DEMONSTRATION STRATEGY AND ACHIEVEMENT OF PHYSICS STUDENTS
BASED ON HIGHER ORDER THINKING SKILLS

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ABSTRACT The objectives of this study include determining the level of achievement of students in a control and in an experimental class along the following higher order thinking skills: analysis, inference, and evaluation, after demonstration strategy was implemented in the experimental class; and determining the level of achievement of the students in the experimental class when they are grouped according to gender and according to multiple intelligences, along the aforementioned thinking skills. Results indicate that the experimental group’s achievement is at a moderate level along analysis and evaluation and at a high level along inference, while the control group had an achievement at a moderate level in all the three skills. Both males and females of the experimental group achieved at a moderate level. The Logical-math group achieved high in analysis and very high in inference and evaluation. The Bodily-kinesthetic group achieved average or moderate along analysis and inference and high in evaluation. The Interpersonal group achieved low in analysis and average in inference and evaluation. Linguistic, Musical and Visual spatial groups achieved high in inference and average in analysis and evaluation. Intrapersonal group achieved average in all the three skills.

INTRODUCTION

Recent international trends in physics education show that educators are in search of ways to teach physics effectively. One of the measures of effective physics instruction is manifested in the higher order thinking skills developed by the students, as reflected in their scores in daily quizzes, periodical tests and even in standardized science tests.

Why is there a need to foster higher order thinking skills inside the classroom? The ability to engage in careful and reflective thinking has been viewed as the fundamental characteristic of an educated person, as requirement and an employability skill in today’s global competitiveness for an increasingly wide range of jobs. Also crucial is to equip students with higher order thinking skills especially in the secondary level of education. When students go to college, they usually encounter difficulties in most of their science and mathematics subjects because they were not exposed to thinking at a higher level.

In general, there is no hard and fast rule on what strategy or method should be used in teaching, especially in physics. Das (2005) stated that there is no rigidity in method of procedure to be followed by the teacher to achieve the objectives of teaching science. In the Philippines, survey researches show that the demonstration method of teaching physics is perceived to be effective by both teachers and students. For instance, Marzan (2000) pointed out that lecture, discussion and demonstration methods of teaching physics are perceived as very effective by both teacher and student respondents in her study on performance of fourth year high school students in the National High Schools in Pangasinan. However, international and national examinations show that the perception of students and teachers are quite contrary to their performance. If they perceive that the methods of teaching used are effective, why is it that during tests they achieve lower than the standard? These considerations were basically the foundations of this study, which tried to determine if the demonstration method in physics instruction really affected student achievement. It is hoped that results of the study can be used as a further basis for physics teachers to utilize demonstration method in their instruction. Perhaps physics teachers would also
be enlightened on what thinking skills can be improved when demonstration method is used in classroom instruction.

The following are the objectives of the study:

1. To determine the level of achievement of the students in the control and in the experimental classes based on post test scores along the following thinking skills: a. analysis, b. inference, c. evaluation.

2. To determine the level of achievement of students in the experimental class, when grouped according to gender, along the three thinking skills.

3. To determine the level of achievement of the students in the experimental class, when grouped according to Multiple Intelligence (MI), along the same skills.

The variables involved in this study include the gender of the subjects under study and their MI scores. These are considered as independent variables because it is believed that they affect the level of achievement of students in physics in a teacher-prepared achievement test composed of items that require analysis, inference and evaluation. The dependent variables include the level of achievement of students in the experimental and control groups, level of achievement of students according to gender, level of achievement of students according to MI, comparison on the level of achievement of students according to gender and comparison on the level of achievement of students according to MI. Some intervening variables that can be identified in this study are: effect of the two-hour laboratory time per week, class schedule, and other factors that affect the learning atmosphere. The relationships among these variables are shown in Figure 1.

![Figure 1. The paradigm of the study](image_url)

**METHODOLOGY**

**Research Design**

This study is experimental in nature with the form posttest-only control group design. The subjects of this study are composed of two groups. One group received the experimental treatment and the other is the control, which received the conventional treatment. The
experimental group experienced demonstration strategy as the teacher’s method of teaching. The control group experienced the usual method-lecture discussion. The demonstration strategy implemented in the experimental group includes teacher demonstrations and student demonstrations guided by the teacher. Five to eight minutes video clips from PASCO’s Physics Demonstrations Part 1 in a DVD format was also used. The topics discussed with demonstrations were rotational motion, translational and rotational equilibrium, mechanical properties of matter and fluid mechanics.

The experimental group was replicated twice when gender was considered. It was also replicated in seven groups when the MI was considered. The Multiple Intelligence Assessment done classified the subjects into seven groups who are strong in the following MI: linguistic, logical-math, musical, visual-spatial, bodily-kinesthetic, interpersonal and intrapersonal. Naturalist as a Multiple Intelligence was not included in the groups since the assessment showed that nobody from the subjects has a dominant quality along this intelligence.

**Population and Locale of the Study**

The study was conducted at the University of Baguio Science High School in Baguio City during the period June to August, 2008. The respondents were the fourth year students who are taking Fundamentals of Physics 2 or Science 4A in the school curriculum. A total of 86 students classified into two sections, namely Quantum Physicists which was assigned as the experimental group/class and Wave Physicists which was assigned as the control group, were the subjects of this study.

**Data Gathering Tool**

A higher order thinking skills test was used in data collection. The questions were selected carefully from physics books and from internet sources. Some of the questions were developed by the researcher, which have been used yearly for almost three years already. The test underwent a content validity examination by a panel of experts in physics and in education. Five members of the committee improved, validated and confirmed if the pretest/posttest was ready for use. The five members were: Dr. Joel Lubrica, Dr. Breetel Dolipas, Prof. Jennifer Lyn Ramos and Dr. Percyveranda Lubrica (all from Benguet State University), and Engr. Jaime Rillorta of the University of Baguio. Thereafter, the test was piloted to 38 respondents. The respondents were composed of 3 MA Physics students and 16 fourth year BSE Physical Science majors of Benguet State University and 19 third year electronics and communications engineering students of the University of Baguio.

This pilot testing became the basis of item analysis. The discrimination indexes of the test are: analysis is 0.53, inference is 0.43 and evaluation is 0.51. These values were interpreted as “good” in terms of the ability to discriminate the upper half of the test takers from the lower half of those who took the test. On the other hand, the difficulty indexes of the test are: analysis, 0.36; inference, 0.41; and evaluation, 0.45. These values were interpreted to be of “average” difficulty. Reliability of the test was also considered. The Kuder-Richardson (KR) 20 reliability test was used. KR 20 reliability coefficient in analysis part is 0.69, inference is 0.64 and evaluation is 0.62. All these values of the KR reliability coefficient were to be interpreted as “moderate” in terms of reliability.

**Data Gathering Procedure and Treatment of the Data**

The test was administered to the subjects in the experimental and control groups. It was actually incorporated in the first part of the first grading examination. The test was divided into three parts, with each part measuring a certain higher order thinking skill. The three thinking skills that were measured are: analysis, inference and evaluation. The collected data were categorized, tabulated and analyzed. Descriptive statistics, specifically mean, was used. To test
the significant difference of the means, t-test for independent sample means and one way Analysis of Variance (ANOVA) were used through the SPSS v. 14 program.

RESULTS AND DISCUSSION

Level of Achievement of the Students in the Control and Experimental Groups

Table 1 shows the level of achievement of the control and experimental groups along the three skills. This is after the demonstration strategy was implemented in the experimental group.

<table>
<thead>
<tr>
<th>Group</th>
<th>Analysis</th>
<th>Inference</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>5.12</td>
<td>7.02</td>
<td>6.91</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>High</td>
<td>Average</td>
</tr>
<tr>
<td>Control</td>
<td>4.56</td>
<td>6.05</td>
<td>6.93</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>Average</td>
<td>Average</td>
</tr>
</tbody>
</table>

$t_c$ 1.239 2.309* -0.524

* significant, ($t_{0.05} 1.671$)

In the analysis part, the experimental group registered a mean score of 5.12 while the control group’s mean score is 4.56. The mean scores of both groups can be interpreted as average or moderate in terms of achievement along this skill. The inference part shows a greater discrepancy of scores between the two groups. The mean score is 7.02 for the experimental and 6.05 control group. In this area, the mean score of the experimental class is interpreted as high achievement while the control group’s mean is moderate or average. The evaluation portion of the test shows that the control group scored a little bit higher. However, both means are interpreted as average or moderate in terms of achievement along evaluation skill.

Table 1 also shows that there is a significant difference in the mean scores of the two groups along inference. This implies that the demonstration strategy helped the experimental class in honing one skill, only along inference.

Why does demonstration strategy seem to improve inferential thinking? Consider what Corpuz and Salandanan (2003) had elaborated about making inferences. This is the ability to form an idea, opinion or a conclusion after a series of reasoning and speculating outcomes of a situation. The students who manifest inference are able to formulate conjectures, consider possibilities and surmise consequences based on sufficient proofs. Demonstration appears to play a great role along the development of inferential thinking because in demonstrations, students are asked first to make predictions. Afterwards, they will observe the teacher and then give explanations on what was observed in the demonstration. In this manner, predictions are corrected if wrong and reinforced if right.

Why do lecture and demonstration methods appear to have developed analytical thinking and evaluation at the same level? It must be considered that demonstration and lecture method belong to the expository methods of teaching (Leus, 2001). Basically, this method aims to give information (exposition). Thus, in terms of their aim in the broadest sense, the demonstration and lecture methods are the same. This is supported by the study of Duran (1999) claiming that both demonstration method and lecture method are perceived to be of the same level of effectiveness as assessed by physics teachers. The equal effectiveness of both lecture and discussion is also supported by the findings of Austria (2006) involving the perceptions of teacher respondents.
Level of Achievement of Students in the Experimental Group According to Gender

Table 2 shows the level of achievement of the males and females in the experimental group along the three skills. Along analysis, males performed better than the females, although both have mean scores that can be interpreted as moderate or average. This interpretation can also be said for the skills of inference and evaluation.

Further, the statistical test for significance indicates that both groups perform equally well, conveying the idea that demonstration strategy does not appeal to any gender. In other words, the strategy appears to have the same effectiveness for both genders. This finding supports the results of the study of Llanes (2002) that there was no significant difference in the level of achievement of fourth year male and female students in physics. The results of this study also reflect the “no significant difference” level of achievement and performance of male and female Filipinos in the science test result of the TIMMS 2003 because male Filipino eight graders had almost the same science scale as the females.

Table 2. Level of achievement of the students in the experimental class grouped according to gender

<table>
<thead>
<tr>
<th>Group</th>
<th>Analysis</th>
<th>Inference</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males (15)</td>
<td>5.20</td>
<td>6.93</td>
<td>6.80</td>
</tr>
<tr>
<td>Females (28)</td>
<td>5.07</td>
<td>7.07</td>
<td>6.96</td>
</tr>
<tr>
<td>t</td>
<td>0.237</td>
<td>-0.258</td>
<td>-0.283</td>
</tr>
</tbody>
</table>

In the international scene, however, there is a contradiction of the results of the study. The Science Daily (2007), in its article “Science Student Gender Gap: A Continuing Challenge”, revealed that researchers composed of physics professors in the University of Colorado at Boulder (UC Boulder) indicated that the gap between males and females stayed roughly the same in interactive classrooms. Males are significantly achieving more than the females even though the classroom atmosphere is changed. In fact, it was reported that there were even some instances where the gender gap got worse. But if demonstration strategy can be considered as interactive in nature provided that, according to Das (2005), the teacher should keep the students engaged by asking relevant questions to the class while conducting a demonstration like what was done in this study, both males and females could equally perform at the same level.

A subtle observation, however, can be made due to the differences in the mean scores of males and females. Although statistically insignificant, males had a higher mean score along analysis while females had a mean score higher than males in both inference and evaluation. Nevertheless, it is not conclusive to say that males are better in analyzing and females are better in inferential thinking and evaluating. In fact, Delica et al., (2002) raised questions on difference of scores of males and females in the Force Concept Inventory (FCI) which can also be, in some way, connected to the differences of scores of males and females in this study. Could it be due to different cultural orientations and interests? Is the data gathering tool gender biased? These questions are not probed in this study and may be worthy of investigation in another setting.

Level of Achievement of the Students in Experimental Group According to Multiple Intelligence

The multiple intelligence assessment result divided the experimental class into seven subgroups. These are: linguistic, logical-math, visual-spatial, bodily kinesthetic, interpersonal, intrapersonal and musical. Results are shown in Table 3.

Along analysis, the logical-math group registered a mean score of 7.00 (or high). The interpersonal group’s mean score is the lowest, 3.50 (or low). The rest of the groups had average
or moderate level of achievement. In the inference part of the test, the logical math group still has the highest mean score of 9.00 (very high). Linguistic, musical and visual-spatial groups have mean scores of 8.22, 6.80 and 7.33 respectively. These mean scores are interpreted as high. The remaining three groups have mean scores which described as average or moderate.

Table 3. Level of achievement of the students in the experimental class grouped according to multiple intelligences

<table>
<thead>
<tr>
<th>Group</th>
<th>Analysis</th>
<th>Inference</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bodily-kinesthetic (7)</td>
<td>4.86 Average</td>
<td>6.57 Average</td>
<td>7.43 High</td>
</tr>
<tr>
<td>Interpersonal (2)</td>
<td>3.50 Low</td>
<td>6.00 Average</td>
<td>5.50 Average</td>
</tr>
<tr>
<td>Intrapersonal (10)</td>
<td>5.10 Average</td>
<td>6.20 Average</td>
<td>6.40 Average</td>
</tr>
<tr>
<td>Linguistic (9)</td>
<td>5.22 Average</td>
<td>8.22 High</td>
<td>6.44 Average</td>
</tr>
<tr>
<td>Logical Math (2)</td>
<td>7.0 High</td>
<td>9.0 Very High</td>
<td>10.0 Very High</td>
</tr>
<tr>
<td>Musical (10)</td>
<td>5.10 Average</td>
<td>6.80 High</td>
<td>7.00 Average</td>
</tr>
<tr>
<td>Visual spatial (3)</td>
<td>5.33 Average</td>
<td>7.33 High</td>
<td>7.33 Average</td>
</tr>
</tbody>
</table>

The one-way Analysis of Variance (ANOVA) was used to test if there is a significant difference among the seven groups along the thinking skills. All the F-values computed are lower than the F-value at 0.05 level of significance, implying that there are no significant differences, at all. This may lead to a conclusion that the demonstration strategy does not particularly apply to any MI group, meaning that it does not matter what MI a student has when using demonstration strategy because they all equally respond to the method and they all equally show the same level of achievement.

In general, out of the seven groups, logical math is consistently registering the highest mean scores along the three skills. Most of the groups settle along the average or moderate level of achievement. The results confirm that persons with logical math intelligence are more inclined to achieve along their field - math and sciences. On the other hand, the linguistic and musical groups fared best in inference. Some groups, such as the bodily-kinesthetic group, had their greatest achievements along evaluation.

Rose (1992), mentioned by Laughlin (1999), worked on multiple intelligences and learning styles. She described auditory study technique as a learning style that works best at asking lots of questions. In the demonstrations in this study, the questions raised often require predicting and explaining. This may have helped the linguistic group along inference. Rose (1992) related linguistic group as a group with auditory learning style and a subtle relation of this can be observed in this study. Rose (1992), in fact, concluded that persons with auditory learning style and linguistic intelligence both prefer to use language either spoken or written, in learning and remember well what they hear.

Through the demonstration method, the visual-spatial group is also assisted greatly to practice inferential thinking. In fact, by simply looking at something, they easily understand it, which is one of the characteristics of this MI. Campbell, et al., (1996) aptly described that persons with this intelligence learn by seeing and observing. Rose (1992), as cited by Laughlin (1999), particularly pointed out that some students learn by visual study techniques. This appeal more to the visual-spatial group and it can be deduced in this study that demonstration strategy helped this group along inference.

It is interesting to note that along evaluation, bodily-kinesthetic group achieved high. Smith (2002) mentioned that Gardner sees mental and physical activity as related to persons with bodily-kinesthetic intelligence. Evaluation involves discriminating ideas and it seems that through demonstration strategy, this group easily responds along this thinking skill. Through demonstrations, the concepts are concretized and it becomes “real-life” experiences to a bodi-
kinesthetic person. Since the concepts are concretized by “sensory-motor experiences” (Campbell et al., 1996), this group easily recognizes concepts and deduce comparisons and contrasts. However, it is also important to note that the bodily-kinesthetic group, like the others, experienced a two-hour laboratory activity weekly. This gives them an added opportunity to learn by doing and makes the concepts being tackled to be more meaningful to them. This intervening variable may have had an effect so it is not conclusive to say that the demonstration strategy is the sole factor that affected the group’s high achievement.

In general, patterns of behavior of linguistic group and bodily-kinesthetic group are quite inconsistent such that their high performance in one skill does not guarantee that demonstration method helped them. In fact, they are in the same level of achievement as the other groups in the other parts of the higher order thinking skills test. At any rate, results of the study support one of the misconceptions on multiple intelligences.Muijs and Reynolds (2005) mentioned that it is sometimes asserted that all subjects or concepts need to be taught using all seven intelligences. According to Gardner (1995), as cited by Muijs and Reynolds (2005), while most topics can be taught in number of ways, it is usually a waste of time to try and teach a topic using all seven intelligences. So the use of one strategy, such as the demonstration method, is usually enough to help all students with different MI to improve their higher order thinking skills.

CONCLUSIONS

Based on the findings of the study, the following conclusions are drawn:

1. Demonstration strategy is effective in developing inferential thinking.
2. Demonstration strategy is as effective as the lecture discussion method in developing analytical thinking and evaluation.
3. Demonstration strategy does not have a significant effect on a certain gender group. It applies to both genders.
4. Demonstration strategy does not have a significant effect on a certain Multiple Intelligence Group. It applies to any MI.
5. Demonstration strategy can help the visual-spatial group, linguistic group and musical group in their level of achievement along inference.

RECOMMENDATIONS

Based on the conclusions drawn, the following are recommended:

1. Demonstration strategy should be used by physics teachers to develop inferential thinking among their students.
2. Demonstration strategy can be in a form of a teacher demonstration, student demonstration or a video clip showing demonstrations of physics principles.
3. Demonstration strategy should be used to develop higher order thinking skills of different MI groups and gender groups.
4. A similar study may be conducted with a bigger number of subjects to determine if there is consistency of results.
5. A similar study may be conducted with subjects who are more heterogeneous (that is, with students who are not screened academically) to see if the same results will be obtained.
6. A similar study may be conducted with the level of achievement related with the laboratory time and class schedule, since these factors were not considered in this study.
LITERATURE CITED


DELICA, S., and ESGUERRA, J. (2002) Gender Differences in the FCI Pretest and Post Test Performance of Introductory Physics Students in the University of the Philippines. Published paper. National Institute of Physics, University of the Philippines, Diliman, Q.C. 


