

Development of Preservice Biology Teachers' Skills in the Causal Process Concerning Photosynthesis

Arzu Saka

Correspondence: Arzu Saka, Trabzon University, Fatih Faculty of Education, Trabzon, 61335, Turkey.

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Abstract

Photosynthesis is the most effective cycle and sustainable natural process known in nature. Students who learn the subject of photosynthesis well will also make better sense of other issues such as environmental problems, the state of the atmosphere, greenhouse gases, climate changes, carbon footprints and conservation of forests. The aim of this study is to present an example of a worksheet that investigates the skill levels possessed by preservice teachers' in the causal process, and also to examine their ability to write a photosynthesis equation by means of a history-based approach that also includes reading skills. The study was conducted with the action research method. The study sample consisted of a total of 71 preservice biology teachers. At the first stage, before the implementation of the worksheet, 34 teacher candidates from within the sample were asked a question with a diagram summarising the photosynthesis process. At the second stage, all the prospective teachers were asked for the skill levels they possessed in the causal process to be assessed via implementation of the worksheet. The answers given by the preservice teachers in the defining variables section in particular make up the least answered section of the worksheet. In the section of the worksheet related to making inferences, The students were asked to write the four separate equations by revising them incrementally, and it is striking that the rates of correct answers given for each were high. There is a need for teaching materials to be designed in the field of science at university level and for these to be made available to science teachers in book format.

Keywords: photosynthesis, causal process skills, pre-service biology teachers

1. Introduction

Life on earth is dependent upon energy coming from the sun, and photosynthesis is the only biological event in which light energy is used (Karaağaç & Peri, 2013; Mason, Losos & Singer, 2011). Since the spread of molecular oxygen into the atmosphere, the formation of the stratospheric ozone layer, the entrapment of atmospheric carbon dioxide and the conversion of energy in the biosphere are all realised through the mechanism of photosynthesis, we can state that this event is the life source of all living things. Considering the present-day effects of global climate change and the existence of people who still experience problems of scarcity and hunger, the importance of entrapping atmospheric carbon dioxide becomes even greater. It can be said that photosynthesis is the most effective cycle and sustainable natural process known in nature (Janssen, Lambreva, Plumere, Bartolucci, Antonacci, Buonasera, Frese, Scognamiglio & Rea, 2014).

It is essential that the concept of photosynthesis, which is so important for the existence of our planet, is taught effectively from elementary school right up to higher education (Ahopelto, Mikkila-Erdmann, Anto & Penttinen, 2011; Matthews, 2009; Metioui, Matoussi & Trudel, 2016; Vartak, 2006). Students who learn the subject of photosynthesis well will also make better sense of other issues such as environmental problems, the state of the atmosphere, greenhouse gases, climate changes, carbon footprints and conservation of forests. Moreover, it can be said that having individuals who are informed citizens for a sustainable environment also features as a key concept (Matthews, 2009). Conducted studies reveal that students at all levels experience problems in perceiving the concept of photosynthesis (Akçay, 2017; Bahar 1999; Crane & Winterbottom, 2008; Domingos-Grilo, Reis-Grilo, Ruiz & Mellado, 2012; Köse, Ayas & Uşak, 2006; Köse, 2008; Matthews, 2009; Özay & Öztaş, 2003; Ross, Tronson & Ritchie, 2006; Svandova, 2014; Tekkaya, Çapa & Yılmaz, 2000; Yenilmez & Tekkaya, 2006). In one study that examined articles on the subject of biology published between 1990 and 2014, it was revealed that a very small number of studies were related to the subjects of photosynthesis and respiration (Patrick & Matteson, 2017). The teaching of subjects like photosynthesis and respiration, which give particular difficulty in comprehension, to students at the primary school stage with research-based activities will lead to the building of new knowledge more solidly and correctly when they encounter the

same subjects at more advanced stages (Köse, Ayas & Taş, 2003; Krall, Lott & Wymer 2009; Patrick & Matteson, 2017). For students to be able to access information, they are required to be scientifically literate individuals. In the related literature, it is stated that scientific literacy is highly correlated with students' reading skills, that any kind of activity conducted towards reading will contribute to students' scientific literacy, and that these activities must not be utilised within the scope of grammar and reading lessons alone (Kaya, 2017). It is known that reading is one of the basic strategies used in learning, and it is stressed that reading is a skill that must be developed at every stage and in every branch of education. Reading comprehension includes the processes of analysing and restructuring paragraphs and texts (Ercan, 2009). Moreover, it is stated that two of the dimensions of scientific literacy are the nature of science and scientific process skills (Driver, Leach, Millar & Scott, 1996; Kılıç, Haymana & Bozylmaz, 2008; McComas, Clough & Almazroa, 1998). It is known that understanding the history of science is also a key to understanding the nature of science (Laçın Şimşek, 2009). By virtue of activities related to the history of science, if students understand how scientific knowledge has developed and how historical events and technology have affected this development, they will possess more comprehensive views regarding science. At the same time, this situation will also increase their interest in learning science (Justi & Gilbert, 1999). It is indicated that in order to increase conceptual understanding, the presentation of scientific knowledge can be enriched or the nature of variables can be elaborated by benefiting from scientific history. By means of education provided to suit all levels, it is possible for these skills to be developed and for the desired targets to be reached in students (Justi & Gilbert, 1999; Laçın Şimşek, 2009).

Scientific process skills are defined as “skills that facilitate learning, build research competence, enable students to be active in the learning environment, develop a sense of taking responsibility for learning and increase retention of learning” (Çepni, 2005). Scientific process skills are classified in different ways in different sources. They may be separated into three as basic skills, causal skills and experimental skills (Çepni, 2005; Karamustafaoğlu & Yaman, 2006), while sometimes, they are divided into two as basic skills and, by a combination of the causal and experimental processes, integrated process skills (Silay & Çelik, 2013). It is known that students' scientific process skills will develop as they use them. Possessing these skills not only ensures the acquisition of knowledge related to scientific subjects, but also contributes to development of their understanding for practical solving of problems that they may encounter in their daily lives (Koray, Bahadır & Geçgin, 2006). Considering the dominance of technology in our daily lives and the possibilities it offers to people for making their lives easier, the importance for future generations of solving every problem that they encounter in their lives not via the internet, but by using their own life skills, becomes even greater. Considering that preservice teachers are people who will enable their students to acquire scientific process skills in the future, there is a need for studies that reveal to what extent they themselves possess these skills (Ürey, 2018). Furthermore, there is also a need for interdisciplinary studies in biology education that examine whether or not factors such as a history-oriented approach (History of Science) and reading skills contribute to scientific literacy (Kaya, 2017). In this context, the present study plans to seek answers to the following questions:

1. What are the levels of preservice biology teachers' skills in the causal process?
2. Does the use of a history-based approach together with reading skills ensure success in forming a photosynthesis equation?

2. Methodology

2.1 Purpose of the Study

The aim of this study is to present an example of a worksheet that investigates the skill levels possessed by preservice teachers' in the causal process, and also to examine their ability to write a photosynthesis equation by means of a history-based approach that also includes reading skills. It is considered that this activity will contribute significantly towards ensuring that the candidates comprehend the stages of scientific method and understand the nature of science, ensuring that their skills in the causal process develop, and making them understand an equation for a key process like photosynthesis without making them learn it by rote.

2.2 Research Method

The study was conducted with the action research method. The researcher teaches the “Scientific Research Methods” and “Nature of Science and History of Science” classes. Within the scope of the lessons, the subjects of science, nature of science, history of science, scientific research methods and scientific process skills are included. In the sample group, who are the teachers of the future, it was observed that some skills included in the scope of these subjects were lacking, and the study was designed to determine this situation and to contribute to the development of some of these skills. The research design and collection and assessment of the findings were carried out entirely by the researcher. It is stated that one of the most important aims of action research is to understand the problems and realities encountered in education in a systematic way and to attempt to improve these (Ekiz, 2013). It is known that in recent years, action research has frequently been used by academicians and teacher researchers to obtain systematic information and to develop

applications. The most distinctive feature of this method is the personal involvement of the researchers in the process in order to change and develop their own actions. In this study, the technical/scientific type of action research was used, since with this approach, the aim is to test or assess an application within a previously defined theoretical framework (Yıldırım & Şimşek, 2005).

2.3 Sample

The study sample consisted of a total of 71 preservice biology teachers receiving training on the Biology Teaching Programme at the Fatih Education Faculty of Karadeniz Technical University during the 2016-17 and 2017-18 academic years. The teacher candidates were third- and fourth-year students. In Turkey, the period of the biology teaching undergraduate programme is four years.

2.4 Data Collection Tools and Implementation

At the first stage, before the implementation of the worksheet, 34 teacher candidates from within the sample were asked a question with a diagram summarising the photosynthesis process (Figure 1). At the second stage, all the prospective teachers (N=71) were asked for the skill levels they possessed in the causal process to be assessed via implementation of the worksheet shown in Appendix 1. This application contains the subject of “Photosynthesis”. The worksheet includes the sections for prediction, defining the variables, interpreting the data and making inferences that make up the causal processes. Prediction is the process of seeing what might happen in the future. In this section of the worksheet, the predictions for Joseph Priestley’s bell jar experiment were asked for. Defining the variables is very important for correct understanding of research. In this section of the worksheet, the dependent and independent variables for Priestley’s experiment were asked for. Interpretation of data is the interpretation of organised data by rational thought. In the relevant section of the worksheet, the interpretation processes with the involvement of different variables were examined. Making inferences is the explanation of the situations that occur. This section of the worksheet was organised by having the students find out how the photosynthesis equation known today appeared by analysing the development stages of the photosynthesis mechanism carried out within the history of science, and obtaining a result equation (Saka, 2016).

2.5 Analysis of Data

In the question with the diagram (Figure 1), the prospective teachers were asked to fill in the blank parts in the diagram:

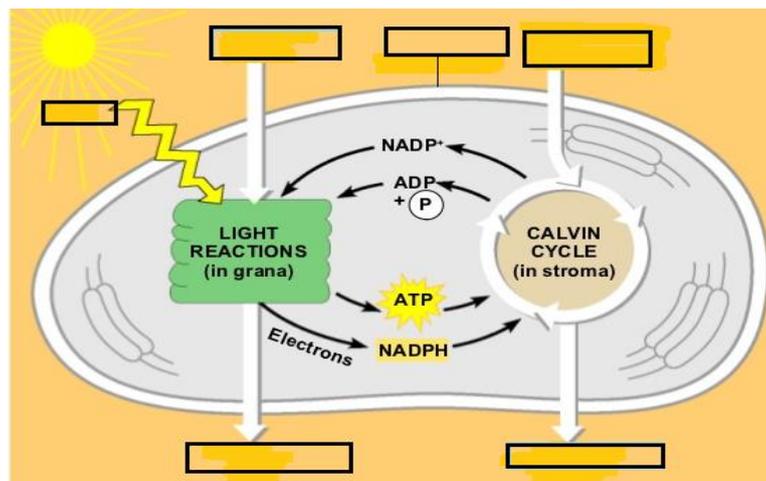


Figure 1. Question with diagram asked to preservice teachers

In the analysis of the sections of the worksheet for prediction, defining the variables, interpreting the data and making inferences, the frequency and percentage values were determined by grouping them as correct, partially correct, incorrect and left blank. In the analysis of the 4th equation of the inferring section and the question with the diagram, rubric 1 was used, and the related answers and explanations are given in Table 1.

Table 1. Rubric 1 used for analysis of question with diagram and inferencing sections of worksheet

Answer category	Explanation
Exactly right	Scientifically correct answer
Partially correct (B)	The answer is correct, but it is incomplete according to the exact answer: Entries and products are correct, others wrong
Incorrect-1 (C)	Partially correct partially incorrect: Only entries or only products are correct
Incorrect -2 (D)	Partially correct and blank answer: Just written light and chloroplast
Incorrect -3 (E)	Completely wrong answer
Unanswered (F)	Blank answer

With the aim of making comparisons between the answers analysed using rubric 1 and of making judgments, rubric 2 below was used (Table 2). Both rubrics were developed by the researcher and had been used in a previous study (Kahraman & Saka, 2010).

Table 2. Rubric 2 used for comparing question with diagram and inferencing sections of worksheet

Symbol	Explanation	Level changes
↓	Individuals who have the right information and then do not change their level	Individuals who answer the question with the diagram A and B level, in the fourth equation do not change their level
↑↓	Individuals who have the right information and then having misinformation	Individuals who answer the question with the diagram A and B level, in the fourth equation there are C, D and E level
↔	Individuals who have the wrong information and remain at the same level	Individuals who answer the question with the diagram C, D and E level, in the fourth equation do not change their level
⊙	Individuals who initially had the wrong / empty information and then obtained the correct information	Individuals who answer the question with the diagram C, D, E and F level, in the fourth equation there are A and B level

3. Findings

Within the framework of the first problem situation of the research, the findings obtained from the worksheet applied to the teacher candidates were calculated separately for each section as frequency and percentages, and presented in the form of tables. The findings obtained from the “prediction” section of the worksheet are given in Table 3.

Table 3. Findings obtained at “prediction” stage of worksheet

Answer category	I. condition*		II. condition*	
	f	%	f	%
Correct	40	56.3	39	54.9
Incorrect	2	2.8	8	11.3
Partially correct	29	40.8	24	33.8
Blank	-	-	-	-

*: I. condition: Case with mouse and candle in bell jar, II. condition: Case with mouse, plant and candle in bell jar

When a mouse and candle are inside the bell jar, since the amount of oxygen therein will decrease after a certain time, the mouse will become unconscious and the candle will be extinguished. It can be understood from Table 3 that 56% of the candidates gave the correct answer to this question. Moreover, it can also be seen that the rate of partially correct answers was high. Examining the answers, it is seen that generally, contrasting situations were expressed, that is, statements were made to the effect that the mouse would pass out but the candle would continue to burn, or vice versa, that the mouse would be unaffected but the candle would go out. The findings obtained from the “defining the variables” section of the worksheet are given in Table 4.

Table 4. Findings obtained from “defining the variables” section of worksheet

Answer category	Dependent variable		Independent variable	
	f	%	f	%
Correct	14	19.7	16	22.5
Incorrect	29	40.8	39	54.9
Partially correct	19	26.8	7	9.9
Blank	9	12.7	9	12.7

In the section for defining the variables in a given experimental setup, it is noticeable that the rates of incorrect and partially correct answers given by the preservice teachers were high, and that, moreover, the rate of correct answers given was rather low. Examining the findings accepted as partially correct, it was determined that generally, the candidates gave correct answers for either the dependent or independent variables only. When a pot plant is added inside the bell jar in the experiment, since the conditions of the mouse and candle are inquired about, the pot plant is expressed as an independent variable, while the conditions of the mouse and candle are expressed as independent variables.

The findings obtained from the “interpretation of the data” section of the worksheet are given in Table 5.

Table 5. Findings obtained from “interpretation of the data” section of worksheet

Answer category	I. condition*		II. condition *		III. condition *		IV. condition *	
	f	%	f	%	f	%	f	%
Correct	32	45.1	20	28.2	26	36.6	22	31
Incorrect	-	-	27	38	29	40.8	30	42.2
Partially correct	38	53.5	23	32.4	15	21.1	18	25.4
Blank	1	1.4	1	1.4	1	1.4	1	1.4

*: I. condition: Case with mouse and candle in bell jar, II. condition: Case with mouse, plant and candle in bell jar, III. condition: Case with mouse and plant in bell jar, IV. condition: Case with plant and candle in bell jar

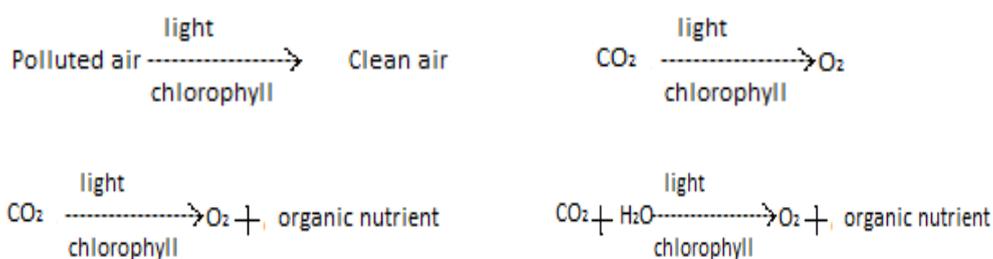
In the data interpretation section, the teacher candidates were asked for their interpretations regarding the changes that would occur in the mouse and candle in different combinations and in the absence of sunlight. Examining the correct answers, a rate of 45% was attained in the first situation only, and in the other situations, lower correct answer rates were determined. In partially correct answers, only the state of the mouse or the candle was given correctly.

The findings obtained from the “making inferences” section of the worksheet are given in Table 6.

Table 6. Findings obtained from “making inferences” section of worksheet

Answer category	1. equation		2. equation		3. equation		4. equation	
	f	%	f	%	f	%	f	%
Correct	67	94.4	62	87.3	47	66.2	57	80.3
Incorrect	4	5.6	5	7	3	4.2	3	4.2
Partially correct	-	-	2	2.8	19	26.8	9	12.7
Blank	-	-	2	2.8	2	2.8	2	2.8

It is noticeable that in the inferencing section inquiring about the prospective teachers’ processes of comprehending what they had read, the rate of correct answers was high. The correct answers for the equations that the teacher candidates were asked to write in the spaces provided after they had read the relevant paragraphs in this section are given in order below.



In the analysis of the data obtained for the second sub-problem of the study, the findings obtained from the answers to the question with the diagram and to the 4th equation in the “making inferences” section of the worksheet were categorised using rubric 1 and are presented in Table 7 below.

Table 7. Findings for answers given by teacher candidates for question with diagram and 4th equation

Answer category	Explanation	Question with the 4. equation			
		Question with the diagram	4. equation		
		f	%	f	%
Exactly right	Scientifically correct answer	5	14.7	27	79.4
Partially correct (B)	The answer is correct, but it is incomplete according to the exact answer: Entries and products are correct, others wrong	1	2.9	-	0
Incorrect-1 (C)	Partially correct partially incorrect: Only entries or only products are correct	1	2.9	3	8.8
Incorrect -2 (D)	Partially correct and blank answer: Just written light and chloroplast	4	11.8	2	5.9
Incorrect -3 (E)	Completely wrong answer	12	35.3	2	5.9
Unanswered (F)	Blank answer	11	32.4	-	-
Total		34	100	34	100

Examining Table 7, it is seen that the correct answer rate for the question with the diagram was considerably low (14.7%), and that the rates for completely wrong answers and blank answers totalled 67.7%. For the 4th equation, the rate of correct answers was as high as 79.4%, while the rates for completely wrong answers and blank answers remained low at 5.9%. The answers given by the preservice teachers to the question with the diagram and the 4th equation included in the inferencing section were analysed by comparison with each other. Students identified categories are presented in Table 8.

Table 8. Findings from analysis made using rubric 2

Symbol	Explanation	f	%
↓	Individuals who have the right information and then do not change their level	6	17.6
↑↓	Individuals who have the right information and then having misinformation	-	-
↔	Individuals who have the wrong information and remain at the same level	6	17.6
⊙	Individuals who initially had the wrong / empty information and then obtained the correct information	22	64.8
Total		34	100

In the data analysed using rubric 2, it was determined that 64.8% of teacher candidates who were at levels C, D, E and F at the beginning (in the answers they gave to the question with the diagram) attained levels A and B later (in the answers they gave for the 4th equation in the “making inferences” section of the worksheet).

4. Discussion and Conclusions

At the prediction stage included in the worksheet, it was determined that just over half of the preservice teachers gave the correct answers, while rates of partially correct answers were determined as 41% for the first condition and 34% for the second condition respectively. Since the preservice biology teachers were 3rd- and 4th-year students, it is considered that they would certainly have encountered the Priestley experiment during the classes they had attended during previous terms, but that a number of them fell short in giving completely correct answers. In a general sense, conceptual change is stated to be change that occurs from students' previous knowledge towards knowledge that can be accepted as scientific (Duit, 1999). In this respect, it is considered that over half the sample had achieved this targeted conceptual change with the education they had received in previous years, but that permanence could not be achieved in a number of students that can be regarded as considerable.

The answers given by the preservice teachers in the defining variables section in particular make up the least answered section of the worksheet. There are studies in the related literature regarding difficulties experienced in the learning and use of skills for identifying and checking variables (Ateş, 2005). In a study conducted by Griffiths & Thompson (1993), it was stated that students perceived the concept of the independent variable as a variable falling outside the limits of the study in question and therefore as a variable having no relevance to the study in question, and that while identifying the dependent variable, they made unacceptably incorrect definitions. It is indicated that making incorrect associations of the terms used (dependent-independent) by learners, and the fact that the ability to define variables requires a higher level of mental ability than that needed for basic process skills, may be factors in the emergence of this situation (Ateş, 2005).

In the data interpretation section, different versions of the Priestley experiment were designed by the researcher and the teacher candidates were required to make interpretations for situations that might occur in the absence of sunlight. Making interpretations is regarded not only as one of the causal processes but also as a constituent of critical thinking (Koray, Köksal, Özdemir & Presley, 2007; Türnüklü & Yeşildere, 2005). It is defined as determining the meaning and significance of various situations, and thereby reaching a conclusion (Çepni, 2005). It can be understood from the analysis of the answers given by the teacher candidates in this section that the rate of correct answers for each situation was below 50% and that the rates of incorrect and partially correct answers were high. In the modern comprehension of education, the aim is not to raise individuals who learn information by heart and soon forget it, but to raise those who can create, interpret, utilise and undertake harmonious teamwork (Arseven, Dervişoğlu & Arseven, 2015). Inclusion of questions that will develop the interpretation skills required for conceptual understanding in classes belonging to teacher training programmes, at least, will contribute to the improvement of interpretation skills in individuals who are to become teachers (Atasoy & Akdeniz, 2007). Furthermore, it is known that in the training of preservice teachers, success in the use of laboratory methods based on creative and critical thinking leads to an increase in scientific process skills, a more positive attitude towards science and increased levels of knowledge retention (Koray, Köksal, Özdemir & Presley, 2007). An increase in such applications will contribute to the development of the desired qualities.

In the implementation made in the section of the worksheet related to making inferences, developing the students' reading comprehension skills with the history-oriented approach, which was the actual target, and teaching them without making them learn by rote, leads to the understanding that scientific knowledge appears as the result of a process and is cumulative. The students were asked to write the four separate equations by revising them incrementally, and it is striking that the rates of correct answers given for each were high. In a study conducted previously, preservice science teachers were asked about the photosynthesis equation and 61% of them gave the correct answers (Ürey, 2018). In another study, it was reported that students knew about photosynthesis as a definition but that they did not have a deep conceptual understanding of the process (Jain, 2015).

When the correct answer rates for the question with the diagram and 4th equation are compared, however, it is useful to examine the findings: The teacher candidates were asked the question with the diagram before the worksheet was given, and thereby their levels of knowledge about the photosynthesis process, the products entering and exiting the process, and the conditions required for realisation of the process were examined. In fact, with this question with the diagram, an examination of the extent to which they perceived that photosynthesis is a biological process rather than a chemical equation was required. The fact that the rate of exactly right answers was as low as 14.7% and that the majority of answers were completely wrong answer (35.3%) or left blank (32.4%) means that most of them could not remember the process or that they did not know about it. However, understanding this process is in fact a socioscientific culture problem, since an individual who knows what photosynthesis means knows about the operation of the ecosystem, can give meaning to environmental issues, such as greenhouse gases, global climate change, carbon footprints and conservation of forests and green areas, that play a key role in our lives, and will carry out the duties imposed on him/her by implementing them in his/her life. Not only that, he/she will be aware of the relationship of the subject with the hunger and poverty resulting from global climate changes, and even the indirect relationship with human migration. To sum up, he/she will lead his/her life as a conscious citizen for a sustainable world. Moreover, this is a situation aimed for in all education systems (Saka, 2016; Ürey 2018). When this situation emerges, the importance of teaching photosynthesis with a wide vision is revealed. In other words, context-based teaching of photosynthesis will be very useful in terms of perceiving its importance. The fact that the rate of correct answers related to the 4th equation reached 79.4% with this application can be evaluated in two dimensions. Firstly, the equation includes memorisation, but when it is asked about in a diagram, students may not be able to answer due to requiring interpretation skills, since interpretation necessitates a high level of process skill, and these teacher candidates already had considerably low success levels in the interpretation section. Secondly, using a history-oriented approach in the implementation and requiring the students to revise the equation after each time they had read the data given may have caused the increase in correct answer rates. It is known that the history of science enables better understanding of scientific concepts and methods (Laçın Şimşek, 2009). Moreover, understanding what one has read means that the reader, by comparing and synthesising his/her prior knowledge with what he/she has read in the text, can attain a new level of thought (Ergüç, 2009). In this study, the targeted reading comprehension category is interpretative comprehension, since this category includes the skill of restructuring what one has read. It is known that there is a relationship between reading comprehension and ensuring success in science and mathematics (Yılmaz, 2008). In whichever dimension, the result also shown in Table 8 was that the rate of individuals who had incorrect knowledge at the beginning but who later attained correct knowledge was 64.8%. This situation indicates that the worksheet used made a positive contribution to education.

It is recommended that similar implementations are used in lessons and developed in new subjects. There are some

studies show that scientific process skills of students at different levels can be improved through various activities (DeBurman, 2002; Huppert, Lomask & Lazarowitz, 2002; Lazarowitz & Huppert, 2014). There is a need for teaching materials to be designed in the field of science at university level and for these to be made available to science teachers in book format (Ahopelto, Mikkilä-Erdmann, Anto & Penttinen, 2011).

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Appendix 1. Applied Work Sheet

PHOTOSYNTHESIS AND CAUSAL PROCESS SKILLS



The first comprehensive work on photosynthesis was made in 1771 by the British scientist Joseph Priestley. In the first phase of the Priestley experiment; places the burning candle and mouse in the bell jar. In the second phase of the experiment, Priestley puts the burning candle, the mouse and a potted plant in a live state into the glass bell jar. In both cases he makes his observations in daylight.



Prediction: What do you expect from the results of these two separate observations that Priestley did? Write your estimates in the table below.

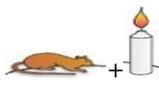
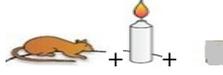
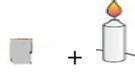
Objects in the bell jar	Sunlight	Time	Observation
	√	After a while	
	√	After a while	

Defining the variables: Please indicate the dependent and independent variables for Priestley's experiment below;

Dependent variable /s:

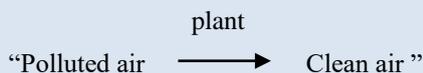
Independent variable /s:

Interpretation of the data: Consider Priestley's experiment and data, and fill in the blanks in the table below.

Objects in the bell jar	Sunlight	Time	Observation
	×	After a while	
	×	After a while	
	×	After a while	
	×	After a while	

Making inferences:

In an article published in London in the same year, Priestley explained his invention: 'I am very happy! I found a coincidence method that refreshes the air that is broken by a burning candle. In the meantime, I discovered one of the vehicles that naturally renewed the weather. This tool is plants. "Priestley's view can be summarized:



Priestley's invention was extremely important in that it was the first time that the air used by humans and animals for millions of years was the first to explain how the air could remain intact and fresh. Soon after, Priestley's findings began to be seen with suspicion. Because other researchers working in this field, and even in the experiments they did not reach the same result. In 1779, Jan INGENHOUSZ made an important discovery and explained his findings in these words: "*The plants growing in polluted weather; this bad weather as Priestley pointed out, I observed that they did not refresh in six or ten days, but only within a few hours. This important process is carried out not only by the leaves of the plant, but also by the effect of sunlight on the plant..*"

Thus, the explanations of Ingenhousz clarified why other researchers and Priestley did not achieve the same conclusions. Because the first experiment is thought to be made in sunlight, other experiments may have been done in an environment without sufficient sunlight. How can we write down an equation that summarizes the finding of Ingenhousz by considering the above equation of Priestley?

Chemist researchers have contributed to this new field by their studies and stated that: polluted air contains too much carbon dioxide and clean air contains too much oxygen.

If you rewrite Ingenhousz's equation in the light of these new information, how can you write it down to the place where it is left blank?

In 1796, Ingenhousz proposed a new idea on the same subject. According to this, "a plant in the sunlight takes CO₂ than holds it's carbon and gives back its oxygen so makes its own food with the carbon it holds ". After the CO₂ is separated by the light, the carbon portion of the compound is used by the plant to make organic matter. On the one hand, the air of the earth is cleaned and the new organic compounds are produced.

How can you describe the equation that summarizes this new idea of Ingenhousz by considering what you have learned so far about photosynthesis?

A few years later, in 1804, Nicolas Theodore De SAUSSURE showed that water was involved in the photosynthesis event as a result of his controlled experiments. He claimed that increase the weight of the plant by photosynthesis, the increase is much more than the amount of carbon dioxide taken by the plant and water contributed to this weight.

Write down the equation of the event of photosynthesis in the area where it is left blank in the light of all the information that is known and correct today with the contributions of Saussure.

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