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# Teaching Grade 5 Life Science with a Case Study Approach

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## Abstract

*The main purpose of this study was to investigate the effects of a case study approach on students' achievement and attitudes towards viruses, bacteria, fungi, and protista. Fifth-grade students (N = 88) from two different classes were involved in the study. One intact class was assigned as the experimental group, whereas the other intact class was assigned as the comparison group. The comparison group students received their instruction by traditional teaching, whereas the experimental group students were instructed with a case study approach. Achievement and attitudes were measured before and after instruction. Results revealed that there were significant differences favoring the case study approach on students' achievement and attitudes towards science.*

## Introduction

One of the major goals of science education is to improve students' scientific understanding, thinking, and problem-solving abilities (Dori & Herscovitz, 1999). Even though several researchers focus on these skills, students who have graduated from traditional schools cannot accomplish them since most instruction has been viewed as the transmission of knowledge from teacher to students (Bredo, 1994). The traditional way of teaching science has not engaged students in authentic activity; rather, they appear to be engaged in rote memory. Constructivism has been advocated in the international science education reforms as one way of addressing, managing, and achieving the goals of science education. A case study approach, which is one of the constructivist methods, is a collection of teaching methods that are organized around narratives that reflect facts, values, and issues. This study explores the use and benefits of a case study approach compared to a traditional approach with 5th-grade students learning about viruses, bacteria, fungi, and protista.

## Background

There are many ways to design case studies; no single case study method will fit the implementation needs of all real classrooms. Different teaching techniques reflect the different objectives of teachers (Barrows, 1986; Herreid, 1994).

## Constructivism

Constructivists think that instruction should focus on providing tools and environments to help students interpret multiple perspectives of the world in order to create their own worldview (Jonassen, 1991). Constructivism as a method of teaching and a model of learning represents a variety of faces, including information processing, interactive-constructivism, social constructivism, and radical constructivism. The two most comprehensive and best-known faces of constructivism are radical and social constructivism. Other faces tend to focus on specific segments or implications of social or radical constructivism (Staver, 1998). Von Glasersfeld (1995), a leading proponent of radical constructivism, set forth several principles that describe knowing and knowledge in their development, nature, function, and purpose. First, he suggested that knowledge is actively built up from within by a thinking person; it is not passively received through the senses or by any form of communication. Second, von Glasersfeld described the importance of social interactions among learners as central to the building of knowledge by individuals. Third, the character of cognition is functional and adaptive. Cognition and the knowledge it produces are a higher form of adaptation in the biological context in which the functional concepts of fit and viability—two concepts embraced in evolutionary theory—also characterize knowledge. Fourth, von Glasersfeld described the purpose of cognition as serving the individual's organization of the learner's experiential world; cognition's purpose is not the discovery of an objective ontological reality.

Social constructivism centers its focus on the study of meaning making through language. For social constructivists, knowledge is created and legitimized in science education by means of social interchange in its many forms (Driver, 1983; Driver, Leach, Millar, & Scott, 1996; Gergen, 1985; Shotter, 1995). Gergen (1995) set forth three essential points about language. First, social interdependence is the conduit through which we attain meaning in language. Language is the means by which humans communicate, and the coordinated endeavors of at least two individuals are required to attain a meaning understood by each and all. Second, within language, its meaning is dependent on the context of the social interdependence. The location of referents for language lies in the particular sociological and historical occurrences, and it does not follow that local agreements about connections between language and referents are necessarily generalizable. Third, the function served by language is primarily communal, and it is paramount in continuing relationships among individuals in communities. In conclusion, the primary differences between radical and social constructivism is that the focus is cognition and the individual in radical constructivism, whereas in social constructivism, the focus is language and the group (Staver, 1998).

## Case Study Methods

*Case study* refers to a group of methods that may be used for achieving different educational purposes. The common component among many variants of case studies is the use of somewhat complex cases or ill-structured problems at some point in the instructional sequence.

Barrows (1986) identified several ways to design problem-based instruction. In a lecture-based problem, the case is presented after lecture, and in problem-based lecture, the case is presented before the lecture. The case focuses students' attention on the material that is to be covered. In the case method, a discussion is carried out after researching the case. Students are given a complete case, and they are required to research it in preparation for class discussion. In the problem-based approach, students solve the case with discussion and research and then evaluate the case in small groups. The closed-loop, problem-centered case method is similar to the problem-based method. After self-directed study is completed, students evaluate the information resources in the closed-loop method. They return to the problem regularly as they evaluate their prior knowledge, reasoning, and information sources.

Herreid (1994) described some of the methods used to teach a case:

- The *discussion technique*—also known as the *Socratic method*—is generally used by business and law schools to teach cases. Instructors ask probing questions, and students analyze the problem in the case. Debate is suitable for cases where two opposing views are given. Two teams of students are prepared to argue either view—pro or con.
- The *public hearing format* is being used when a student panel role-plays the jury to render a judgment. Different student groups make presentations to express different views.
- The *trial format* of case studies has two opposing sides, both of which have attorneys, witnesses, and cross-examiner.
- The *scientific research team format* focuses on the problems, questions, and dilemmas that scientists face. They use the hypothetico-deductive method, which includes asking questions, making hypotheses, making predictions, testing predictions with observations, making evaluations, and drawing conclusions.
- The *team learning format* uses individual reading assignments before starting cooperative/collaborative learning in small groups. Students apply the facts and principles they have learned from reading while solving case problems.
- In the *problem-based learning* (*PBL*) *format*, solving a typical case has many steps. In the first meeting, the instructor presents a written case. A tutor and the students together try to understand the case. In the second meeting, students share their findings and discuss their opinions. PBL provides opportunities for interacting, thinking, discussing, and sharing information among students.

Lohman's (2002) extensive literature review reveals four problem-based approaches to professional development: (1) case study, (2) goal-based scenario, (3) problem-based learning, and (4) action learning. This literature review contrasts the designs of the four approaches and finds key differences in the nature of their case problems and training strategies. Specifically, in a goal-based scenario, trainees are responsible for accomplishing a goal in a simulated work environment. The simulation begins with the presentation of the training goal and objectives (Kolonder, 1993). Trainees receive a minimum amount of problem information at this point. They are allowed to take a variety of paths to gather information and work toward their goal, but they must work with the information and paths that are specified by the simulation. A goal-based scenario ends when a trainee produces a product that closely matches the one specified by the simulation. Goal-based scenario problems are characterized as moderately structured because they require engagement in some problem-framing activities, they provide a number of paths to take in deriving a solution, and they contain a limited number of model solutions. These moderately structured problems tend to be prototypical, representing common types of work problems found in practice (Macpherson, Berman, & Joseph, 1996).

Cases in problem-based learning are more ill-structured than either those used in a case study or a goal-based scenario. In problem-based learning, trainees acquire the knowledge and skills they need to identify, understand, and solve a problem as they encounter it (Galey, 1998). Ill-structured cases in problem-based learning are prototypical of problems regularly found in practice (Lohman & Finkelstein, 2000).

Action learning also focuses on solving ill-structured problems (Marsick, 1990); however, the problems addressed in action learning may be the least prototypical of all four problem-based approaches because participants generally choose which problems to work on, and their decisions are based on the impact that problems presently have or may have on organizational performance. Action learning problems are classified as ill-structured because they lack clear identification, procedures for specifying solutions, and no single right solution. They are not necessarily prototypical of other work problems that action learning participants routinely face in their organizations.

Long-structured cases, which were not identified by Lohman (2002), are generally used in the case study approach to actively involve participants on the problem-solving process (Birchall & Smith, 1998; Fulmer, 1992; Harling & Akridge, 1998). A long-structured case consists of a rich, written account of a problem situation. This account details relevant facts, constraints, extraneous information, and conflicting viewpoints of people involved in the situation (McWilliam, 1992); it also includes ancillary materials such as diagrams, charts, financial reports, memorandums, and market data (Graham, Morecroft, Senge, & Sterman, 1992). Procedures for solving a case problem are generally prescribed for trainees prior to or during the analysis of the problem. As problem analysis proceeds, trainees are guided toward one or several appropriate solutions. In this case study approach, therefore, the problem situation is generally framed for trainees; procedures for specifying solutions are provided; and trainees are led toward one of several best solutions (Gallagher, 1997).

The most prevalent implementation and research of case study instruction has been carried out in medical education (Albanese, 2000; Albanese & Mitchell, 1993; Colliver, 2000; Norman & Schmidt, 1992). The use of the case study approach in teacher education and precollege educational programs is relatively new and, thus, little research is available (Arellano et al., 2001; Barnet, 1998; Faux, 1999; Kinzie, Hrabe, & Larsen, 1998; Whitenack, Knipping, Novinger, Coutts, & Standifer, 2000). Studies conducted on case study instruction in undergraduate science education are very limited in number and content. Most of the available research reports end-of-course evaluations and instructor beliefs or experience (Arambula-Greenfield, 1996; Brink, Goodney, Hudak, & Silverstein, 1995; Cheng, 1995; Cliff & Curtin, 2000; Cornely, 1998; Herreid, 1994; Jones, 1997; Wilcox, 1999).

Stepien and Gallager (1993) found that students behave as scientists to solve problems in PBL environments. Their findings revealed that the PBL approach appears to help students appreciate scientists by using realistic, ill-structured problems; focusing on metacognitive skills; and feeling some ownership over the learning process. These researchers believed that PBL is not simply a way to learn problem solving; it is a way to learn the content and that learning is as authentic as learning could get. Richmond and Striley (1994) explored 10th-, 11th-, and 12th-grade students' understanding in an integrated PBL science course. Based on the students' responses, the researchers concluded that students learned more in an integrated PBL science course than in other science classes. Specifically, they learned how to work as a team member, listen to others' ideas, become more actively involved in class discussions, and how to make connections between concepts. Also, they understood why they were learning a particular subject and why it was important, and they benefited from the use of real-life context.

Gabel (1999) applied the case study method for teaching an elementary school science course. She was interested in improving students' higher order thinking skills. The findings of the study indicated that students' interest was stimulated, which, in turn, stimulated higher levels of thinking. Gabel concluded that the teacher's way of facilitating the case study approach was a big factor in the depth of class discussion and in the evaluation of critical thinking skills. This approach appeared to increase students' interest in learning science, but instructional resources, such as Internet conferencing, were necessary for students' use.

The use of case study instruction in elementary and secondary schools is relatively new. The related literature is, therefore, very limited, with most being reports of teachers and students during the implementation of case study methods and a few research-based articles. Barden, Frase, and Kovac (1997) explored teaching scientific ethics using a case study approach in secondary schools. These researchers' primary conclusion was that the case method is an effective teaching technique for discussing scientific ethics with secondary school science students. They believed that the students gained an appreciation for the scientific enterprise that is beyond the normal goals of understanding scientific concepts and the process of conducting research.

Elshafei (1998) examined a case study approach with 342 students within five secondary schools using quasi-experimental techniques. He found that students who solve problems in groups perform better and generate more plausible solutions than traditionally taught students. The results indicated that students preferred a more constructivist form of instruction. Furthermore, the students and teachers involved with the PBL unit wanted to use this type of instruction in the future. Dori and Herscovitz (1999) investigated the scientific question-posing capabilities among 10th-grade students studying air quality in a cooperative learning environment using the jigsaw method. The students' question-posing skills were evaluated by using questionnaires before and after completion of the case study. These researchers concluded that the fostering of question-posing into the case study-based teaching and learning approach was the preferred strategy, especially when environmental issues were involved.

Passmore and Stewart (2002) designed a case study to bring students to an understanding of the practice of evolutionary biology by engaging them in developing, elaborating, and using Darwin's model of natural selection. Students' work samples illustrated the potential for sophisticated reasoning that exists when students are given the opportunity and conceptual tools to engage in realistic inquiry. Dori, Tsaushu, and Tal (2003) investigated the ability of 200 nonscience majors in eight 10th- to 12th-grade classes to use various thinking skills in analyzing environmental and moral conflicts presented through case studies in a biotechnology module. Their research demonstrated that the case study approach appeared to contribute to the development of scientific and technological literacy as well as to the higher order thinking skills of these nonscience majors.

Traditional life science courses require students to do a lot of memorizing. Such courses can challenge instructors to encourage students to go beyond rote memorization of lower level ideas to in-depth understanding of concepts, processes, and the larger view of biological sciences. *Viruses, Bacteria, Fungi, and Protista* is a common unit in life science for the middle years of elementary school. This unit basically describes these organisms' shape and structure, where they live, and how they affect other living things. Understanding this unit influences students' understanding of life science because of the integrated nature of the biological sciences. The present study attempted to explore this important science area by examining the effectiveness of case study instruction on 5th-grade elementary school students' achievement and attitudes towards viruses, bacteria, fungi, and protista.

## Methodology

### Subjects

The subjects of this study consisted of 88 5th-grade students from two intact science classes. One class was randomly assigned as the experimental group and experienced the case study approach, whereas the other class was assigned as the comparison group and experienced traditional instruction. Participants of the study belonged to middle-class families. The school where the study was conducted was a public school. Students began to study science in 4th grade with one life science unit and one earth science unit. Before 4th grade, the students took a course where science and social science topics were taught together. The students' home language and the language of instruction was Turkish. There were 43 students (18 male, 25 female) in the experimental group and 45 students (21 male, 24 female) in the comparison group.

### Instruments

In this study, a two-group, pretest/posttest design was utilized in order to determine the effectiveness of the two different instructional methods: (1) case study and (2) conventional large group. The students' reflections about the instruction written in their journals at the end of the treatment served as qualitative data. Quantitative data was collected using two instruments administered as pretests and posttests: (1) Science Achievement Test (SAT) and (2) Attitude Scale Towards Science (ASTS). The students' science achievement on the *Viruses, Bacteria, Fungi, and Protista* unit was measured with a 25-item, multiple-choice test (SAT) developed by the researcher. The developmental stage of the SAT was guided by the instructional objectives stated for the *Viruses, Bacteria, Fungi, and Protista* unit. Careful consideration of the learning outcomes defined the content of the test. Bloom and Krathwohl's (1956) taxonomy of cognitive levels was considered during the preparation of the test items related to the learning outcomes. Each test item included one correct answer and three distractors. A group of experts in measurement and evaluation, science, and science education examined the test for the appropriateness of the items in terms of the extent to which the test measures a representative sample of the domain of tasks (validity) with respect to the *Viruses, Bacteria, Fungi, and Protista* unit of the elementary school science course. The internal consistency and reliability of the test was found to be .80. As a result of the item analysis, item difficulty was determined to be between .67 and .94, with a mean difficulty of the items of .83. Items having less than .24 item difficulty were eliminated from the test in order to develop the final form of the SAT. The sample item provided illustrates typical test items.

*Multiple-Choice Question:* Melih smeared some particles onto the piece of bread and put the bread into a jar. After two or three days, he saw some cotton-like structures on the bread. Which one of the living things could cause these structures?

(i) Bacteria
(ii) Protista
(iii) Fungi
(iv) Viruses

The ASTS, developed by Sahin, Çakır, and Sahin (2000), was administered to measure students' attitudes toward science (reliability = 0.95). The Likert-type scale has 27 items with four dimensions (interest, like, importance, and fear) developed from factor analyses. Students were required to indicate their agreement on a 5-point response scale going from 5, strongly agree, to 1, strongly disagree.

### Treatment

This pretest-posttest study lasted approximately six weeks. While one class was randomly assigned as the comparison group, the other class was assigned as the experimental group. The comparison group was exposed to traditional instruction, and the experimental group was exposed to the case study approach. The topics related to the *Viruses, Bacteria, Fungi, and Protista* unit were part of the regular curriculum in the elementary science course.

In traditional instruction, students were given a reading assignment to be completed prior to the lesson. One student was called upon in class to explain the important concepts of the viruses, bacteria, fungi, and protista covered in the reading assignment. The students recorded the teacher's explanation in the classroom in writing. The teacher asked questions about unclear parts during the lesson instruction.

In the experimental group, a case unit was developed in order to examine the effects of the case study on students' achievement and attitudes toward science. No case studies written for elementary school life science courses were found; therefore, the researcher developed the cases for the experimental group. A problem situation was written and a scenario was developed by considering students' interests and backgrounds. In order to create questions in students' minds, some conflicting issues were inserted into the scenario (McWilliam, 1992). These conflicting situations increased their motivation to research the central topic. In addition, during development of the scenario, issues were selected from real-life situations to increase students' interest. At the end of the scenario, students were directed to the library and Internet to respond to the questions and conflicting situations given in the scenario (Gallagher, 1997; Lohman, 2002). Articles, Internet sites, true medical cases, and science magazines were explored and evaluated for inclusion in the case to help guide students' research. The objectives of each case were determined based on the elementary school science curriculum and an interview with the teacher. Students' cognitive, psychomotor, and affective characteristics were also taken into consideration in developing the cases (Figure 1).

**Figure 1. An Illustrative Case Study from the Topic of Viruses, Bacteria, Fungi, and Protista**

**Invisible Predators**

It was Saturday. I and my mother decided to go shopping. We took some vegetables, such as tomato, cucumber, eggplant, and peach. Grocer selected the rotten vegetables and threw them away. I asked him why these vegetables were rotten. After grocery, we went to butcher to buy chicken, meat, and salami. Butcher wore his gloves and gave our orders. I was curious about the reason for wearing of gloves by butcher. We got our orders and returned to home. Although we were tired, my mother and grandmother started to make canned foods and pickle for winter. I had a question in my mind, what would be the reason for making canned food and pickle? While they were making them, I went outside and played with my friends. It was autumn. My mother warned me about cold weather of the autumn. I played until I was hungry. I came to home and ate salami sandwich. After that, I started to do my homework. 3-4 hours later, I felt a very bad pain in my stomach. My mother saw me while I was crying because of the stomachache. She asked me what I ate for dinner. She went to kitchen and realized something was smelling very bad. She looked around to find source of this bad smell and noticed that she had forgotten the salami on the table instead of putting it in the refrigerator. I asked my mother why the food was rotten. She talked about bacteria which are invisible with naked eye. It was interesting. I could not see bacteria but they caused trouble in my stomach. Therefore, I would like to learn much more about the bacteria, for example, what do they look like? Where and how do they live? Were all of them harmful? I went to library, read some book, and searched internet to find answers to these questions.

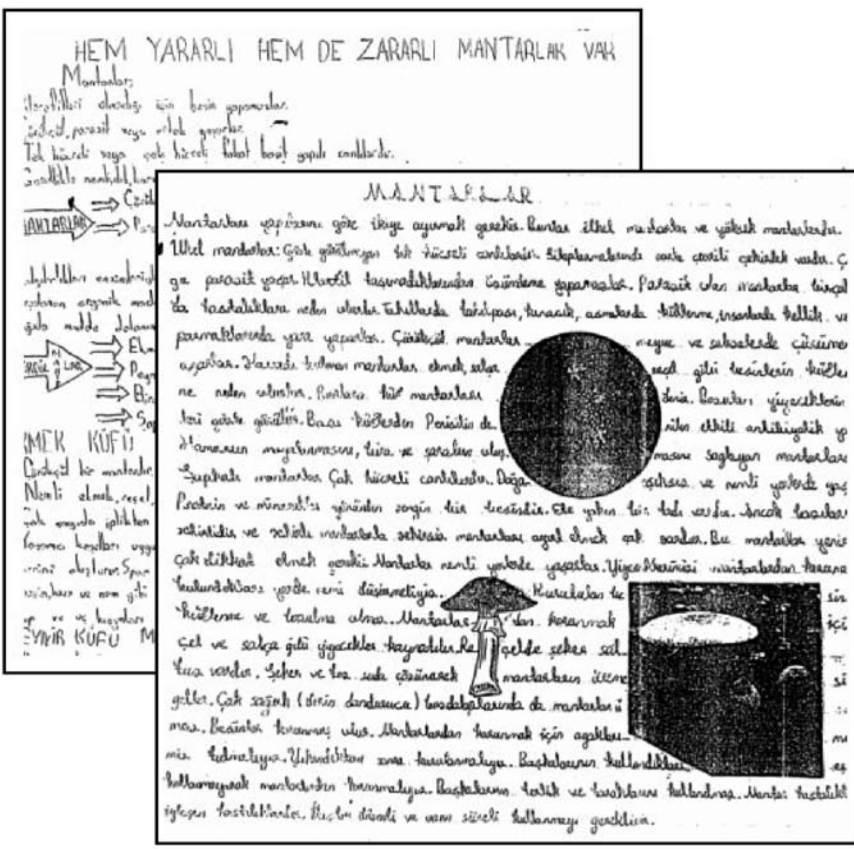
The teacher was provided professional development to implement the case study approach at the beginning of the treatment. She was encouraged to become a metacognitive coach, that is, the teacher was encouraged to pose questions instead of providing answers; prepare a risk-free environment in which students express their thoughts about the situation; help students understand the questions; ask questions during problem definition, analysis, and synthesis; help students take on the role of problem-solver; and think aloud with students. The teacher was also given a teacher's manual that explained how to implement the case study approach.

Before coming to school, students were asked to read the material given with the cases and were asked to search through different materials and Internet sites related to the topic. They were encouraged to investigate significant science concepts about viruses, bacteria, fungi, and protista. Although the case study approach has been mostly used with older students, there were some research studies that indicated this approach was effectively used with elementary school students without any language problems (Gabel, 1999). The students were divided into heterogeneous small groups by considering their success in other courses and to establish potential support and expertise within each group.

On the first day of each case implementation, one student in the class read the case scenarios aloud. The teacher asked the students if there was any unclear part(s) in the cases. After that, the students in each group were asked to analyze the case scenarios. Each case was read, and the students discussed the questions inserted into the case during the first half of the class period. Meanwhile, the teacher monitored and provided assistance but not solutions. The groups combined their individual findings into a single report for each case study. During the second half of the class period, a whole class discussion was held where the students went through their group reports. In this session, they responded to the questions inserted into the case and also shared information about the topic that was acquired by searching through different information sources.

After completing the case, the students were asked to write their responses to follow-up questions individually (Figure 2). Generally, test experts recommend the descriptive rating scale for assessing essay type questions since it is the richest in description and easiest to use (Haladyna, 1997). Therefore, descriptive rating scales were used to rate individually responded follow-up questions. A holistic type of descriptive scale was developed to measure main objectives of written instruction. The teacher and the researcher got together before scoring the written responses. They came to a consensus to score: "0 – not understanding" if the student did not write true information; "1 – understanding" if the student wrote true information but not an example; "2 – good understanding" if the student wrote true information and an example; and "3 – better understanding" if the student wrote true information and more than one example.

**Figure 2. Examples of Two Students' Individual Responses to Follow-Up Questions**



The posttest was administered after the six-week period in which four cases were completed. The teachers and the researcher evaluated these responses by using performance-based assessment. Essay-type questions in the posttest were assessed by using an analytic rating scale that is used to measure detailed description in written form. Again, the teacher and researcher came together to define the categories of the analytic rating scale as "facts," "opinions," and "come to conclusion," all of which had four alternatives (Figure 3).

**Figure 3. Outline of Analytic Rubric Developed to Assess Essay-Type Questions in Pretest and Posttest**

**Facts**

4 All of the facts are true and logical.
3 Most of the facts are true and logical.
2 Facts are not enough and generalized.
1 Facts are not suitable and logical.

**Opinions**

4 Opinions are clear, consistent, and supported by many examples.
3 Opinions are clear and supported by some examples.
2 Opinions are clear but not supported by examples.
1 Opinions are not clear, and there are no examples.

**Come to Conclusion**

4 Results are supported by facts and evidence.
3 Results are supported by facts but no evidence.
2 Results are supported by a few facts.
1 Results are not supported by any facts or evidence.

## Results

The experimental and comparison groups' previous learning about the topics in the *Viruses, Bacteria, Fungi, and Protista* unit and their prior attitudes toward science were assessed using two pretests (SAT and ASTS). The means and standard deviations of the pretest and posttest results are presented in Table 1. The pretest means for the two groups were tested using two-group *t*-tests to explore whether the two groups were similar at the beginning of the study. The results indicated that no significant differences were found between the experimental and the comparison group in terms of achievement about the topic ($t = 0.411$, $p > 0.05$) and attitudes toward science as a school subject ($t = 1.276$, $p > 0.05$) at the beginning of the treatment. Therefore, it was decided to use the posttests as indicators of instructional effects.

**Table 1. Means (M) and Standard Deviations (SD) of the Pretest and Posttest results of the SAT and ASTS as a School Subject**

| Group | N | Pre-SAT | | Post-SAT | | Pre-ASTS | | Post-ASTS | |
|---|---|---|---|---|---|---|---|---|---|
| | | M | SD | M | SD | M | SD | M | SD |
| Experimental group | 43 | 46.74 | 12.39 | 87.79 | 11.61 | 106.70 | 11.77 | 116.49 | 8.68 |
| Comparison group | 45 | 47.89 | 13.67 | 71.44 | 12.95 | 103.13 | 14.25 | 104.20 | 14.32 |

Statistics ($t$-test) were used to compare the effectiveness of two different instructional methods on the achievement and attitude results obtained from the posttest scores after the treatment. The results indicated that there was a significant difference between the achievement of students in the experimental group and of the students in the comparison group ($t = 6.223$, $p < 0.05$). Higher mean scores demonstrated by the experimental group indicated that the students taught by the case study instruction scored significantly better than students taught by the traditional instruction (Table 1).

In addition, there was a significant difference between posttest attitude mean scores of the students taught with the case study instruction and those taught with the traditional instruction ($t = 4.841$, $p < 0.05$). Posttest attitude mean scores revealed that the students taught with case study instruction got higher scores than the students taught with traditional instruction (Table 1).

The statistical results were supported by the reflections of comparison and experimental groups' ideas about the instructional treatment (Table 2). Students in the experimental group demonstrated positive attitudes in their reflection letters. For instance, one student stated that he felt science was not boring when science topics were selected from life itself; however, students in the comparison group generally expressed their negative attitudes toward the science course. For example, one student stated that he was frustrated about science. These responses appear to suggest that case study instruction could help improve students' attitudes toward science.

**Table 2. Reflections of the Students: Comparison and Experimental Group Students' Ideas About the Treatment**

| Students' Ideas About Treatment | |
|---|---|
| **Comparison Group** | **Experimental Group** |
| • Listening to the teacher without doing nothing was very boring.<br>• Lessons were monotonous.<br>• I am frustrated about science.<br>• I was bored in the course.<br>• This course is not easy to learn and therefore I do not want to learn.<br>• I have been bored and frustrated from science for all my life. Therefore, I am not interested in science. | • It was fun for me<br>• After this course, I felt science is funny and necessary.<br>• Science has a very strong relationship with real life.<br>• When learning science topics selected from life itself, I feel science is not boring.<br>• This course was amazing.<br>• Gathering different ideas from various groups in our science classroom provided the opportunity to have different information about the topic.<br>• I was very active in the classroom and I was not bored. I learned a lot during class discussions. |

## Discussions and Implications

The case study instruction appeared to produce a significantly better acquisition of knowledge about viruses, bacteria, fungi, and protista than the traditional instruction. This result supports the notion that it is not easy to obtain achievement about viruses, bacteria, fungi, and protista by employing traditional instructional methods in which students read and teachers tell. The underlying principle in traditional instruction is that the knowledge resides with the teacher, and it is the teacher's responsibility to transmit that knowledge to passive but receptive students. The case study approach provides students with a vehicle to discuss, analyze, and develop criteria and potential solutions for the problems presented in the case. The case design and classroom implementation encourage contextual, authentic, and active learning and motivation. It has also been shown that the case study teaching supports students learning by doing, developing analytical and decisionmaking skills, internalizing learning, dealing with real-life problems, and developing oral communication skills (Herreid, 1994). This method of learning and teaching gives opportunities to students to take ownership and direct their own learning as they explore the complex situations (Waterman, 1998). The case method also enhances students' understanding of essential concepts and encourages their critical thinking (Cliff & Curtin, 2000).

Moreover, the experimental and the comparison groups demonstrated statistically different attitudes towards school science in favor of the case study group. Learning by case study instruction involved an interaction among the students in the experimental group not frequently found in traditional science classrooms. The verbal communications between teacher and students in the experimental group reflected active engagement not apparent in the comparison group. Students in the experimental group learned by doing, analyzing, and researching while students in the traditional group were passively involved in finding answers. These reasons may have caused a significant difference between the groups in terms of the students' attitudes toward science. In addition, students' reflections, which were taken at the end of the study, indicated that the experimental group students had more positive feelings than the comparison group students. Gabel (1999) found that the case method stimulated students' interest, while Arambula-Greenfield (1996) indicated that problem-based learning is an effective teaching method for developing positive attitudes towards learning. Moreover, Brink et al. (1995) pointed out that students taught with case studies enjoy the instruction more than students in traditional instruction. These types of interactive and constructive environments require large spaces with individual tables and chairs for implementation.

This study suggested that students improved their achievement and attitude toward science by using the case study instruction. However, there were some limitations that reduced the possibility of students having much better scores during the case study implementation. For example, there were some limitations in group work. In order to prevent the negative effect of group work—that is, one or two students handling most of the work in groups—students should be trained about cooperative learning skills. In other words, they should be aware of sharing information, caring for each other, and respecting each other's ideas. Learning these kinds of skills will help students share responsibilities in groups. In addition, students had difficulty adapting to the case study approach because, except for the life science course, they had previously been taught with traditional instruction. This could cause confusion in students' minds. Moreover, many regular classrooms were not appropriate for implementing case study instruction. The case study space should be suitable for both individual study and group study.

A well-designed case study approach to life science instruction represents an alternative approach to the traditional method to increase students' achievement and improve attitudes toward science. The instructional strategy has to be designed in such a way that the individual is convinced that doing research and thinking scientifically are more useful than rote memorization of facts. Science educators must become more involved in developing and designing such case study learning environments, and teachers should be informed about the application of case study instruction in their classrooms.

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