weeks to eight weeks. A possible reason for not changing the students' attitudes could be due to the short application times.

Although the students who had SPS training developed a positive attitude towards the course during the training, the attitudes of the students in the group where the traditional training also developed positively, so it is difficult to say that the improvement in the attitudes of the SPS trained students resulted directly from the SPS training.

3. When SC scores were compared for both groups, the increaseon the scientific creativity of the students given SPS training constituted a significant difference compared to the students in the traditional group.

In the following studies, an increase of students' creative thinking skills was found; for example, when SPS training was done by simple and creative activities in the study of Lee and Lee (2002); in the study of Sungur (1988), the students who had the creative problem solving education were more creative; when activities were directed by SPS training in the study done by Lin and the others (2003); and also Chiang and Tang (1999) found the same result when the V-map strategy was used to improve the scientific creativity of the students in their studies; and so do Laius and Rannikmae (2005) when scientific and technological literacy education was done. These results show that giving SPS training to the students or performing the activities directed to gain SPSs increased the SC of the students.

It can be said that SPS improves scientific creativity and academic achievement. Scientific creativity is an educable or a learned skill in some activities rather than an innate or an extraordinary understanding skill. In addition, SPS can be used for improving students' scientific creativity.

Suggestions

The following suggestions can be related to the results obtained in the research. Suggestions related to SPS training and the variables whose effects are investigated:

1) If we want students to be able to can solve the problems related to them and close relatives or friends, their SPS levels and SC levels should be improved. Scientific statements related to real life should be given in the worksheets in this study. Generally during the lectures, the problem statements related to subject were given, but the scientific statements related to real life were not given. This condition does not give the students the opportunity to improve their learning and thinking skills. Hypothesizing and formulating the problem are two of the most important opportunities to improve students' creativity in science.

2) It is necessary to emphasize the scientific process skills which are also emphasized inscience and technology education program in the classroom, and experiments should be done to gain these skills. Moreover, since the open-ended laboratory experiments improved the creative thinking methods of the students, these types of experiments must be increased.

The experiments given in the books were generally prepared to verify scientific knowledge and theories. The experiment books contain step-by-step instructions. These types of experiments only improve hand skills (what are hand skills? Hard skills?). However the experiments providing the students to think and use their brains, as well as improving their hand skills, are necessary.

Suggestions for the researchers who will work on this subject:

1) Activity sheets should be prepared directed to SPS training during the science education could help teaching of the subject, and improving the scientific process skills and scientific creativity.

2) For further study, the effects of the other methods and techniques improving the creativity on the students' achievements, attitudes, and creativities can be examined.

3) By applying activities improving creativity, not only in a certain period, but also as a longitudinal study that takes more time, students' developments can be examined.

4) The measurement tools developed during the research, and the materials developed can be used at the other studies and in teaching the relevant subjects.

5) The effects of SPS training and the scientific creativity on the students' metacognitive ideas, ideas related to nature of science, epistemological, ontological ideas and the correlations among them can be investigated.

6) By performing the SPS training using other methods, correlations and effects with different variables can be investigated and the results can be compared with the results of this study.

7) The effects of the students' sociodemographic characteristics on their scientific creativities and SPSs can be investigated

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Appendix 1

Closed Ended Work Sheet Example

Problem Sentence: Can you measure your friend's walking speed? How?

My assumption or hypothesis:

I can find his/her speed by measuring the distance that my friend would walk and the time that he/she covered this distance.

a. What are our variables?

The variable which we will change: The distance covered

The variable which we will measure: The time spent for the distance that we covered.

The variable which we will keep constant: Walking by equal length and equal time steps in each try.

b. How will I perform the experiment?

- One of our friends will walk the distances of 2 m, 4 m, 6 m and 8 m respectively which we marked at the classroom in equal steps, and each time we will measure the time which he/she covered the distances.

c. How will I collect my data? (Which measurement tool will I use?)

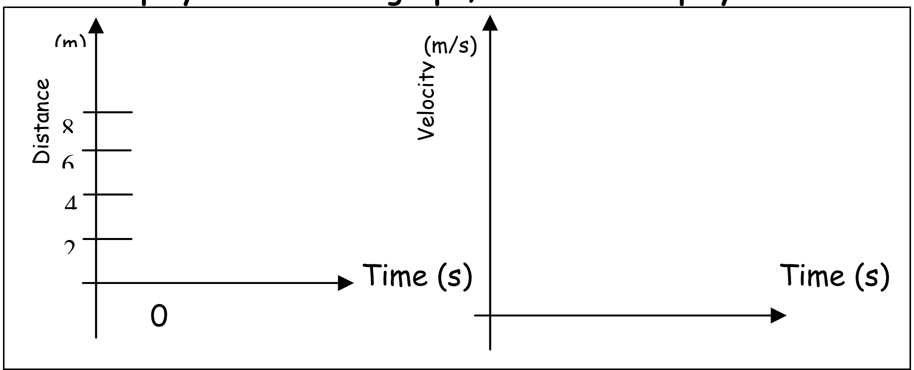
To determine the lengths, we can use a ruler.
And to measure the walking time, we can use a watch that we can read the seconds, a cellular phone, or a chronometer.

2. Let's create a table which we can take note the data that we collected while doing experiment.

Let's create a table containing the covered distance, time, and velocity columns.

Covered distance (m)	Time (s)	Velocity (m/s)
2		
4		
6		
8		

3. If we can display our table in graph, then let's display it.



4. **Which results did we obtain after doing this experiment? What do our graphs tell us?**

5. **Does our result obtained verify our answer at the beginning?**

6. **Did we encounter an unexpected result?**

7. **At the end of this activity, what did you learn that you did not know before?**

8. **During this activity, which knowledges and skills that you had before did you use?**

Appendix 2

Semi Open-Ended Work Sheet Example

Problem Sentence: Haydar's Uncle was driving his car too fast. At the same time he forgot to wear his seatbelt. While he was driving on the road, he suddenly came across a dog. He braked in order to not hit the dog, but, since he did not wear his seatbelt, he flew out from the car's windshield. What must Haydar's Uncle do in order to not fly out and have accident? How can you prove the reasoning of your answer?

My assumption or hypothesis:

If Haydar's Uncle was driving slower, then he could not have had accident and flown out the window.

a. What are our variables?

The variable which we will change: Velocity of the body

The variable which we will measure: Distance between the car and the place where the body flew out.

The variable which we will keep constant: Mass of the body

b. How will I perform the experiment?

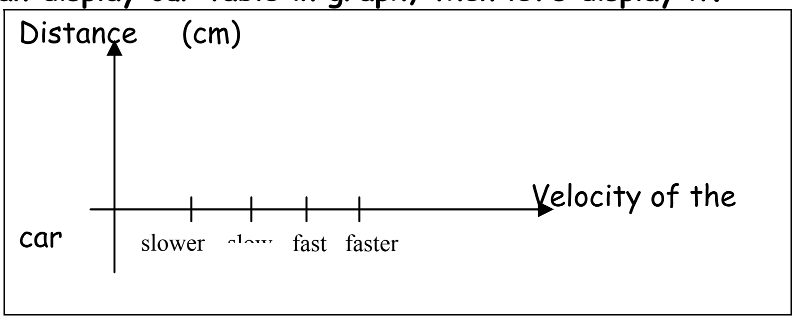
c. How will I collect my data? (Which measurement tool will I use?)

To measure the distances, we can use a ruler.

1. **Let's create a table which we can take note the data that we collected while doing experiment.**

Velocity of the car	Distance of human model from the barrier (cm)
Slower	
Slow	
fast	
faster	

2. **If we can display our table in graph, then let's display it.**



3. **Which results did we obtain after doing this experiment? What do our graphs tell us?**

4. **Does our result obtained verify our answer?**

5. **Did we encounter an unexpected result?**

6. **At the end of this activity, what did you learn that you did not know before?**

7. **During this activity, which knowledges and skills that you had before did you use?**

Appendix 3

Open-Ended Work Sheet Example

Problem Sentence: How can you find which of us is stronger?

My assumption or hypothesis:

a. What are our variables?

The variable which we will change:

The variable which we will measure:

The variable which we will keep constant:

b. How will I perform the experiment?

c. How will I collect my data? (Which measurement tool will I use?)

2. **Let's create a table which we can take note the data that we collected while doing experiment.**

3. **If we can display our table in graph, then let's display it.**

4. **Which results did we obtain after doing this experiment?**

5. **Does our result obtained verify our answer?**

6. **Did we encounter an unexpected result?**

7. **At the end of this activity, what did you learn that you did not know before?**

8. **During this activity, which knowledges and skills that you had before did you use?**