DEVELOPING CRITICAL THINKING SKILLS THROUGH INTERACTIVE APPROACH OF TEACHING AND LEARNING GENETICS

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ABSTRACT

This study was conducted to determine the effects of Interactive Approach on the development of critical thinking skills in learning biological concepts in Genetics among students of St. Michael’s College, Tibanga, Iligan City. The heterogeneously-grouped students belonging to two intact classes were chosen as respondents of the study. The experimental group was exposed to Interactive Approach of teaching using teacher-formulated interactive activities in Genetics. The same topics were given to control group using the Traditional Method of teaching. As revealed on the data analyses results, it was concluded that the critical thinking skills of students in experimental group were developed after the intervention as evidenced by the significant difference of the students’ critical thinking skills test gain scores. The levels of students’ critical thinking skills such as collecting evidence and judging reliability; analysis, grouping, and classification; inference (reasoning); and making value judgments were elevated from below average to average and were more evident in the experimental group than in control group. Furthermore, the statistical results showed that Interactive Approach of teaching made a remarkable increase in the posttest scores obtained by the experimental group, hence, developing the students’ critical thinking skills compared to the posttest scores garnered by the control group. Since Interactive Approach has been found to be more effective for developing students’ critical thinking skills, it is recommended that teachers should be encouraged to use Interactive Approach as a mode of instruction. School Administrators must take into consideration the availability of trainings and seminars related to Interactive Approach of teaching.

Field of Research: Critical thinking, critical thinking skills, Interactive Approach of teaching

1. Introduction

The educational system, in all its forms, does a poor job of fostering critical thinking. This is a real problem, because humans are inclined to embrace ideologies rather than information (Fernandez, 2011). It is frustrating to see students using poor critical thinking in completing classroom tasks and assignment. However, it is a reward of a teacher when students can think critically and understand faulty reasoning patterns and distinguish good data from poor data. When students think critically, they are evaluating the outcomes of their thought processes as to how a good decision is or how well a problem is solved. Teaching children to become effective thinkers is increasingly recognized as an immediate goal of education. If students are to function successfully in a highly technical society, then they must be equipped with lifelong learning and thinking skills necessary to acquire and process information in an ever-changing world.

Critical thinking ability is not universal. Most students do not score well in tests that measure ability to recognize assumptions, evaluate arguments, and appraise inferences. The development of critical thinking among students of St. Michael’s College, Basic Education Department has been observed to be unsatisfactory as shown by the results of Religious of the Virgin Mary (RVM) Achievement Tests.
given to them last January 2008. Among 160 Second Year students who took the tests only 31 percent was able to answer the questions proficiently in the area of Higher Order Thinking Skills (RVM, National Assessment program, January 2008). On the same note, based on the three rounds of the Trends in Math and Science Study or TIMSS conducted in 1995, 1999, and 2003, Filipino students in grade four and second year high school are grappling with their Math and Science knowledge and skills. This showed time and again that their math and science functional literacy is on the decline. University of the Philippines professor Dr. Michael Tan (2006) in his newspaper column pointed out how the Philippines fared in the TIMSS 2003. For the fourth graders, the Philippines ranked 23rd among 25 countries in both math and science. Test results for the 8th graders (equivalent to second year high school) showed that the Philippines is at the 40th rank in math and 41st in science among 45 countries. Among the Asian countries that participated, Taipei (Taiwan), Hong Kong SAR, Indonesia, Japan, Republic of Korea, Malaysia, and Singapore the Philippines had the lowest scores in Science and Math.

In view of this low performance of the students, the teacher plays a vital role to look into effective teaching approach to develop students’ critical thinking skills making these students able to face the realities in life.

In the history of the country’s educational system, a number of surveys and tests have been conducted; many programs have been implemented to improve science curriculum and instruction. New approaches to teaching Biology have been introduced to deviate from lecture method as a traditional way of teaching. The world now is with high technologies, computers and Internets alike, but considered as insufficient approaches in teaching. Each student is known to be intelligent in a certain aspect, as it is stated in the multiple intelligences. A better understanding with the strength of the learner, the availability of the materials plus the proper approach may develop students’ ability on critical thinking.

The effects of interactive approach in teaching Biology must be determined so that if this teaching method will be found effective in the development of the learner’s critical thinking then this will encourage the other teachers to use the interactive approach in teaching their assigned subject.

2. Critical Thinking

Critical thinking is defined as a self-guided, self-disciplined thinking which attempts to reason at the highest level of quality in a fair-minded way. People who think critically attempt to live rationally, reasonably, and empathically (Paul and Elder, 2007).

3. Critical Thinking Skills

Schraer and Stoltze (1995) grouped critical thinking skills into several subskills such as: collecting evidence and judging reliability; analysis, grouping, and classification; inference; and making value judgment. Collecting evidence and judging reliability includes evaluating firsthand observations and evaluating secondhand information. Relating parts and wholes; comparing and contrasting; ordering; classifying; identifying reasons; and identifying assumptions are under analysis, grouping, and classification. Inference could be induction or deduction. Induction includes generalizing, identifying causes, reasoning by analogy, and predicting while deduction includes reasoning categorically and reasoning conditionally. Making value judgments are referred to judgments of usefulness (of things and ideas) and making ethical judgments.
4. Interactive Approach in Teaching

The hands-on approach that encourages learning from experience through an extensive and carefully graded series of exercises (Shapiro, 1992). In this study, it refers to a classroom teaching approach wherein there is interaction of students to the materials, students to the activities, students to students, and students to teachers. This is the teaching approach employed in the experimental group.

5. Research Questions

5.1 The study intended to answer the following questions:

1. What is the achievement score and level of students’ critical thinking skills before and after interventions?
2. Is there a significant difference in the achievement gain scores and level of students’ critical thinking skills in the traditional and interactive groups?
3. How do students’ critical thinking skills influenced by the types of interventions?

5.2 Statement of the Null Hypotheses

The following null hypotheses were formulated based on the research questions 2 and 3:

1. There is no significant difference in the achievement score and critical thinking skills of the students in the traditional and interactive groups.
2. There is no significant difference in the critical thinking skills test as influenced by the types of intervention.

6. Theoretical Framework of the Study

The study is anchored on Jerome Bruner’s, Jean Piaget’s, John Dewey’s, and Lev Vygotsky’s Constructivist Learning Theory that supports the idea that the use of Interactive Approach in teaching has an effect to the learners’ critical thinking skills depending on certain factors. Constructivist Theory supports the effectiveness of Interactive Approach in teaching in a way students’ engage in discovery learning using interactive materials obtaining knowledge by themselves. They select relevant ideas to construct hypotheses, transform information, use their own thinking, and make decisions to arrive at correct solutions to problems.

Constructivist teaching fosters critical thinking and creates motivated and independent learners (Gray, 2005). Gray emphasized that students and teachers are interactive in a constructivist classroom.

7. Conceptual Framework of the Study

On the basis of the discussed theoretical framework, this study conceptualized that Interactive Approach of teaching has an effect on the development of critical thinking skills of sophomore students of St. Michael’s College, Iligan City. To determine the effect of the use of Interactive Approach, this study has derived its conceptual framework as shown in Figure 1. Two groups of intact students were used in this study. The experimental group carried out the treatment which was Interactive Approach. The other group served as the control group, taught using the Traditional Method of teaching. This study tested the effectiveness of teaching approaches in the development of critical thinking skills as shown in the achievement scores. Furthermore, the diagram shows the role of pretest as covariate.
Independent Variable

<table>
<thead>
<tr>
<th>Teaching Approaches</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Interactive Approach of teaching</td>
<td>• Achievement Score</td>
</tr>
<tr>
<td>• Traditional Method Of teaching</td>
<td></td>
</tr>
</tbody>
</table>

Pretest
(Covariate)

Figure 1. Conceptual Framework of the Study

8. Methodology

8.1 Research Design

An experimental research design was utilized in this study to determine the effects of interactive approach to the development of critical thinking skills of the students. The development of students’ critical thinking skills was determined through their gain scores in the teacher-made multiple choice and open-ended critical thinking skills tests given to the two groups before and after intervention. Specifically, this study used the Quasi-Experimental Pretest-Posttest Nonequivalent Groups Design. This design was chosen over the True Experimental Design because the sampled subjects of this study came from the intact heterogeneous sections. This design is shown below:

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Treatment</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental Group</td>
<td>N</td>
<td>O₁</td>
<td>X</td>
</tr>
<tr>
<td>Control Group</td>
<td>N</td>
<td>O₃</td>
<td>O₄</td>
</tr>
</tbody>
</table>

The design notation for the Non-Equivalent Groups Design (NEGD) showed that there were two groups, an experimental and control, and that each was measured pretest and posttest. Moreover, O₁ and O₃ represented the first administration of the critical thinking skills pretest (achievement) to the experimental and control group. O₂ and O₄ represented the second administration of the instrument as posttest (achievement) to the experimental and control group. The symbol X signified the intervention as Interactive Approach in teaching Biological concepts particularly in Genetics and N signified the non-equivalent.

8.2 Research Locale and Setting

The study was conducted in St Michael’s College, Basic Education Department, Brgy. San Miguel, Tibanga, Iligan City. St. Michael’s College is Catholic institution of higher learning administered by the Religious of the Virgin Mary (RVM).

8.3 Subjects of the Study and Sampling Procedure
The second year high school students belonging to sections Simplicity and Generosity of St. Michael’s College were chosen as respondents of the study.

**8.4 Data Gathering Procedure**

**8.4.1 Preliminary Activities**

The Interactive Activities were formulated by the researcher with a self-made format consisting of introduction, objectives, materials to be used, procedure, and questions to be answered. Selection of these activities was based on the identified subtopics of genetics in biology learning competencies of St. Michael’s College in accordance with the DepEd.

**8.4.2 The Intervention**

The multiple choice pretests-posttests were administered before the intervention to both experimental and control groups. In performing the Interactive Activities, the students in the experimental group interacted with the materials, with their classmates, and teacher-researcher. When the activities called for the use of computers or laboratory materials, the activities were performed in the Computer Laboratory and Biology Laboratory otherwise in the classroom.

In the control group, the teacher-researcher taught the same topics using Traditional Method of teaching with minimum materials and visual aids. The classes using this method were only done in the classroom. Though this method is purely lecture, the researcher also entertained questions for clarification. The control group and experimental group differed only in the teaching method since both were given the same topics, evaluation and assignment to assess their understanding of the lesson.

At the end of the intervention, the critical thinking skills posttests were administered to the experimental and control groups.

**8.5. The Research Instrument**

**8.5.a Critical Thinking Skills Test.** This is the instrument used in gathering data. To proportionally cover all Genetics subtopics, the test construction was guided by a table of specification. The subtopics covered were Mendel’s Experiments; Monohybrid and Dihybrid Crosses Using Punnett square; Probability Ratios; Formation of Boys and Girls in a Family; Inheritance of Human Traits and Pedigree Analysis. Two hundred (200) items multiple-choice type of test were formulated basing on the Critical Thinking Skills sample questions by Schraer and Stoltze (1995).

**8.5.b Content Validity of the Instrument.** The draft of the test was shown to the research adviser for corrections, comments and suggestions. The test items were checked by the thesis adviser and revised by the researcher several times. To determine the validity of the test questions, the researcher consulted three (3) Biology education experts to validate the content and make the necessary corrections, comments and suggestions in order to improve the test. Only 146 multiple choice test items were left after the validations.

**8.4.c Reliability of the Instrument.** Cronbach Alpha was used to measure the internal consistency reliability coefficient of the Critical Thinking Skills Test. As computed, the reliability coefficient was 0.752 which meant that the constructed achievement test had a higher reliability. The test questionnaire was finally composed of 35 items multiple choice questions.
9. Statistical Treatment of Data
The data were analyzed using the Statistical Package for Social Sciences (SPSS) Version 11.5 for Windows. Mean and Standard Deviation were used to determine the levels of students’ critical thinking skills. To determine if the improvement on each group was significant, further analysis was done through t-test of correlated means for samples (paired t-test). That is, investigating whether the gain scores of each group were significant and can be attributed to fact that they have prior knowledge on this regard. To test the effectiveness of the interactive approach on developing critical thinking skills compared to traditional approach while controlling the respondents’ prior knowledge (pretest), one-way ANCOVA (Analysis of Covariance) was utilized.

10. Finding & Discussion
Investigating the first research question concerning the level of critical thinking skills of the students before and after the intervention, achievement pre-test and post-test in Genetics were administered prior to and after the treatment was given and descriptive statistics were calculated. Result is shown in Table 1.

<table>
<thead>
<tr>
<th>Achievement Scores (Critical Thinking Skills)</th>
<th>Teaching Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Traditional</td>
</tr>
<tr>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Pre-test</td>
<td>14.95</td>
</tr>
<tr>
<td>Post-test</td>
<td>22.92</td>
</tr>
</tbody>
</table>

*Very High = 33 – 35; High = 30 – 32; Above Average = 27 – 29; Average = 24 – 26; Below Average = 21 – 23; Low = 18 – 20; Very Low = 17 and below

It can be noted that control group was exposed to the Traditional Method of teaching while experimental group was treated by Interactive Approach of teaching. As shown in Table 1, control group got a little higher pre-test mean score of the achievement test (M = 14.95, SD = 2.97) than the experimental group (M = 13.55, SD = 2.57) though these scores fall under on the same level (very low) of critical thinking skills. As post-test was conducted after the specified time frame of the treatment, improvements of their achievement scores can be seen directly on each group. Great improvement was exhibited by the experimental group who was exposed to Interactive Approach of Teaching (M = 25.10, SD = 3.73) than the control group (M = 22.92, SD = 4.14) which implied improvements also in their critical thinking skills to “average” and “below average” respectively. To determine if this improvement on each group was significant, further analysis was done through t-test of correlated means for samples (paired t-test). That is, investigating the second research question whether the gain scores of each group were significant and can be attributed to fact that they have prior knowledge on this regard. Results are shown in Tables 2 and 3.

<table>
<thead>
<tr>
<th>Teaching Approaches</th>
<th>Paired Samples</th>
<th>Correlation Coefficient</th>
<th>Description</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>Pre-test and Post-test</td>
<td>.459</td>
<td>Strong Relationship</td>
<td>.003*</td>
</tr>
</tbody>
</table>
The following table provides a summary of the paired samples test results:

<table>
<thead>
<tr>
<th>Teaching Approaches</th>
<th>Paired Samples</th>
<th>Correlation Coefficient</th>
<th>Description</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interactive</td>
<td>Pre-test and Post-test</td>
<td>.392</td>
<td>Moderately strong Relationship</td>
<td>.011*</td>
</tr>
</tbody>
</table>

*Significant at 0.05 level

As reflected, pre-test and post-test of the two groups were positively correlated to each other. Students who were exposed to traditional method of teaching who got higher pre-test scores among the others tend to have higher scores in the post-test, \( r = .456, p = .003 \) which their pre-test explained about 20.8% of the variance in their post-test which suggest a strong influence of their post-test. This implies that students were consistent on their achievement scores, that is, those who got higher pre-test most of them also got higher post-test as they were exposed in Traditional Approach of Teaching.

On the other end, students who were exposed through Interactive Approach of Teaching showed also a positive correlation between their pre-test and post-test, \( r = .392, p = .011 \). Over-all, their pre-test only accounted 15.4% of the variance of their post-test, indicating a small-moderate effect. This suggests that the relationship of their pre-test and post-test is not so strong however significant and directly correlated to each other. Meaning, students who got higher scores in pre-test as expected also got higher score in post-test though this relationship was limited to moderate association. This further suggests that not all students who got higher scores in pre-test got also the higher scores in post-test, there were some students who even got higher post-test whose pre-tests were not quite as good as the others.

Further analysis was done in order to investigate these apparently odds between difference of association of the pre-test and post-test of the control and experimental group, paired t-test result is shown in Table 1 to support the above claimed and to determine whether their gain scores are statistically significant.

### Table 3. Summary Results of the Paired Samples Test

<table>
<thead>
<tr>
<th>Achievement Scores</th>
<th>Pre-test</th>
<th>Post-test</th>
<th>Paired Differences</th>
<th>t-value</th>
<th>df</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical Thinking Skills</td>
<td>Mean</td>
<td>DE*</td>
<td>Mean</td>
<td>DE*</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Traditional</td>
<td>14.95</td>
<td>(VL)</td>
<td>22.92</td>
<td>(VL)</td>
<td>-7.97</td>
<td>3.826</td>
</tr>
<tr>
<td>Interactive</td>
<td>13.55</td>
<td>(BA)</td>
<td>25.10</td>
<td>(A)</td>
<td>-11.55</td>
<td>3.603</td>
</tr>
</tbody>
</table>

*Descriptive Equivalent (DE): (VL) = Very Low; (BA) = Below Average; (A) = Average
** Significant at 0.05 level

It can be observed that experimental group has the higher gain score (11.55) than the control group (7.97). Hence, this supported the above claimed that there were students from interactive group got higher post-test scores whose pre-tests are seemingly low than the others who got also higher scores from the post-test. It can noted however, that both gain scores of the traditional and interactive groups were highly significant at 0.05 level, \( t(39) = -13.182, p < .001 \) and \( t(40) = -20.720, p < .001 \) respectively. This implies that this great improvement of the interactive groups can be attributed to the fact that their critical thinking skills were developed through this method of teaching. Related study was carried out by Knight and Wood (2005) to determine whether student
learning gains in a large, traditionally taught, upper-division lecture course in developmental biology could be increased by partially changing to a more interactive classroom format. The results indicated significantly higher learning gains and better conceptual understanding in the more interactive course. On the basis of this evidence, they propose a general model for teaching large biology courses that incorporates interactive engagement and cooperative work in place of some lecturing, while retaining course content by demanding greater student responsibility for learning outside of class.

However, it cannot be denied that somehow this result can be confounded with some attributes, one of that is their prior knowledge on some extent. Hence, further analysis was conducted to investigate whether this improvement can be attributed solely to the treatment done in the interactive group through interactive teaching by controlling their pre-test. This led to investigate the last research question of this study, the effect of the interactive approach of teaching in developing critical thinking skills of the students. The analysis was done through one-way ANCOVA (Analysis of Variance) and the result is shown in Table 4.

Table 4. Summary Table of One-Way Analysis of Covariance (ANCOVA) on the Achievement Scores and Level of Critical Thinking Skills of the Students as Influenced by the Teaching Approaches

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>Sum of Squares</th>
<th>Df</th>
<th>Mean Square</th>
<th>F-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching Approaches</td>
<td>173.216</td>
<td>1</td>
<td>173.216</td>
<td>13.581</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Error</td>
<td>982.091</td>
<td>77</td>
<td>12.754</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>47433.000</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Significant at 0.05 level

Using pre-test as the covariate, the result of the analysis revealed that there exists a significant difference between the mean scores of traditional (\(M = 22.92, SD = 4.14\)) and interactive (\(M = 25.10, SD = 3.73\)) groups in the post-test, \(F(1, 77) = 13.581, p<.001\) at 0.05 level of significance. This implies that the students who were exposed to Interactive Approach of teaching performed much better than students whose intervention was based from the Traditional Method of teaching which in a way led the development of students’ critical thinking skills This is supported by Potts, B. (1994) in his statement: “Promoting interaction among students as they learn helps each member achieve more.” Shymansky & Penick (1981) also concluded after his study that activity-centered classrooms encourage student creativity in problem solving, promote student independence, and help low ability students overcome initial handicaps. It can be inferred that students’ performance in the achievement test was influenced by the given treatment through interactive approach of teaching as the intervention of developing students’ critical thinking skills. Hence, Interactive Approach of teaching is a very effective tool in developing learners’ critical thinking skills. This result is supported by some studies that showed evidences of the effects of interactive approach to students’ critical thinking skills. Johnston (2002) investigated the effect of interactive teaching on the development of learning in Physics using recognized international tests and observational analysis. Pupils taught in the traditional didactic way, using secondary sources, have been tested alongside those pupils taught using the interactive approach. Initial results have indicated that pupils engaged in interactive learning score higher on tests of knowledge than pupils taught using the more traditional approach. These pupils appear to have a better conceptual understanding of physics and are more able to apply their knowledge and understanding in unfamiliar contexts.
8. Conclusion and Future Recommendation

The results revealed that Interactive Approach in teaching Biological concepts specifically in Genetics had positive effects on the development of Critical Thinking Skills. The results further showed that the students who were exposed to Interactive Approach became more efficient in their learning process that they were able to manage their own learning. It is safe to say that the instructional materials used in the interactive activities, individualized and small-group exercises, challenged the students to learn new skills and develop creative problem-solving strategies. Hands-on learning as in interactive learning was an important method for a student’s education. Manipulation and experiential learning gave students a reference for importance of material. Through interactive learning, students were given meaningful experiences that helped them develop their critical thinking skills. As students were exposed to interactive activities, there is a reason to believe that through this they became more skillful in answering and solving problems embedded in the interactive activities.

Although the results significantly showed that the experimental group had a remarkable increase in their critical thinking skills test scores, the control group scores should also be taken into consideration. The fact that the students in the control group had also a remarkable increase though not as much as the experimental group, directs the teacher to rethink about the route of teaching and learning. This implies that Traditional Method of teaching has also its way to learning but may inhibit the development of the students’ critical thinking skills. Teachers should always look for varied teaching approaches for students’ learning experiences to be more enjoyable and meaningful.

Inasmuch as the students exposed to interactive approach in teaching showed remarkable increase in the critical thinking skills test score, it is imperative that science teachers should constantly expose the students to interactive activities. By so doing, students would have enough experience with the activities thereby improving their performance in science. The results of this study will serve as basis for designing a skills-training program for the teachers’ teaching method and strategies that promote the development and improvement of critical thinking skills among the students.

Acknowledgement

This paper is under scholarship of the St. Michael’s College.

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B. Periodicals


C. Internet Accessed Articles


