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## An alternative technique to use in science education: Aim-gapped experimentation

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### Abstract

This study was conducted to propose a new experiment technique, which keeps the curiosity alive in students, contributes to meaningful learning instead of just verifying a scientific truth and can be done in a short time. The new proposed experiment technique that is “aim-gapped experimentation” is built on ideas derived from information-gap theory (Lowenstein, 1994; cited in Dijk & Zeelenberg, 2007). The effect of the aim-gapped experimentation to the student achievement at the 7<sup>th</sup> grade “Light Unit” is tested. At the end of the research, teaching with aim-gapped experimentation was found to be a technique having a positive effect on student achievement.

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### 1. Introduction

There are a rich number of method and techniques to use in science education (Gurdal, Sahin & Çağlar, 2001; Trownbrige, Bybee & Powell, 2004; Kaptan, 1999). Science lessons stand on observation and experimentation as per its nature. As Aufshnaiter states; “as a result of textbook centered teaching and a “transmission” style of presentation of facts, students generally see little connection or relevance between themselves, the world around them or science” (cited in Adamson, 1999). Because of that, the lessons in which students would participate actively to experiments are very important. Laboratory is an effective method and for over a century it had been given a central and distinctive role in science education (Hofstein & Lunetta, 2003). The role of laboratory is to build a bridge between the notional world of thoughts and concepts and the concrete world of physical facts (Jone & Lewis, 1978). Through the laboratory activities students engage in a process of constructing knowledge (Tobin, 1990).

Laboratory activities are categorized variously in literature. Within a project on labwork in science education in six European countries which was carried out to find out how labwork should be organised and supervised, five types of labwork were defined: 1. Demonstration experiments 2. Experiments carried out by the students 3. Open ended labwork 4. Strongly guided experiments 5. Using modern technologies (Welzel *et al.*, 1998). The categorization as “open ended” and “expository” is very common. This type of categorization is done according to the problem, procedure and outcome of the experiment are given or not (Millar, Marechal&Tiberghien, 1999, p.35).

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Almost over 30 years some educators seriously question both the effectiveness and the role of laboratory work (Hofstein & Lunetta, 2003). Especially expository experiments in school laboratories are named as cookbook type experiments (Wong, 2004; Hoffstein 1988) and their effects on student achievement are discussed (Hoffstein, 1988; Bencze, 1995). Science educators draw attention to the importance of seeking new trials (Anders at all, 2003).

Theaching in laboratory and consequently experiments are indispensable part of science education. Since the discussions about the effect of laboratory work are increasing for recent years alternative techniques should be tested for effective and attractive science lessons. In this study, by keeping in view this subject a new experimentation technique named as “aim-gapped experimentation” (Güven, 2009) is proposed.

### *1.1. Aim-Gapped Experimentation*

Loewenstein defines “curiosity” as “the desire to know.” Loewenstein’s (1994; cited in Dijk & Zeelenberg, 2007) “information-gap theory views curiosity as resulting from a gap in one’s knowledge”. Loewenstein, argued that situational determinants may intensify curiosity and curiosity may be positively related to the knowledge we already have. According to Loewenstein the more we know, the more curious we are about what we do not know. To illuminate, he described an individual only knowing three of the 50 US state capitals, and one knowing 47 of them. He argued that the latter individual would more likely focus on the knowledge gap than the former individual, and therefore be more curious to learn the capitals of the other states. First empirical evidence came from unpublished research by Loewenstein, Adler, Behrens, and Gillis who showed participants zero to three pictures of different body parts (hand, feet, and torso) of a man or woman, and then asked how curious they were to see the picture of the whole person. Participants were more curious the more parts they had seen (Loewenstein, 1994; cited in Dijk & Zeelenberg, 2007).

To study the consequences of increased knowledge for decision-making Dijk and Zeelenberg developed the “sealed-package paradigm”. They presented participants a decision scenario in which they could either receive 15 euros (the certain option), or a sealed package with unknown content (the uncertain option). For one-third of the participants this was all information they had about the package. The others received some additional information. One-third learned that the content was round, and one-third learned that the content was not round. Based on information-gap theory, they reasoned that additional knowledge about the content should increase curiosity and they set their hypothesis. At the end of research, they saw that participants receiving no additional information less often opted for the package (33%, 10 out of 30) than participants who received information that the content was round (70%, 21 out of 30;), or not round (67%, 20 out of 30). These findings support their hypothesis and indicate that people may become more likely to choose options that might result in regret if curiosity is evoked by increased knowledge (Dijk & Zeelenberg, 2007).

If the student has full concentration to the experiment, he will learn more from the experiment. This is possible only when the student does the experiment with curiosity and attention. As Engel (2006) indicates, curiosity leads to better learning. Aim-gapped experimentation makes use of both open-ended and expository experimentation techniques. In aim-gapped experimentation technique, experiment name and procedure are given as in the case of expository experiments; on the other hand, students are expected to find the outcome themselves as in the case of open-ended experiments. Expository means that students follow given instructions, and the outcome is predetermined. Open-ended means that the problem may have multiple solutions and in open-ended experiments, procedure is student generated and the outcome is undetermined (Anders at all, 2003). A considerable contribution of open-ended experiments to student success and attitude has been proven by studies (Akpınar & Yılmaz, 2006; Anders at all, 2003; Raloff, 1996). Nevertheless, performing open-ended experiments in elementary level may not be very easy and it can take lots of time. Aim-gapped experiments may be used easily in elementary level. Aim-gapped experimentation technique corresponds with information-gap theory. Everything about experiment is not given, an unknown part is being, but some knowledge (exp: procedure) about experiment is given. By that, a gap is formed and the curiosity of student is strived to be very high. In brief, if we explain the three experiment techniques (expository, open-ended and aim-gapped) on behalf of information-gap theory, there is information but not gap, in expository experiment technique. In open-ended experiment technique there is much more gap according to information. In aim-gapped experimentation technique there is much more information according to gap. This relation is given in table below:

Table 1: Experiment techniques with respect to information-gap theory

EXPERIMENT TECHNIQUES	INFORMATION	GAP
<b>Expository experiments</b>	<ul style="list-style-type: none"> <li>▪ Apparatus</li> <li>▪ Name of the experiment</li> <li>▪ Aim of the experiment</li> <li>▪ Procedure</li> <li>▪ Outcome of the experiment</li> </ul>	
<b>Aim-gapped experiments</b>	<ul style="list-style-type: none"> <li>▪ Apparatus</li> <li>▪ Name of the experiment</li> <li>▪ Procedure</li> <li>▪ Router questions</li> <li>▪ Tables for data collection</li> </ul>	<ul style="list-style-type: none"> <li>▪ Aim of the experiment (problem)</li> <li>▪ Outcome of the experiment</li> </ul>
<b>Open-ended experiments</b>	<ul style="list-style-type: none"> <li>▪ Apparatus</li> <li>▪ Problem</li> </ul>	<ul style="list-style-type: none"> <li>▪ Name of the experiment</li> <li>▪ Procedure</li> <li>▪ Outcome of the experiment</li> </ul>

As seen on table above, everything is given in expository experiments. In open ended experiments, the rate of information according to gap is very small. For aim-gapped experiments, the rate of given information according to gap is bigger.

### 1.2. Purpose of the study

The purpose of this study is to design an alternative experiment technique for science and technology lessons, and to plan a sample science lesson which is supported with aim-gapped experiments and test its effectiveness in terms of student success. The main research question of this study is “Is there any significant effect of teaching 7th grade “Light Unit” in 2005 Science and Technology Program (TTKB, 2006) in lessons which are planned with aim-gapped experiments?”. For that these sub-research questions are investigated:

- Is there any statistically meaningful difference between “Light Unit Achievement Test”(LAT) scores of the students taught in the control group.
- Is there any statistically meaningful difference between LAT scores of the students taught in the experimental group.
- Is there any statistically meaningful difference between LAT scores of the students taught in the control group and experimental group.

## 2. Method

In this research, experimental design, consisting of pre-test and post-test including a control group, is used. The sample of study is composed of totally 70 students from an elementary school in Istanbul, in the second semester of 2006-2007 education year. Participants of the study were 7<sup>th</sup> grade students from two different classes, in which the same teacher taught the science and technology lesson. Control and experimental groups are assigned randomly between these two classes. In the control group, the teacher planned the lessons according to the student expectations of 7<sup>th</sup> grade “Light Unit” of 2005 Science and Technology Program. He followed the 7<sup>th</sup> grade Science and Technology textbook (Tunç *et al.*, 2006), the teacher book and the student book. The teacher divided the class into groups (4-5 students) before beginning the unit, and gave them the activities of the unit as homework. Each group had been prepared for their own part. The experiments in the book named as activity were done by groups in front of the class in the laboratory. The teacher used many methods in addition to experiments like; direct explaining method, question-answer, observation, student book activities, taking notes, visual materials, problem solving, analogy, role play, brainstorming, models, examples from daily life, watching video and homeworks. The lessons were done with rich methods and techniques, as it should be according to the “2005 Science and Technology Program” requirements (TTKB, 2006).

In the experimental group; lessons for “Light Unit” in the 7<sup>th</sup> grade 2005 Science and Technology Program were replanned for testing of a new application. The experiments for the “Light Unit” in the 7<sup>th</sup> grade science and technology textbook which were done in the control group were reprepared in a new format for application. This new format of experiments is named as “aim-gapped experimentation technique”. This technique is differing from expository laboratory experiments, in that the students were not given the aim and the outcome of the experiment. The experiment sheets were prepared according to this new technique. The sheets were given to the students before

laboratory. This group of students were divided into small groups (2-3 students) and all groups did the experiments by following the experiment sheets. At the end of the experiments, students were made to write laboratory reports. The teacher used the same teaching methods as in the control group. Just the experiments were done differently. In experimental group, the importance of doing experiments with small groups, writing individual laboratory reports and making the curiosity of students alive were considered. To make the curiosity alive, aim-gapped experiments were used. Aim-gapped experiments are welded from the researcher’s master thesis in which she introduced the “experiments that the aims are not given” (Guvén, 2001). Researcher presented the results of the effects of “experiments that the aims are not given” on student success in the “88th Canadian Chemistry Conference and Exhibition” in Canada and the Reg Friesen Award was given to her (Guvén & Gurdal, 2005). Aim-gapped experimentation technique is based on the idea of that curiosity leads to better learning (Engel, 2006). Quick literature survey shows that “cook-book” type experiments are criticized and the new studies are being done for treatment (Hoffstein, 1988). Aim-gapped experiments are formed by mixing the expository and open-ended experiment methods. The experiment sheet is given to the students like the case in expository experiments, but some gaps are formed just like the case in open-ended experiments. In the experiment sheet the aim of the experiment is not given. The name of the experiment is defined again carefully that includes no clue about the aim of the experiment. The procedure is given but the outcome of the experiment is not given with the experiment sheets. There are a few router questions in the sheet to make the students write the observations and the results of the experiment. At the end of the experiment, students were made to write the aim of the experiment and for evaluation they wrote experiment reports.

2.1. Instrument and data analysis

The researcher aimed to test the effectiveness of the new application in the light of the achievement. “Light Unit Achievement Test” (LAT) is used to test the student success. The test composed of 30 multiple choice questions and the calculated cronbach alpha reliability coefficient of the test is 0,87. The mean difficulty of test was calculated as 0,59. LAT was applied to both groups (control and experimental) as pre-test before the instruction and as post-test after the instruction. The results of the LAT was evaluated with SPSS 11.0 program.

3. Results

LAT was applied before and after the implementation as pretest and posttest. The data obtained from the tests was assessed by using SPSS program. Analysis of the quantitative data is given in the tables below.

Table 2: Pre-test Results of LAT

	Group	N	Mean	SD	Independent t-test		
					df	t	P
Pre-test	Control	34	8,65	2,56	68	1,14	>0,05
	Experimental	36	7,69	4,19			

According to scores of the independent t-test of pretests which were done between two groups there was no significant difference between the control and experimental groups in terms of their achievement in the “light unit”. This result indicated that students in these two groups were similar in achievement on the beginning of the study.

Table 3: Pre-test and Post-test Results of LAT

Group	Test	N	Mean	SD	Paired Samples t-test		
					df	t	P
Control Group	Pre-test	34	8,65	2,56	33	-11,69	<0,01
	Post-test		16,38	3,94			
Experimental Group	Pre-test	36	7,69	4,19	35	-16,72	<0,01
	Post-test		24,08	3,52			

The results of paired samples t-test between the pre-test and post-tests of the control group showed that there was a significant difference on behalf of the post-test (t=-11,69, p<0,01). This result means that the lesson was affected the student success positively in control group.

The results of paired samples t-test between the pre-test and post-tests of the experimental group showed that there was a significant difference on behalf of the post-test ( $t=-16,72$ ,  $p<0,01$ ). As can be inferred from the table the student success significantly increased in experimental group, while it was not very good before implementation. This result means that the lesson with aim-gapped experiments was affected the student success positively in experimental group.

Table 4: Post-test Results of LAT

	Group	N	Mean	SD	Paired Samples t-test		
					df	T	P
Post-test	Control	34	16,38	3,94	68	-8,63	<0,01
	Experimental	36	24,08	3,52			

Independent t-test was conducted to see if there was a significant difference between the post-test scores of LAT of the control and experimental groups. According to these results there is a statistically significant difference on behalf of the experimental group ( $t=-8,63$ ;  $p<0,01$ ). This means that doing aim-gapped experiments with small groups and making students to write reports at the end of the experiments, has a significantly important effect on student success.

### 3. Conclusion and Discussion

This study supports the general opinion that students are more successful when they engage with practical work in science lessons (Arons, 1993; Guven & Gurdal, 2002; Lazarowiz & Tamir, 1994). However the key point in this research was not just doing practical work but performing more useful and enjoyable laboratory activities. For that, the light unit was planned with aim-gapped experiments by which students do experiments more curiously. As literature supports curiosity is important for better learning (Engel, 2006). Aim-gapped experiments are designed by taking into account of compelling need to move away from the traditional 'cookbook' experiments (Wong, 2004). For recent years traditional "cook-book" type experiments are criticized (Hoffstein, 1988) and have been indicated to achieve little meaningful learning by students (Hart *et al.*, 2000). In this study it is tried to give a respond to the need of alternative laboratory techniques. With aim-gapped experiments it is aimed to make students learn through the process not just through the results. Thus, the experiment sheets which were given to students before the experiments were not prepared just like recipes, they were informational sheets with some gaps in it. So students followed up them curiously during the experiments. As Priemer (2006) states, successful students in science don't prefer expository experiments, and also during open-ended experiment tasks the risk of overextending students should be countered by giving selective support to them in different stages of the experimental work. Before this study, physics experiments for high school students were prepared closely to aim-gapped experiments and a positive effect was seen on student success (Guyen, 2001; Guven & Gurdal, 2005).

In this study aim-gapped experiments are performed by small groups and students wrote experiment reports for evaluation. The evaluation of experiments is as much important as doing them (Boud, 2005) and the evaluation techniques also must be determined during the planning process of experimentation (Ottander & Grelsson, 2006). In this study evaluation of the experiments in experimental group was done with reports. Students made to write experiment reports after application and the teacher marked them. Rijlaarsdam, Couzijn, Janssen, Braaksma and Kieft (2006) points out the importance of writing reports for laboratory experiments.

As a suggestion aim-gapped experiments should take place in science lessons. All students must have a chance of doing experiments in schools, for that experiments should be performed by small groups. Also students should write experiment reports after finishing labwork in school.

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