



A COMPARISON BETWEEN THE KNOWLEDGE LEVELS OF PROSPECTIVE SCIENCE AND TECHNOLOGY TEACHERS AND ELEMENTARY STUDENTS ABOUT RESPIRATION-PHOTOSYNTHESIS IN PLANTS

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Abstract

The present study aims to compare the knowledge levels of prospective science and technology teachers and 6th, 7th, and 8th-grade students about respiration-photosynthesis in plants. To this end, it used the survey model as a quantitative research method. The study was carried out in two elementary schools in Demirci during the first semester of academic year 2009–2010 and with the prospective science and technology teachers studying in the Faculty of Education at Celal Bayar University during the second semester of the same academic year. The study sample consists of 192 prospective science and technology teachers and 191 elementary students. The concept cartoon tests were used to collect data in the study. SPSS 17 software was used to analyze concept cartoons. The results of the study demonstrate that the knowledge levels of pre-service teachers and elementary students about respiration-photosynthesis in plants differed in favor of the pre-service teachers. Furthermore, the participants exhibited the highest knowledge levels about the subject in the 5th concept cartoon question, which is ‘respiration and photosynthesis phenomena in plants’. Nevertheless, the knowledge levels were low for pre-service teachers about ‘the relationship between respiration-photosynthesis in plants’, and for elementary students about living things that can carry out photosynthesis. In the light of these results, some suggestions are made about respiration-photosynthesis in plants.

Keywords: *Concept cartoon, knowledge level, respiration-photosynthesis in plants, prospective science and technology teacher, elementary student.*

INTRODUCTION

The question of how much and how individuals learn in learning processes is one of the main elements of a great deal of educational research. As is well known, the behaviorist and the constructivist views argue that the learning phenomenon displays different characteristics in individuals, and therefore various assessment-evaluation instruments are needed to shed light upon the question of how much learning takes place. Particularly because the curriculum in Turkey was organized on the basis of the constructivist approach in the academic year 2005-2006, the emphasis shifted to alternative assessment techniques such as portfolios, performance assessment and interviews instead of the techniques focusing on product assessment in learning process in accordance with the behaviorist approach such as multiple-choice tests and short-answer questions. Concepts cartoons constitute one of the recent alternative assessment techniques that can be used to reveal conceptual understanding and knowledge levels of students.

Concept cartoons can be defined as drawings that involve the different perspectives about an event of three or more caricaturized characters (Keogh, Naylor & Wilson, 1998; Keogh & Naylor, 1999). These visual aids are used for various purposes in the learning and assessment processes. Chin & Teou (2009) note that concept cartoons have many uses in the classroom environment as an instrument of assessment and teaching-learning. An initial look at the structure of concept cartoons will show that they resemble multiple choice questions in a broad sense. Concept cartoons correspond to the multiple-choice question type; however, as opposed to many multiple-choice questions, a visual stimulant and written sentences in the form of speech are simultaneously used in concept cartoons (Keogh & Naylor, 1999; Naylor & Keogh, 1999; De Lange, 2009). In addition, in concept cartoons students state the opinion that fits them along with their reasons for agreeing with that opinion. Therefore, students may, in a sense, provide clues about their conceptual structures, and the misconceptions and shortcomings in these structures. Korkmaz (2004) argues that concept cartoons can be particularly employed to facilitate conceptual learning in small classrooms, to reveal students' conceptions and to identify what they have learned. In a similar view, Allen (2006) claims that teachers can make use of concept cartoons to evaluate what students have understood at the end of a unit.

A review of the relevant literature detects research that usually focuses on the fields of physics and biology with regard to the use of concept cartoons to determine knowledge level or conceptual

understanding. As for physics subjects, Ingec (2008) attempted to identify misconceptions of pre-service teachers about propulsion and momentum by using concept cartoons. Similarly in their study, Atasoy & Akdeniz (2009) used concept cartoons to reveal the understanding of pre-service teachers about action and reaction forces. As for biology subjects, Chin & Teou (2010) used concept cartoons, drawings and group discussion in combination in their study so as to reveal the opinions and understanding of students about heredity. Ekici, Ekici & Aydin's (2007) study is the closest to the subject of the present study. In their study, the researchers attempted to identify the misconceptions of students about photosynthesis using concept cartoons, and examined the effects of concept cartoon applications in eliminating such misconceptions. Another study on photosynthesis was conducted by Sasmaz-Oren, Ormanci, Karatekin & Erdem (2010). In their study, the researchers employed concept cartoons to identify elementary students' misconceptions about respiration-photosynthesis in plants. Ormanci & Sasmaz-Oren (2011), on the other hand, carried out a study to evaluate concept cartoons developed about photosynthesis and respiration in plants and to present examples from this evaluation. As a result, the literature on concept cartoons contains research that separately examines conceptual understanding/misconceptions of pre-service teachers and students. Yet, the literature review detected no study aiming to determine and compare pre-service teachers' and students' understanding of respiration-photosynthesis in plants using concept cartoons. That is why; we deemed it necessary to conduct the present study. In this context, this study aimed to compare the knowledge levels of pre-service science and technology teachers and 6th, 7th, and 8th-grade elementary students about respiration-photosynthesis in plants by using concept cartoons. The study's problem statement could be formulated as follows:

- Is there a significant difference between the knowledge levels of pre-service science and technology teachers and elementary students about respiration-photosynthesis in plants?

METHOD

Aiming to compare the knowledge levels of pre-service science and technology teachers and elementary students about respiration-photosynthesis in plants, the present study employed the survey model, which is a quantitative research method. "A social survey is a method of obtaining large amounts of data, usually in a statistical form, from a large number of people in a relatively short time" (McNeill &

Chapman, 2005: 28). The study was carried out with 6th, 7th, and 8th-grade students in two elementary schools in the Demirci district of the Manisa province during the first semester of the academic year 2009–2010 and with pre-service science and technology teachers studying in the Education Faculty at Celal Bayar University during the second semester of the same year. The study sample consists of 192 pre-service science and technology teachers and 191 elementary students; or 383 individuals in total. The concept cartoon tests developed about respiration-photosynthesis in plants for elementary and university levels were used as the data collection instrument in the study. Both tests contain a total of eight questions. In developing the concept cartoon tests, the researchers reviewed the research on concept cartoons and respiration-photosynthesis in plants and thus, formulated the initial version of the questions they planned to use in the tests. Expert opinion was sought to test the validity of the questions and the final versions were formulated by making necessary corrections in accordance with expert opinions. The questions in the two different concept cartoon tests for elementary and university levels were about the same content or similar misconceptions. Due to the differences in the course contents at elementary and university levels, some questions in the tests were developed to be the same for two different education levels, while others were formulated to contain certain differences in the characters' statements. Thus, some of the eight questions in the concept cartoon tests were made easier for the elementary level in accordance with the students' levels, while some were made more difficult for the university level. The concept cartoons in the tests involved two main stages, one of which consists of a cartoon and related question, and the other stage required that the students should write down the reasons for their responses. In the concept cartoon tests developed for elementary and university levels, question 1 was about "food source of plants", question 2 about "energy source of plants", question 3 about "photosynthesis", question 4 about "the living things that can carry out photosynthesis", question 5 about "respiration and photosynthesis phenomena in plants", question 6 about "the relationship between respiration and photosynthesis in plants", question 7 about "respiration in plants", and question 8 about "the process of respiration-photosynthesis in plants". Question 8 for university level is presented in the Appendix as an example of the questions. In this study, concept cartoons were analyzed using both stages. The scoring key developed by Ormanci & Sasmaz-Oren (2010) was used to analyze the concept cartoons. The scoring key is demonstrated in Table 1 below.

Table 1. The Scoring Key used in the analysis of concept cartoons tests

<i>Assessment Criteria</i>	<i>Score</i>		<i>Scoring Criteria</i>
	<i>Score</i>	<i>Percentage (%)</i>	
Correct Answer – Correct Explanation	3	100	* <u>Correct Explanation</u> : Explanation where the answer is implied with all scientific aspects
Correct Answer – Partially Correct Explanation	2	67	* <u>Partially Correct Explanation</u> : Explanation where the answer is not implied with all scientific aspects or which involves some misconceptions
Wrong Answer - Correct Explanation	2	67	
Correct Answer – Wrong Explanation	1	34	* <u>Wrong Explanation</u> : (1) The answer is scientifically totally wrong, (2) is irrelevant, (3) is repeated as a whole, (4) is completely composed of misconception, (5) left as blank
Wrong Answer – Partially Correct Explanation	1	34	
Wrong Answer – Wrong Explanation	0	0	

The concept cartoons were analyzed by two of the study's authors on the basis of the scoring key given in Table 1. Kappa agreement value was calculated for each question to determine inter-rater agreement, while intraclass correlation analysis value was computed to determine the agreement between the scores obtained on all questions. Thus, the first item had a kappa value of .77 ($p=.000<.05$); the kappa value for the second, third, and fifth items was .83 ($p=.000<.05$); .88 ($p=.000<.05$) for the fourth one; .86 ($p=.000<.05$) for the sixth one; .76 ($p=.000<.05$) for the seventh item; and .82 ($p=.000<.05$) for the eighth one. Since the total scores were continuous, interrater agreement value was found to be .97 in the intraclass correlation analysis. Furthermore, parametric criteria were not met (as demonstrated by the Kolmogorov-Smirnov test and histogram graphs) so the non-parametric Mann-Whitney U test was used to compare the scores obtained by the pre-service teachers and students on each question. Parametric conditions were met in the total test scores of the participants and the results were analyzed by ANOVA.

FINDINGS

Table 2 shows the mean and standard deviation values for each question in the study with a view to compare the knowledge levels of the pre-service science and technology teachers and 6th, 7th, and 8th-grade elementary students about respiration-photosynthesis in plants.

Table 2. The results of the descriptive analysis for the knowledge levels of the pre-service teachers and elementary students about respiration-photosynthesis in plants

Participants	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8	Total
	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>	<i>M(SD)</i>
Pre-service teachers	1.21(.97)	1.84(1.14)	1.70(1.00)	2.11(.87)	2.38(.78)	1.09(1.26)	1.45(1.23)	1.79(1.39)	13.57(4.30)
Elementary Students	0.63(.90)	0.57(.97)	0.91 (.99)	0.48(.70)	1.41(1.16)	0.72(.98)	0.64(.90)	1.36(1.20)	6.71(3.13)

According to the results of the Mann-Whitney U test used to compare the scores of pre-service teachers and elementary students for each question, a significant difference was detected between the groups in favor of the pre-service teachers: $Z=6.45$, $p=.000<.05$ for question 1; $Z=10.13$, $p=.000<.05$ for question 2; $Z=7.26$; $p=.000<.05$ for question 3; $Z=14.30$, $p=.000<.05$ for question 4; $Z=8.24$, $p=.000<.05$ for question 5; $Z=3.44$, $p=.001<.05$ for question 6; $Z=6.56$, $p=.000<.05$ for question 7; and $Z=3.97$, $p=.000<.05$ for question 8. As shown by the results of ANOVA used to compare the total scores, a significant intergroup difference was also found in favor of the pre-service teachers ($F_{(1,381)}=317.26$, $p=.000<.05$, $\eta^2_{\text{partial}}=.45$). Figure 1 presents the comparison of the arithmetic means of total scores obtained by the pre-service teachers and elementary students for each question in the concept cartoon tests.

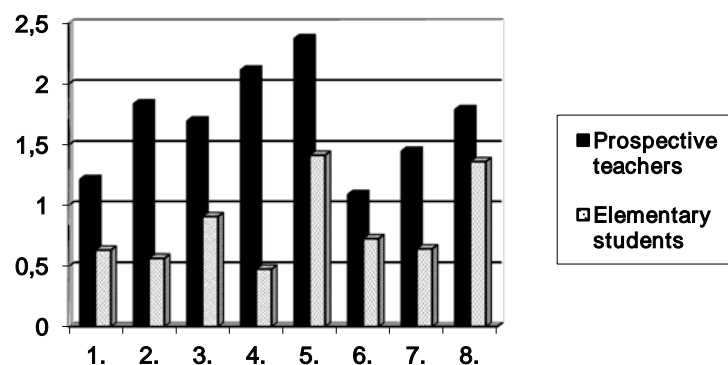


Figure 1. Comparison of the scores of the pre-service teachers and elementary students

DISCUSSION

It is known that various assessment methods are employed to determine individuals' understanding or knowledge levels about any subject. These methods have recently gained diversity and greater significance as the constructivist approach has highlighted the importance of determining learners' previous knowledge. It is observed that in the literature, methods regarded as alternatives to conventional assessment techniques are now being used to determine learners' knowledge levels and conceptual understanding and these alternative methods include drawings, concept maps, interviews, and two-tier diagnostic tests. Celikler & Topal (2011) identified the knowledge levels of pre-service science teachers about the cycle of carbon dioxide and water using drawings. In their study, Reiss & Tunnicliffe (2001) used drawings to determine students' levels of understanding humans' internal structure and organ system. On the other hand, in another study, Freeman & Urbaczewski (2002) employed concept maps to determine the participants' levels of understanding about telecommunications. In a study conducted with university students, Bilgin (2006) used two-tier diagnostic tests to determine their conceptual understanding levels and alternative concepts about qualitative analysis. Apart from all these, concept cartoons constitute another alternative assessment instrument for identifying students' levels of knowledge and understanding. Therefore, the present study used concept cartoons to determine and compare the knowledge levels of pre-service teachers and elementary students about respiration-photosynthesis in plants.

The scoring key developed by Ormanci & Sasmaz-Oren (2010) was used in this study that aims to determine and compare the participants' knowledge levels about respiration-photosynthesis in plants. A literature review will show that different scoring keys have been developed and employed for the use of

concept cartoons for assessment purposes. In a study about physics education, Ingec (2008) used concept cartoons as an assessment instrument and developed a key with the scores of 0-1-2. In her study, Sasmaz-Oren (2009) developed a scoring key with the scores of 1-2-3-4 so as to assess the concept cartoons prepared by students. Moreover, Ingec, Guzel & Karakaya (2008) conducted a study with pre-service physics teachers, in which they employed concept cartoons and concept maps to explain the concepts of heat/temperature and made use of a scoring key consisting of the scores of 0-1-2 to assess the concept cartoons. So, various scoring keys have been developed in the literature to assess concept cartoons.

In the present study, the knowledge levels of pre-service science and technology teachers and 6th, 7th, and 8th-grade elementary students about respiration-photosynthesis in plants were compared with the help of a concept cartoon test and a significant difference was detected in favor of the pre-service teachers with regard to both the questions in the test and the total scores. It is an expected finding that the results would be in favor of the pre-service teachers. For even though the questions in the concept cartoons were prepared in accordance with the participants' education levels, pre-service teachers had received a greater amount of training about respiration-photosynthesis in plants throughout their education process and had been gradually taught about the subject during their elementary-high school-university education periods. Moreover, the pre-service science and technology teachers had received their high school education in quantitative departments, which is believed to have increased their knowledge levels about the subject. On the other hand, the elementary students had only been given preliminary information about respiration-photosynthesis in plants in the unit on "Reproduction, growth, and development in a flowering plant" taught at sixth grade and are fully taught about the subject during the unit on "Living things and energy relationships" at eighth grade. Therefore, it is natural that the elementary students had lower levels of knowledge about the subject when compared to the pre-service teachers.

In the study, the knowledge levels of the pre-service teachers and elementary students were the highest in question 5, which involves a concept cartoon about "respiration and photosynthesis phenomena in plants". In view of this concept cartoon, it is believed that the question is concerned with daily life and that is why the participants at two different education levels provided correct responses. On the other hand, in the 4th concept cartoon question about "living things that can carry out photosynthesis", the

pre-service teachers exhibited high knowledge levels, while the elementary students had very low levels of knowledge. This is supposed to be because the pre-service teachers knew that there are other living things beside plants that can carry out photosynthesis, whereas the elementary students thought that only green plants can carry out photosynthesis since they have chlorophylls. Similarly, in their studies on photosynthesis and respiration in plants, Tekkaya & Balci (2003) and Ekici et al. (2007) detected the misconception that only green plants can carry out photosynthesis. The present study also found that the pre-service teachers displayed low knowledge levels in the 6th concept cartoon question, which concerns “the relationship between respiration-photosynthesis in plants”. This question involves the most frequently detected misconceptions in the literature on concept cartoons: “photosynthesis and respiration are the opposite of each other” (Kose, Ayas & Tas, 2003) and “both of the phenomena of photosynthesis and respiration involve a gas exchange” (Kose, Gezer, Durken & Erol, 2005; Tekkaya, Ozkan & Balci, 2002). In parallel, the participants had low knowledge levels since they had such misconceptions.

CONCLUSION

Following the discussion and interpretation of the study’s results, the knowledge levels of pre-service teachers and elementary students about respiration-photosynthesis in plants were compared by using concept cartoons and a significant difference was found in favor of the pre-service teachers. Since the study detected low knowledge levels among elementary students about the subject, it is believed that the subject should be gradually taught in the science and technology curriculum starting from elementary sixth grade. Furthermore, as the subject of respiration-photosynthesis in plants involves abstract concepts, it should be taught at different education levels with the help of different methods, techniques, and instruments based on the constructivist approach. Another suggestion could be to obtain more detailed information about the underlying reasons by conducting interviews with elementary students about the parts of the subject of respiration-photosynthesis in plants in which they have low knowledge levels, and to carry out further studies to determine the conceptual understanding levels about the subject.

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APPENDIX

A mouse and a plant were placed under a sealed glass cover in a dark environment. The students are talking about what could happen after 10 or 15 days. (The mouse's needs of water and food are met.)

The diagram shows a rectangular glass container divided by a vertical wire mesh. On the left side of the mesh, a small mouse is sitting on the floor. On the right side, a potted plant with green leaves and orange flowers is sitting on the floor. The container is labeled 'The glass cover is sealed and transparent.' and 'Wire mesh'.

Pelin (top left): The mouse will die, while the plant will survive.

Hakan (top right): I think both organisms will die.

Selim (bottom left): Guys, both organisms will survive.

Zeynep (bottom right): The plant cannot survive as it cannot carry out photosynthesis, but the mouse will survive.

Which student(s) do you think is/are right?

- Pelin Selim Hakan Zeynep

Why do you think so?

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