ACTA DIDACTICA NAPOCENSIA

Volume 17, Number 1, 2024 - DOI: 10.24193/adn.17.1.2

EFFECT OF STRUCTURED INQUIRY POWERED BY WEB 2.0 TECHNOLOGIES ON CONCEPTUAL UNDERSTANDING: LIGHT CONCEPT

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Abstract: The purpose of this study was to investigate the effect of the structured inquiry powered by Web 2.0 technologies on remedying sixth-grade students' alternative conceptions of "light" and improving their conceptual understanding. The sample of the study consisted of 16 sixth-grade students enrolled to a science course at a public secondary school. Since the study evaluated student gains in conceptual understanding by means of pretest and posttest scores, the study employed a single group pretest-posttest research design, with a conceptual understanding test (CUT) and semi-structured interviews employed as the data collection tools. The collected quantitative data was analyzed using IBM's SPSS 15 statistical software, whilst the qualitative data was analyzed by way of content analysis. The analytical results showed that the structured inquiry powered by Web 2.0 technologies positively impacted the students' conceptual understanding of light, as evidenced by their ability to differentiate between different types of reflection and provide coherent explanations for light-related phenomena.

Key words: Structured inquiry-based learning, 5E model, Web 2.0 technologies, conceptual understanding, light concept.

1. Introduction

In education, 21st-century skills are explicitly incorporated through inquiry-based learning approaches, which aim to develop critical thinking, problem-solving, and decision-making skills (Abdusselam et al., 2018). Additionally, the use of innovative technologies and collaborative platforms, such as Web 2.0 tools and Google Classroom, fosters the development of skills related to information and communication technologies, flexibility, adaptability, and cooperation (Avcı Yücel, 2017). In the workplace, these skills are often integrated into project-based tasks, where employees are required to demonstrate critical thinking, creativity, and effective decision-making to solve complex problems and contribute to innovative solutions (Çalık & Ebenezer, 2018). An individual equipped with these "21st century skills" is expected to be able to think critically and creatively, to solve the problems they encounter, possess the ability to make effective decisions, to be flexible, adaptable, and open to cooperation, and to have acquired the necessary competencies related to information and communication technologies (Care et al., 2018). Inquiry-based learning has been integrated into science education programs to promote active, research-based learning and the acquisition of new knowledge and competences (Urdanivia Alarcon et al., 2023). Inquiry-based learning is a student-centered process that mimics the practices of professionals in the field, emphasizing evidence-based discourse and collaborative problem-solving across disciplines (Nollmeyer & Baldwin, 2022). In this context, certain reforms have been undertaken in the field of education. Science education has been significantly influenced by these reforms and the inquiry-based learning approach has been adopted in numerous science education programs (National Research Council [NRC], 2013). Technology supported inquiry-based teaching has been found to enhance students' scientific achievements and scientific process skills (Koyunlu Unlu & Dokme, 2020). Another one research found that utilizing inquiry-based learning focused on socio-scientific issues enhances the implementation of classroom learning strategies, resulting in the enhancement of students' higher-order thinking abilities (Qamariyah, Rahayu, Fajaroh & Alsulami, 2021). In the realm of science education, there's been a

Received October 2023.

Cite as: Şahin Çakır, Ç., Abdusselam, M. & Özer, M. (2024). Effect of Structured Inquiry Powered by Web 2.0 Technologies on Conceptual Understanding: Light Concept. *Acta Didactica Napocensia*, 17(1), 14-35, https://doi.org/10.24193/adn.17.1.2

growing acknowledgment of the effectiveness of inquiry-based learning in fostering the development of students' advanced cognitive abilities. In a meta-analysis research, calculated the collective weighted effect size of g = 0.893 indicates a notably substantial and beneficial influence of inquiry-based approaches on the enhancement of students' higher-order thinking skills. In the same meta-analysis research, while different inquiry-based methodologies proved successful when integrated with additional instructional techniques for imparting scientific concepts, only a limited number of studies incorporated technology into the execution of inquiry-based approaches in science education (Antonio & Prudente, 2024). In this context, it is believed that integrating technology into inquiry-based learning in this research, will make a significant contribution to the literature.

One of the main aims of inquiry-based learning is that students acquire 21st century skills (Chu et al., 2021) in order that they can recognize the problems they face, examine such problems as they occur in daily life, try to resolve these issues, and to suggest new ideas based on thorough research (Palupi & Subiyantoro, 2020). The investigative personality, which is formed according to the inquiry-based learning process, ensures that students conscientiously explore concepts, gaining a thorough understanding through meaningful learning practices (Güler & Şahin, 2018). Inquiry-based learning equips students with the necessary skills and competences to overcome the challenges of an uncertain and changing world (Kuhlthau, 2010). Inquiry-based learning can enhance critical thinking skills (Maharani et al., 2023), collaboration (Syarifuddin, 2023), communication (Pattipeilohy. et al., 2022), and creativity (Yonwong et al., 2024). The published research has demonstrated that inquiry-based digital laboratory applications were effective in remedying students' misconceptions (Siantuba, Nkhata & de Jong, 2023).

The published research has demonstrated that it can positively affect students' academic success and attitude (Kaya & Yılmaz, 2016), their inquiry learning skills perception (Evrekli & Balım, 2015), cognitive learning (Kırılmazkaya, 2014; Küçüker, 2008), and their research and inquiry skills (Li, et al., 2010). The active engagement fostered by inquiry-based learning allows students to draw connections between academic content and their own lives, leading to a deeper understanding of the material (Maharani et. al, 2023). Additionally, inquiry-based learning promotes problem-solving skills, as students are encouraged to explore and investigate concepts on their own (Sartika et al., 2023). This hands-on approach to learning also enhances critical thinking skills, as students are challenged to analyze information, evaluate evidence, and make informed decisions (Syarifuddin, 2023). These factors contribute to improved academic success, as students are actively involved in the learning process and are able to apply their knowledge in real-world contexts. It has also been determined that inquiry-based learning is an effective approach in tackling students' misconceptions on science subjects such as substances and changes in substances, electrochemistry and oxidation reduction, density, force and movement, momentum, pressure, photoelectric effect, as well as series and parallel connection (Kaya & Yılmaz, 2016). Assem, Owusu, Issah & Issah (2024) demonstrated that education based on inquiry-based learning significantly alleviated students' misconceptions regarding electricity and magnetism. The researchers utilized the 5E instructional model when planning the teaching process according to the inquiry-based learning approach. It has been suggested that inquiry techniques empower learners to assume responsibility for their learning, uncover latent abilities within students, and motivate them to pursue further clarification on matters concerning causes and their consequences. If you do not actively have been engaged with and challenge misunderstandings, they do not go away. Similarly, Mekonen & Kelkay (2023) suggest that employing the guided inquiry teaching approach yields a notably distinct impact on enhancing students' conceptual grasp of photosynthesis in comparison to utilizing the lecture method. Also, the study's findings also revealed that the guided inquiry teaching method holds significance for students beyond enhancing their conceptual comprehension. It aids in developing their investigative skills, fostering independence in learning, and motivating student participation and confidence. Researchers carried out this guided inquiry teaching approach process according to the 5E model.

The content of science consists of facts, concepts, principles, generalizations, theories, and the laws of nature (Hodge & Cantor, 2020). Concepts in science are structured and understood by students through the acquisition of knowledge. One of the cores aims of science education is to support students in developing a meaningful understanding of science concepts and to enable students to

understand how these concepts can be applied in daily life (Dewi & Primayana, 2019). Science education aims to develop positive attitudes in students towards science and scientific process skills in order that they can construct the required knowledge to understand concepts based on natural phenomena (Suryawati & Osman, 2017). Accordingly, science content should be taught during the early stages of school life so that students can connect and define one concept with other concepts in order to explain natural events that occur in daily life. However, certain misconceptions may occur within this process. The most basic reasons behind misconceptions that make concept teaching difficult can be explained as incomplete or misunderstanding of previously acquired concepts, differences in the understanding of concepts used in daily language compared to scientific language, and the inability to create suitable educational environments for teaching subjects and concepts (Chi, 1992). These situations can also indirectly negatively affect the inquiry process.

There are numerous ways to apply inquiry-based science learning in schools, including the use of web-based technologies. Especially in recent years, Web 2.0 technologies have been preferred by many researchers since students have been shown to be more motivated and take a more active role within the learning process (Ozcinar, et al., 2020). Technology, particularly Web 2.0 tools and services, can play a crucial role in facilitating the inquiry process by supporting essential thinking skills. The emphasis lies on prioritizing student learning over the technology itself. The focus should be on identifying the phase(s) of inquiry that students are engaged in and determining which technological tool can best complement the thinking processes and instructional methods employed during that phase. This approach enhances the effectiveness of both the learning journey and the integration of technology. For example, in the connect phases of inquiry coluld be used the Google Earth, Teacher Tube, Flickr web 2.0 tools for engagement and exploration activities (Berger, 2010). Researchers have used technology to increase the effect of inquiry-based education on students' learning. The use of Information and Communication Technologies (ICT) in physics education has been found to enhance students' performance by making the learning process more entertaining, engaging, effective, and meaningful (Zangmo et al., 2022). Since educational technologies can be effective in concretizing abstract concepts, presenting information in both visual and graphic form increases the permanence of the subjects learned and increases students' motivation to learn. Also, they allow students to experience applications which cannot otherwise be performed within the classroom environment as well as experiments which cannot be performed within a laboratory through simulation or animation (Kim, 2011).

"Light" is one concept about which students often have misconceptions (Mazlum & Yiğit, 2017). In the literature on teaching the concept of light based on inquiry-based learning, it can be observed that research studies have been conducted to determine the effect of this approach on students' academic success, their attitudes towards science, as well as their metacognition, inquiry perception, scientific process skills, and levels of understanding the nature of science (Öztürk & Dökme, 2015). It is thought, therefore, that studies on the effect of inquiry-based instruction powered by Web 2.0 technologies on conceptual understanding will help contribute to the field in terms of teaching the concept of light. In the current study, Web 2.0 technologies were employed within the inquiry-based teaching and learning process. In our study, Antropi Teach, kahoot and Socrative tools were used in the introduction phase in order to reveal the students' prior knowledge, attract their attention and motivate them. Algodoo was used in the discovery phase to enable students to gain experience and research. In the explanation phase, simulations and videos were used to encourage students to make explanations about their questioned views. In the deepening phase, Google Drive and Google Classroom were used to encourage students to discuss the topics they learned in order to relate them to daily life. During the evaluation phase, Google forms was used so that students could reflect on their questioned opinions. The researchers in the current study believed that students would participate in the inquiry process more eagerly and actively through the use of Web 2.0 technologies. Thus, inquiry-based learning is more effective when supported by appropriate technologies. Technology-supported scientific inquiry enables individuals to conduct scientific research, conceptualize scientifically, and establish scientific communication (Tamir, 1978). Innovative technologies support individuals' learning by questioning (Vogel, et al.).

Also, the structured inquiry model was employed in the current study; an approach that has been shown to be effective in the successful participation of students who have not previously participated in inquiry-based learning. The primary objective of structured inquiry is the development of inquiry-structured thinking skills-oriented learning process (Sanjaya, 2009, as cited in Salim & Tiawa, 2015). Also, interaction between the structured inquiry learning model and students' attitudes and perceptions has been shown to be higher (Salim & Tiawa, 2015).

Various ways were applied to remedy students' misconceptions and to ensure meaningful learning. One approach is through remedial learning, which involves identifying and addressing misconceptions (Islamiyah et al, 2022). Effective remedial learning strategies include the use of Problem-Based Learning (PBL), Guided Inquiry, and Conceptual Change Model (CCM) (Islamiyah et al, 2022; Maknun & Marwiah, 2022). One of these alternative ways is the structured inquiry. Indeed, such alternative teaching ways are primarily necessary for teachers, who are willing to adapt structured inquiry-based learning powered by web 2.0 technologies into science classes (e.g. Çalık, 2013; Çalık, Ebenezer, Özsevgeç, Küçük & Artun, 2015). This study not only integrated the structured inquiry-based learning, as an alternative way, into science classes but also denoted how to pedagogically teach the light concept through web 2.0 technologies. In addition, it was explained how technology was used in the applications made in this study and how the conceptualization was provided. Hence, this study would give an opportunity for six grade students to construct and inquiry by use web 2.0 technologies their own knowledge. In addition, this study would provide invaluable learning activities for students, teachers and researchers to apply in the teaching and learning process.

The purpose of the current study was to investigate the effect of the structured inquiry activities powered by Web 2.0 technologies on remedying sixth-grade students' alternative conceptions of "light" and to improve their conceptual understanding. In parallel with this main purpose, the sub-objectives of the research were presented below:

1. To determine whether structured inquiry activities powered with web 2.0 technologies create a significant difference in students' conceptual understanding of the light.

2. To determine the impact of structured inquiry activities powered with web 2.0 technologies on students' conceptual understanding of the light.2. Method

The pre-experimental method was employed in the current research. In this approach, the steps of the experimental method are included but no comparison is performed with a control group (Cohen, et al., 2000). This research design could be viewed as posing a greater threat to validity due to its absence of random assignments and control groups, which reduces confidence in attributing causality to an intervention. However, in studies with experimental and control groups, it is considered obvious that the experimental group will be more successful than the control group, since there is a special intervention for the experimental group. For this reason, since there is no control group in studies with a single experimental group, the development of the experimental group can be examined in more detail with data obtained from different data collection tools or a follow-up test can be applied (Karsli & Yigit, 2017). Within the scope of this research, in addition to the CUT, students were also asked drawing questions and semi-structured interviews. Thus, an attempt was made to eliminate the validity threat that may arise by using the pre-experimental research method. As such, the application was performed with one group only, the experimental group, and the effect of the intervention researched on this one group according to the pre-experimental method. Having only one experimental group and no control group in the study may be considered as a thread for the validity of the research. However, as the experimental group was subject to the applied teaching intervention within a significant period, the educators expected the students to learn at least something about the basic content. For this reason, it was considered an expected situation that the students in the experimental group would exhibit better performances in a posttest compared to any control group (Sadler, 2009). Therefore, the researchers in the current study opted to employ the experimental design using a singular experimental group and no control group. In addition, the second researcher was a science teacher who taught only one class with sixth-grade students. Other classes with other teachers were not determined as a control group in order to control the teacher variable. In the literature, Karslı and Yiğit (2017) preferred a pre-

experimental design in their research in order to examine the detailed effect of an experimental intervention with a single experimental group. In the current study, the conceptual understanding of the participant students was examined in detail through both quantitative and qualitative data. The quantitative data of the research was obtained from the application of The CUT whilst semi-structured interviews were performed with the students at the end of the educational period to gather qualitative data through which to thoroughly examine their conceptual understanding. The research steps of the study are visualized in presented in Figure 1.

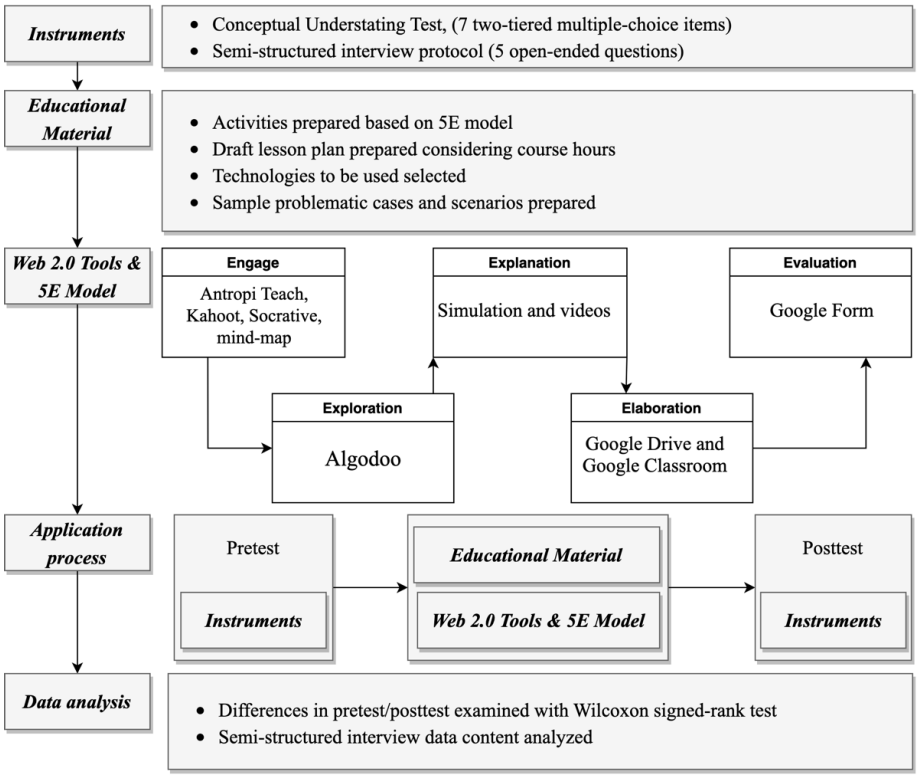


Figure 1. *Research steps*

2. 1. The Participant

The participant of this study consisted of 16 (six female, 10 male) sixth-grade students aged 11-12 years old enrolled to a science course at public secondary school in the Black Sea region of Turkey. The small number of the sample group of this study can be expressed as a limitation for this research. Although the small sample size is seen as a threat to the generalizability of the findings, it is anticipated that similar results can be achieved if a similar application is carried out with small sample groups as in the current research. However, the low number of sample group can be seen as an advantage in terms of facilitating implementations of the structured inquiry powered by Web 2.0 technologies. A pretest study was completed with the participant students during the first week, and a posttest during the final (fifth) week, whilst the application itself lasted for a period of 3 weeks. The teaching intervention was then conducted in a science classroom for 6 teaching hours (6 x 40 minutes).

2.2. Instrument and Procedures

"The conceptual understanding test (CUT) was developed as a two-tier test. There were 4 options in the first stage of the CUT each item. In the second stage of the CUT each item, there were 4 options and an open-ended section where students can write their own opinions apart from these options. With the open-ended part in the second stage of the CUT each item, students were given the opportunity to write their own opinions if they have a different opinion other than the specified options. While preparing the CUT options, scientifically correct statements were written in the correct option, while

misconceptions identified in the literature were written in the distractors. There were 7 items in the CUT. The CUT questions were prepared according to the gains in the Science Course Curriculum (MNE, 2018).

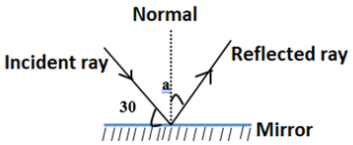
Gains:

- "6.4.1.1. Observes the reflections of light on smooth and rough surfaces and shows them by drawing rays. (4 questions)"
- "6.4.1.2. Explains the relationship between the incident ray, the reflected ray and the normal to the surface in the reflection of light. (3 questions)" (NME, 2018).

The validity of the CUT was established by two faculty members from science education, one faculty member from physics education, and three science teachers. Also, as the CUT was developed and applied in the Turkish language, it was examined by a Turkish language education expert in order to validate the grammar used. To ensure that the CUT was reliable, it was applied to a different sample with a similar background to the main study. The Cronbach alpha reliability coefficient of the scores was established as being .94 for the CUT. Item analysis was conducted for the options in both stages of the CUT items. The average difficulty index of the CUT items was calculated as .56 and the average discrimination index was .46. The CUT was applied to the sample group twice, as a pre-test before the teaching intervention and as a post-test after the teaching intervention. The full version of the CUT and the item analysis results of the CUT were presented as supplementary materials.

One example item from the CUT was presented in Figure 2.

Question 1: Which of the following is true about the reflection mechanism of light in a plane mirror?



A) The angle of incidence of the incident ray is 30 degrees.
B) The angle between the reflected ray and the mirror is 60 degrees.
C) "a" is called the angle of reflection.
D) The angle of reflection is 30 degrees.

The reason I chose this option;
A) The angle of incidence is the angle that the incident ray makes with the surface.
B) The angle of reflection is the angle between the reflected ray and the normal to the surface.
C) The angle that the incident ray makes with the mirror is equal to the angle that the reflected ray makes with the normal to the surface.
D) The angle of incidence and the angle that the reflected ray makes with the mirror are equal.
Other:……

Figure 2. *Sample item from the CUT*

The second data collection instrument used in the current study was a semi-structured interview protocol that consisted of five open-ended questions. Four of these questions were regarding the concept of light in daily life, plus one drawing-based question regarding the reflection of light. The semi-structured interview questions were prepared in parallel to the CUT and based on daily life situations in a way to lead the students towards inquiry-based thinking. The appearance and content validity of the semi-structured interview questions were confirmed with two science education faculty members, one physics education faculty member, and three science teachers. Also, two students who were not in the study's sample were asked to read the questions from the CUT and the semi-structured interview protocol in order to identify any questions that were unclear or confusing, after which minor revisions were applied as appropriate. An example question from the semi-structured interview protocol is given as follows:

- "Photographers use tools to soften and diffuse light for indoor photography. Why do these tools need to be used? Explain."

The semi-structured interviews were conducted by the science teacher with a total of six students, with each interview lasting almost 30 minutes. While processing the CUT data of the students in the sample group, the students were coded as S1, S2 ... S16. After the instructional intervention, the CUT was applied to the students as a posttest, and according to the post CUT results, semi-structured interviews were held with a total of 6 volunteer students, 2 each from high, medium and low successful students. Therefore, since the students were coded beforehand, the codes of the students who voluntarily participated in the semi-structured interview were also indicated with their current codes (S3, S4, S7, S9, S11, and S16)."

How the interviews were to be conducted was discussed between the first researcher and the science teacher (second researcher), and a pilot interview was then conducted with a student not in the study's sample but with a similar background.

2.3. Teaching Intervention-Implementation

The following process steps were applied in developing the educational material for the technology-assisted, inquiry-based learning.

1. Literature on the inquiry-based learning approach were examined where the studies were technology assisted and educational materials developed (Kaya & Yılmaz, 2016). Additionally, literature related to the 5E teaching model were examined (Abdusselam et al., 2018; Çepni & Şahin, 2012). Technology-assisted, inquiry-based activities were prepared and implemented in the current study according to the 5E model. The model is comprised of five main stages; engage, exploration, explanation, elaboration, and evaluation (Abdusselam et al., 2018).
2. Faculty members' opinions were sought from the fields of science education and also computer education and instructional technology regarding how best to prepare a 5E model enriched with Web 2.0 technologies based on structured inquiry activities. The learning outcomes from the secondary school sixth-grade syllabus related to the topic of light were reviewed, and then a draft lesson plan was prepared considering the required course hours.
3. The Web 2.0 technologies used were selected by taking into account the available technical equipment of the school where the research was conducted. Utilizing Web 2.0 technologies enabled the participant students to work collaboratively on the course content, to create learning content together, and to be interactive throughout the learning process (Avcı Yücel, 2017).
4. The sample problematic cases and scenarios of the educational material to be presented during the elaboration stage were prepared by the researchers, and the opinion sought of appropriate subject-matter education experts. Attention was paid to preparing problem scenarios that were in conformity with daily life and also related to the content being taught.
5. During the engage stage, Antropi Teach, Kahoot, and Socrative applications were employed, whilst Algodoo was used in the exploration stage. For the explanation stage, simulation and videos were employed, whilst Google Drive and Google Classroom were used during the elaboration stage. Finally, Google Form was utilized in the evaluation stage (see Figure 1).

Algodoo: It is a simulation program used especially in teaching physics subjects. Algodoo application was used in the discovery phase of smooth and diffuse reflection and reflection laws. In experiments conducted in the discovery phase, students make observations and test hypotheses. However, the experiments are inadequate at some point because the concept of "Light" is an abstract concept. In most cases, it is not possible to observe whether the rays are spread symmetrically or diffusely in the uniform and diffuse reflection of light. Regarding smooth and diffuse reflection, the shapes drawn by the students are just the drawings drawn by their teachers. However, performing the same activity in the Algodoo application not only allows students to learn the concept of uniform and diffuse reflection in a more concrete way, but also makes it easier for them to try different situations because it allows them to change shapes and rays.

Antropi Teach: It was used to draw a mind map in order to determine the students' prior knowledge about the concept of "Light". Through group discussion, students created a mind map about the

concepts that come to mind when they hear "Light". Afterwards, the groups presented their mind maps to their other group members. The concepts in each group's mind map were written on smart boards in the Antropi Teach application and a class mind map was created. During this process, students had group discussions and used inquiry processes by discussing concepts within the group.

Kahoot: At the engage stage, questions that would direct students to research and questioning were applied to students through the kahoot application. In this way, students were tried to be curious and motivated about the subject they would learn. Students answered kahoot questions through group discussion. The groups entered the kahoot application with the code given and answered the kahoot questions as a group.

Socrative: Like the kahoot application, the Socrative application is a web 2.0 tool used to attract students' attention and motivate them. The difference from the Kahoot application is that the Socrative application can ask students long or short answer questions and questions that the students must write the answers themselves. This directs students to think about the questions and write common answers as a group. In this way, students also gain the skills to express their thoughts in writing by discussing. The questions asked in the Socrative application are questions that will stimulate students' thinking processes. The question asked in the Socrative application is “The mirror surface and the wall surface reflect the incoming rays. But while we see ourselves when we look in the mirror, we cannot see ourselves when we look at the wall. From where?" The question directs students to daily life and allows them to discuss and express their ideas.

Google Drive: problem scenarios related to the subject were shared with students with the help of Google Drive. Problem scenarios were shared with students via Google Docs in Google Drive. In the shared problem scenarios, students were given problems from daily life and were guided to find solutions to these problem situations using their previous knowledge. With the help of problem scenarios, students were directed to questioning and group discussion and were asked to produce different and creative solution suggestions. In the problem scenario sent to the students regarding the smooth and diffuse reflection of light, information about "Interior Photography" was given, and they were asked to find answers to the questions asked by blending this situation in daily life with the information they learned in the course. One of these questions is “Outdoor photographers use tools such as umbrellas, overhead flashes and reflectors in photo shoots. What is the purpose of using these tools? What kind of surfaces do you think these vehicles should have?” Students try to answer the question by doing group work and discussing within the group and try to produce solutions.

2.4. Application Process

Within the scope of the current research, lessons took place on two sub-topics of the “light” teaching unit, namely “specular and diffuse reflection of light” and “laws of reflection.” For each topic, a teaching intervention 5E model enriched with Web 2.0 technologies was developed based on structured inquiry. The teaching intervention was presented to a science education faculty member, a computer education and instructional technology faculty member, and also a science teacher in order for them to evaluate the compatibility of the proposed 5E model enriched with Web 2.0 technologies based on structured inquiry with the target student level as well as its scientific accuracy. The experts thereby helped to ensure that the lesson content of the teaching intervention was appropriate.

With the opinion of an expert in the Department of Computer and Instructional Technologies Education, it was decided to use similar web 2.0 tools at the same stages of all lesson plans. In selecting the web 2.0 tools to be used, the technical equipment at the school where the research would be conducted was also taken into account. The suitability of the teaching material prepared for each course with technology-supported education and research-inquiry approach was checked by 1 science education expert and 1 computer and instructional technologies education expert. The science field education expert emphasized that the problem scenarios to be used in the deepening phase should be appropriate to daily life and relevant to current situations. The Science teacher also provided feedback that the lessons could be taught with web 2.0 tools in the prepared lesson plans.

2.5. Example Lesson Plan

The student-centered 5E model was developed by Bybee (1997), and is considered to as a model used to provoke students' curiosity and interest towards inquiry. This approach allows them to learn more meaningfully as they are integral to the experiment, and therefore encouraged to research according to a logical sequence of study and results with a holistic perspective. The 5E model may be defined as one in which students are guided by questions to help them obtain valid information, and which prioritizes student exploration over learning scientific concept definitions (Abdusselam et al., 2018; Çepni & Şahin, 2012). The lesson plan demonstrated in the current study is presented in Table 1. A sample lesson plan was provided as supplementary material.

Table 1. *Lesson plan*

Web 2.0 technologies	IBL process followed	5E model
Antropi Teach	Students create a mind map about the concept of light, helping students to review/query their prior knowledge.	Engage
Kahoot / Socrative	Students are asked scientific questions about reflection of light in their practices of Kahoot and Socrative. Students' explanations are not accepted immediately, allowing them time to deliberate. Students are encouraged to seek out evidence.	
Algodoo	Students try to solve questions by looking at the evidence. Students investigate the reflection of light on rough and smooth surfaces through experimentation with Algodoo.	Exploration
Simulation / videos	Students self-evaluate based on video explanations reflecting the scientific approach. Students present their explanations together with their evidence.	Explanation
Google Drive / Google Classroom	Students research specular and diffuse reflection (via Google Drive) to solve a daily life problem scenario. Students search for evidence to solve the problem scenario.	Elaboration
Google Forms	Students attempt to answer questions presented via Google Forms. Students explain their answers based on evidence.	Evaluation

2.6. Data Analysis

In the analysis of the CUT, the students were awarded 1 point for a correct response and 0 points for an incorrect response. Differences between pretest and posttest were examined using the Wilcoxon signed-rank test, which is a recognized non-parametric test, and a Windows version of IBM's Statistical Package for Social Sciences (SPSS version 15). The Shapiro-Wilk normality test results showed that the data were not normally distributed, with the p value shown to be $p < .05$ (see Table 2). As there is a normal distribution assumption in the parametric tests, non-parametric tests were used (Büyüköztürk, 2012).

Table 2. *Light CUT Shapiro-Wilk normality test results*

Tests	*N*	Statistic	*df*	Sig.
Pretest	16	.54	15	.000
Posttest	16	.59	15	.000

In the semi-structured interviews, consent of the student participants were sought for the interviews to be audio recorded, and then transcribed by the first researcher. The collected semi-structured interview data were then content analyzed according to the understanding categories developed by Abraham et al. (1992) (see Table 3).

Table 3. *Understanding categories and descriptions*

Understanding category	Description
Sound understanding	Response includes all key concepts
Partial understanding	Response contains one but not all components of a valid response
Alternative understanding	Unreasonable or incorrect response
Not answered	Response left empty, "I don't know," "I didn't understand," repeated question, or an irrelevant or unclear response

The students' responses from their semi-structured interviews were coded separately by the two researchers, who had each received qualitative data analysis training, so as to ensure the reliability of the data analysis process. Then, the analysis categories of the two researchers were compared and any items categorized differently by the two researchers discussed and joint decision reached. Direct quotations from the transcribed semi-structured interviews are presented in order to validate the presented results according to each respective category.

3. Results

This section presents the results obtained from the CUT and semi-structured interviews. First, the descriptive statistics results from the CUT are shown in Table 4.

Table 4. *Wilcoxon signed rank test descriptive statistics findings*

Test	n	Mean	Std. Deviation	Minimum	Maximum
Pre CUT	16	4,4375	1,75000	2,00	8,00
Post CUT	16	7,5000	3,18329	2,00	12,00

Wilcoxon rank-signs test results are presented in Table 5.

Table 5. *Wilcoxon signed rank test comparison of pre-CUT and post-CUT data*

Test comparison	Rank	*n*	Mean Rank	Rank total	*z*	*p*	*r*
Pretest - Posttest	Negative	1	8.00	8.00	-2.811	.005	.70
	Positive	13	7.46	97.00			
	Equal (neutral)	2					
	Total	16					

The results of the Wilcoxon signed rank test in Table 5 show that there were significant differences between the pre- and post-CUT scores ($z = -2.811$, $p < .05$). Considering the pre-CUT ($\chi = .3170$) and post-CUT mean scores ($\chi = .5357$), it was observed that the difference was in favor of the post-CUT scores. In addition, r effect size ($r = .70$) results supported the significant difference between the pretest and posttest scores. r value of .1 is considered a small effect, an r value of .3 is considered a medium effect, and an r value of .5 is considered a large effect (Field, 2009). The r value can be interpreted as 49% of the variance originating from the application.

The findings from the semi-structured interviews were presented in Table 6.

Table 6. *The findings from the semi-structured interviews*

Question	Conceptual understanding categories		Students' quotation statements
1. In your opinion, what is the difference between reading books with pages made using glossy paper and without?	Sound understanding	S11	Significant light is reflected when pages use glossy paper. For example, the paper used in this year's textbook is very glossy and is like waxed paper; whereas, non-glossy paper reflects much less.
		S3	Bright objects reflect more light. We couldn't read the text easily. It would be easier if it was made of normal paper.
	Sound understanding	S4	For example, the whiteboard sometimes shines when light is reflected on it and I can't see it properly. Reading from glossy paper may also be difficult.
	Partial understanding	S16	Glossy pages strain our eyes more than non-glossy pages. Specular and diffuse reflection occur.
	Sound understanding	S7	Light shines on glossy paper but it doesn't shine on non-glossy paper. If light shines, it is hard to see and our eyes get tired.
	Partial understanding	S9	While looking at a glossy page, our eyes get tired because light is reflected more. For this reason, we should prefer books with non-glossy pages.
2. Photographers often use tools to soften and diffuse light for indoor photography. Why are such tools used? Please explain.	Sound understanding	S11	I think it is to increase or decrease light. The surfaces of these tools are different, with some rough and some smooth. This causes them to give off different reflections, like specular and diffuse.
	Partial understanding	S3	We use these tools to prevent reflected light. If we don't use them, we cannot take clear photos. For example, it is generally dark when taking photos at night, but using these tools may help limit the effect of the dark.
	Sound understanding	S16	If it is rough, diffuse reflection occurs; but, if it is less rough, specular reflection occurs. Light should be reflected as specular and parallel. We should use rough surfaces when light needs to be reflected as blurred.
	Partial understanding	S4	It is to prevent light from reflecting directly on our faces. Instead, it reflects in a diffused way so our face doesn't shine. A rough surface is needed to make light spread out in all directions.
	Sound understanding	S7	For example, if there is too much light in the environment, this light will need to be diffused in all directions else the photographs will shine. For example, when we turn on the flash, sometimes photographs become very glossy. Or if we don't position the camera in the right direction for the sunlight, sometimes photographs are left in the dark even if it is daytime. This is why these tools should be used.
	Partial understanding	S9	These tools are used to prevent light from shining and to prevent darkness.
3. There are umbrella-like shades in the outer parts of household shades and	Alternative understanding	S11	The intended use of shades is to diffuse light. It illuminates all parts of the room by diffusing light.
		S3	It is done to diffuse light to all directions.

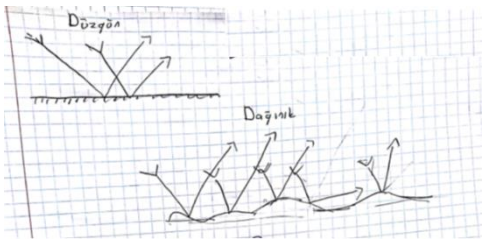
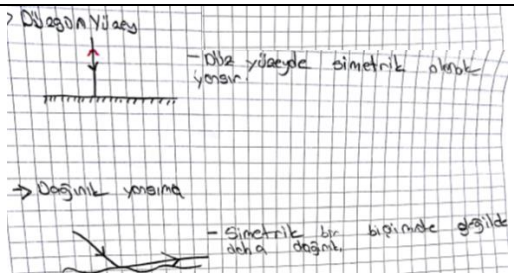
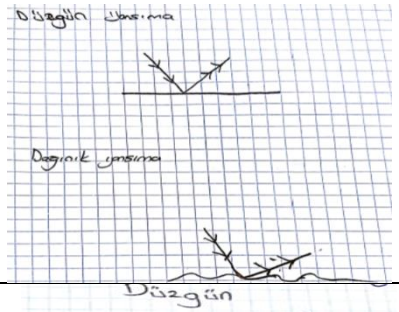
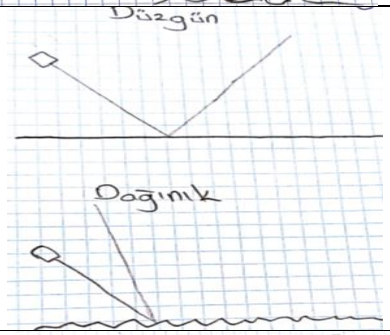
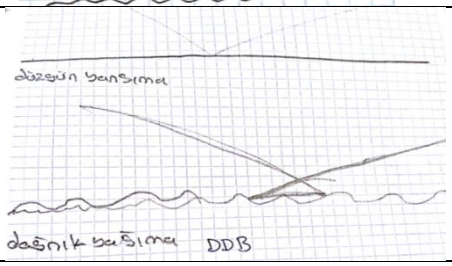
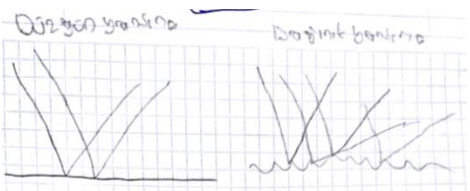
Question	Conceptual understanding categories		Students' quotation statements
chandeliers. Please explain the intended use of these shades.	Partial understanding	S4	This is to provide light to diffuse to all directions. In this way, light is reflected as we want. For example, street lamps should be like this.
	Sound understanding	S16	It is used to prevent light from dazzling. If we do not have shades, light is reflected very brightly towards our eyes. Shades reduce light and make light reflect downwards.
		S7	These shades provide diffused reflection of light and the direction of light is changed.
	Alternative understanding	S9	These shades absorb light.
4. Why is driving more dangerous on wet asphalt? Answer based on information learned in lessons on light and reflection.	Alternative understanding	S11	For example, on a wet floor, friction decreases, that is, it becomes smooth. Asphalt also becomes smooth when it gets wet, so light is reflected more. For example, there are wet ground warnings on electronic traffic signs in rainy weather.
	Partial understanding	S3	When we look at the wet asphalt, driving is dangerous as light is reflected more.
	Alternative understanding	S4	Cars may skid on wet ground. Or, for example, when there is too much snow, light reflected from snow hits our eyes. The same may also happen on wet asphalt.
		S16	Wet asphalt is more slippery, and therefore it reflects light to eyes.
	Sound understanding	S7	When sunlight hits wet asphalt, more light is reflected to our eyes. Normally asphalt has a dark color, but has a lighter color when it gets wet.
	Alternative understanding	S9	When asphalt gets wet, cars skid and cannot stop. For example, when a tile gets wet, it also becomes slippery.

Table 6 provides a selection of the students' responses to questions posed during the semi-structured interviews, with answers categorized as sound understanding, partial understanding, and alternative understanding of conceptions or misunderstanding.

In the first question, when the students' responses were examined, reflection on glossy objects were included in the sound understanding category. An example of this was given by S4, and was considered as a correct response. In an answer offered by S16, only specular and diffuse reflection was mentioned, but not reflection on glossy and dull surfaces, hence it was listed under the partial understanding category. While the answers given in the partial understanding category were that glossy papers tire the eyes more than non-shiny papers, it was seen in the answers in the sound understanding category that the reason why glossy papers tire the eyes was explained by associating it with the light reflected from glossy papers. From the students' answers, it can be seen that they generally learned information about the reflection of light, types of reflection and reflection laws and that they were able to associate this information with daily life. However, it is also seen that some students have misconceptions about the purpose of using the shades outside the chandeliers and associating the reason why driving on wet asphalt is dangerous with the reflection of light.

The results obtained from the drawings of the students are presented in Table 7.

Table 7. *Students' drawings on specular and diffuse reflection*

Question	Understanding level		Students' drawings
Draw an example of how light is reflected on specular and diffuse surfaces.	Sound understanding	S3	
	Sound understanding	S11	
	Sound understanding	S4	
	Sound understanding	S16	
	Partial understanding	S9	
	Sound understanding	S7	

When Table 7 was examined, it can be observed that the students differentiated smooth and rough surfaces in their drawings about specular and diffuse reflection. The students drew smooth surfaces as a straight line and rough surfaces as wavy. In the same way, it can be seen that they tried to draw a symmetric reflection to express specular reflection on smooth surfaces, and reflection on rough surfaces by reflecting the incident and reflected rays in different directions. As seen, the students did not include the values of angles, and drew by rule of thumb.

4. Discussion

When the results obtained from the CUT were examined, it was observed that a significant difference existed between the students' pretest and posttest CUT scores, which was in favor of the posttest (see Table 4). In addition, the fact that the calculated *r* effect size was at a high effect level also supports this situation. In other words, it can be said that the difference between the students' pre- and post-test results was due to the application. Again, the findings obtained from semi-structured interviews also support the quantitative findings. Students were generally able to explain correctly or partially correctly the questions about reflection, the laws of reflection and the association of reflection with daily life. Therefore, it may be stated that the 5E model enriched with Web 2.0 technologies based on structured inquiry had a significant effect on the students' conceptual understanding. Küçüker (2008) revealed that students' conceptual understanding in an experimental group in which the computer-assisted scientific research method applied in chemistry lessons differed significantly from the control group exposed only to traditional teaching methods. In a study by Kırılmazkaya (2014), it was determined that web-based open inquiry and guided inquiry approaches resulted in significant differences in the attitudes of prospective teachers towards conceptual success, scientific process skills, self-efficacy, and scientific experimentation when compared to the structured inquiry approach. In research by Çalık and Ebenezer (2018), it was stated that assisting the application of scientific inquiry through technology in lessons was used by students in recording and creating graphics, in modeling, embodying data, conceptual change and inquiry, and in scientific communication.

In general, it has been observed that web-based (Kırılmazkaya, 2014), simulation and animation (Küçüker, 2008), and virtual reality technologies used to support teaching (Sypsas et al., 2019) have been mentioned the most in the literature within the scope of the 5E model enriched with Web 2.0 technologies based on structured inquiry. In the current study, using Antropi Teach, Kahoot and Socrative tools, preliminary knowledge about the reflection of light was determined and students were enabled to connect with the subject and become motivated. Antropi Teach, Kahoot, Socrative tools were used in the introduction phase in order to reveal the students' prior knowledge, attract their attention and motivate them. Algodoo was used in the discovery phase to enable students to gain experience and research. In the explanation phase, simulations and videos were used to encourage students to make explanations about their questioned views. In the elaborate phase, Google Drive and Google Classroom were used to encourage students to discuss the topics they learned in order to relate them to daily life. During the evaluation phase, Google forms was used so that students could reflect on their questioned opinions Antropi Teach, Kahoot, Socrative tools were used in the introduction phase in order to reveal the students' prior knowledge, attract their attention and motivate them. Algodoo was used in the discovery phase to enable students to gain experience and research. In the explanation phase, simulations and videos were used to encourage students to make explanations about their questioned views. In the deepening phase, Google Drive and Google Classroom were used to encourage students to discuss the topics they learned in order to relate them to daily life. During the evaluation phase, Google forms was used so that students could reflect on their questioned opinions From this aspect, the current study can be said to differ from other studies in the literature in which the 5E model was enriched with Web 2.0 technologies and based on structured inquiry.

In the semi-structured interviews, it was observed that the participant students attempted to explain questions by giving examples from their immediate surrounding such as the textbook they were using or their classroom's whiteboard. Also, the students expressed that glossy surfaces reflected lighter and that it was more difficult to read text presented on glossy surfaces. Whilst the students gave the desired answers backed up with examples indicated a satisfactory understanding of the subject, that they gave examples of objects around them may point to the technology-assisted, inquiry-based education

having contributed to their conceptual learning (Mazlum & Yiğit, 2017). In this study, students gained experience in the Algoodo application regarding the reflection of light on rough and smooth surfaces and had the opportunity to learn by researching and questioning with Algoodo. They had a learning experience by concretizing the reflection of light through videos and simulations. They also discussed the situations in which light reflection is encountered in daily life through case studies presented in Google Drive. They elaborated the connection between the reflection of light and daily life in a discussion environment with Google Drive. Kapucu et al. (2021) stated that Web 2.0 applications facilitate learning and can positively affect learning, especially through visualization and the concretizing of abstract concepts which attracts learners' attention, ensuring their active participation in lessons (Avcı Yücel, 2017), and fostering interaction between teachers and students (Chitanana, 2021). In the current study, it was observed that students whose answers were not categorized as sound understanding stated that their eyes became tired quickly when reading text presented on glossy surfaces, but were unable to express the reason behind their observation. The correct response expected from the students was that glossy objects reflected light, which then affected their vision. It was also observed in the literature that students may believe that light is reflected more on smooth, glossy surfaces, meaning that more light is reflected towards our eyes from such surfaces (Mazlum & Yiğit, 2017).

In the examination of the results obtained from second question posed in the study's semi-structured interview, it was observed that the students expressed that the surfaces of the tools differed from each other, and that was the reason why they reflected light in different ways and varying intensity rates, and that they associated this situation with specular and diffuse reflection. This finding also demonstrated that the students were able to adapt the specular and diffuse reflection concepts they had learned in the class to different daily life situations. During the teaching process, students were also allowed to discuss interior photography via Google Drive. It can be said that google drive discussions were effective in students' associating the reasons for using the tools used by interior photographers with the reflection of light. In the literature, diffusing light towards all sides and diffusing light regularly has been explained by the roughness of a surface, and through specular and diffuse reflection (Mazlum & Yiğit, 2017). However, there are certain misconceptions mentioned in the literature that students have, including that light is not reflected from rough surfaces and is only reflected from smooth surfaces (Ayvacı & Candaş, 2018). In the material formed in the current study, an experiment was created to observe reflected rays by sending light to different items for teaching specular and diffuse reflection, and a problem scenario was sent via Google Drive with thought provoking questions added within the process.

In the examination of the students' responses to the third question in the semi-structured interview, it was observed that 50% answered within the alternative understanding category and only one student's response was categorized as having a sound understanding. When the students' answers were examined, it was observed that they thought the umbrella around the floor lamp was used for purposes such as enlightening all parts of the room, reflecting light, and absorbing light, but that a great majority of the students did not relate it to diffuse reflection. Although the students were able to establish the relationship between the purpose of use of the tools used by the interior photographers, who were given the opportunity to be discussed in class, and the reflection of light, they had difficulty in explaining the relationship between the use of hats on the chandeliers and the reflection of light, and they explained it by using misconceptual expressions, that is, by comparing the reflection of light and the absorption of light. From this, the need to discuss different daily life examples in the course emerges.

With the subject of reflection considered abstract, diffuse reflection is more difficult to understand compared to specular reflection, and daily life association included in the lesson was shown to be inadequate and considered to be among the reasons why the students failed to relate it to the situation presented (Kaplan, 2017). Mazlum and Yiğit (2017) found that students mostly talked about light according to illumination and sight, and therefore concluded that students are affected by daily life events when they structure concepts. They also suggested that science textbooks should be reviewed and only activities and examples should be included that will clearly not cause misconceptions for students. Teachers should only use activities and examples which will provide clear scientific

understanding. In the current study, different questions were asked in the teaching material that explicitly required the students to establish links with daily life situations and that were based on inquiry. Also, daily life relationships were attempted to be established in the problem scenarios shared in the 5E model enriched with Web 2.0 technologies based on structured inquiry educational material and in the homework assigned to the students for evaluation purposes. According to Özmen (2003), students' skills to associate information they obtain with daily life demonstrates the education they have received. Lessons in the current study were taught in a way that led the students towards research and inquiry, making the students effectively responsible for their own learning. The questions and problem cases in the course material were prepared to be directly associated with daily life in order to make the students' understanding of the concepts more meaningful and easier to comprehend. However, despite these efforts, the students still experienced some difficulty in associating the diffuse reflection concept with daily life.

It was observed that the students established the relationship between reflection and sleek surfaces, and gave answers such as wet asphalt reflecting more light compared to normal asphalt, and that light is fully reflected on smooth surfaces. Also, they tried to explain this situation with examples related to daily life; as an example, some of the students likened wet ground to the reflective characteristic of snow. There have also been mentions in the literature that surfaces which are smoother and glossier reflect more light (Mazlum & Yiğit, 2017). However, some studies in the literature have stated that students can have the misconception that diffuse reflection will occur on surfaces which are smoother and sleeker (Kaplan, 2017).

In the material prepared in the current study, especially at the beginning of the course, the teacher attempted to draw the attention of the students with examples from daily life. The students made observations through experiments performed in the exploring stage, whereby the process was enhanced using Algodoo software and simulations as specular and diffuse reflection is an abstract subject. With Algodoo, it is seen that the light coming to the plane reflective surfaces is reflected at the angle it comes from. Using the Algodoo program, two of the laws of reflection; It can be explained that "the angle of the incident ray with the normal is equal to the angle of the reflected ray with the normal" and "rays arriving in the normal direction are reflected back in the direction they came from." (Özdemir & Çoramık, 2021). In order to overcome the difficulties experienced in teaching concepts in physics lessons, attempts can be made to concretize abstract concepts using simulations like Algodoo (Gregorcic & Bodin, 2017). It was considered that especially the experiment performed on specular and diffuse reflection, as well as the problem scenario sent to the students via Google Drive, were affective in terms of the answers given by the students. Cloud technology plays an important role in today's education sector in terms of supporting the learning process, and therefore on the interaction between educators and learners, the usability of applications, and their integration into education (Sadik, 2017).

In the examination of the students' answers to the semi-structured interview questions, it was observed that the students tried to give examples from daily life, and to describe the events based on their causes and effects. For example, they mentioned the surface of the current textbook they were using and the surface of the classroom's whiteboard as examples of glossy surfaces. They also attempted to diversify their examples according to their surroundings and associate the subject with daily life, which demonstrated that they had learned the subject and had become skillful at integrating new situations. It was observed that the students were able to differentiate between rough and smooth surfaces, and that light was reflected differently on rougher surfaces.

It was also observed that the students were successful in illustrating specular and diffuse reflection. In examining the students' drawings, it was observed that specular and diffuse reflections, according to the students, changed based on the surfaces of objects. The students drew smooth surfaces using a straight line and wavy lines for rough surfaces; whilst they demonstrated that incident and reflected rays from smooth surfaces were symmetrical to each other, and that diffuse reflection was presented as randomly scattered rays. The students' illustrations were seen as being linked to the students having used Algodoo, together with the animations and simulations used within the educational process (via Google Drive). It was also observed that straight lines were used for smooth surfaces in Algodoo, whereas wavy lines were used for rough surfaces whilst discussing specular and diffuse reflection: As

such, it may be said that this approach was affective in terms of the drawings presented by the students. When the students' drawings were grouped according to their answer category, it was observed that the drawings of five students were included in the sound understanding category, whilst one student's drawing was included in the partial understanding category. The use of Algodoo allowed the students to embody the abstract light concepts, which may explain the students' illustrations about specular and diffuse reflection being placed in the sound and partial understanding category. Gregorcic and Bodin (2017) stated that simulations prepared with Algodoo software in their study made embodying the concepts and learning the concepts much easier. In a study published by Özer et al. (2015), the thoughts of sixth-grade students were examined on their use of Algodoo software in learning about "power and movement" and "light and sound"; with students having stated in their interviews that Algodoo software embodied the concepts they had learned, and contributed to their learning of concepts and improved conceptual learning. Gregorcic and Bodin (2017) concluded that the prospective teachers in their study considered Algodoo, which was used to support their integrated teaching knowledge, to be interesting, useful, entertaining, and didactic. Also, that Algodoo software can help contribute to students' visualization of a subject, embodying abstract concepts, and to learning permanently and meaningfully. With the Algodoo application, students can learn about the reflection of light on smooth and rough surfaces by actively participating in the process when they draw a ray coming from a laser on any surface, in other words, the path followed by the reflected ray. Students can receive instant feedback about the drawing they have made in the Algodoo application and can repeat their drawings many times. In this process, students learn by exploring and investigating the path of light arriving at smooth and rough surfaces. The reflection of light questions the law and structures it in their minds. In a study by Sertkaya (2018), it was reported that the 5E model supported by Algodoo software was effective on the academic success of students studying a unit on simple machines. Also, in the problem cases provided to the students in the current study about specular and diffuse reflection and the laws of reflection, the experimentation and the created models (periscope) were effective on the students' conceptual understanding.

Kaplan (2017) stated that different methods and techniques are needed in order to effectively teach the concepts of specular and diffuse reflection, as these are generally considered to be abstract concepts. In a study by Mazlum and Yiğit (2017), it was found that participant students thought that specular reflection occurred when surfaces were drawn as a straight line and that diffuse reflection occurred when drawn as a wavy surface; that is, the students have thought that specular and diffuse reflection was related to how the surface was drawn. When the students were asked why they had drawn the surfaces in that way, they responded that they had learned it like that from their course, and that it was also illustrated that way in their textbooks.

5.Conclusions and Recommendations

In the current study, it was concluded that the 5E model enriched with Web 2.0 technologies based on structured inquiry was effective in remediating many of the students' alternative conceptions, and also in enhancing their conceptual understanding of "light." The model was also considered to be effective in helping the sixth-grade students to establish links between scientific concepts and daily life events. However, some students used misconceptions when associating the reflection of light with daily life examples such as hats on lampshades or the danger of driving on wet roads. In this context, it can be prepared with an activity that will give students the opportunity to gain experience with more and various examples during the inquiry process. Within the scope of this research, Antropi Teach, kahoot and Socrative, Algodoo, simulation and Google Drive were used. Other technologies, such as virtual experiment laboratories, can be integrated into lesson plans to help students relate the reflection of light to daily life. For other abstract science subjects that students find challenging, activities based on the 5E model enriched with Web 2.0 technologies based on structured inquiry could be developed and their effectiveness analyzed accordingly.

Through focusing specifically on the identified alternative concepts, the daily life examples, and inquiry on light concepts such as reflection, refraction, mirrors, lenses, sight, image, and shadow, contextual learning activities enriched with different technologies could be developed and their effectiveness also analyzed. In this study, students actively participated with the Algodoo application

and learned the reflection of light on smooth and rough surfaces and the laws of reflection. It was an opportunity for the students to observe the reflection of light, the angle of the incoming light and the reflected light with the normal, as soon as they drew concretely and accurately. Therefore, it can be recommended that teachers and researchers use the Algodoo application when teaching the reflection of light.

Since the web 2.0 tools used in this study were selected by taking into account the characteristics and infrastructure of the school where the application will be implemented, the applications were carried out as planned. Therefore, researchers who will conduct similar research should take into account the infrastructure facilities of the place where the study is planned to integrate technology into the teaching process.

In this study, students' preliminary knowledge about the reflection of light was determined and students were enabled to connect with the subject and become motivated through Antropi Teach, Kahoot and Socrative tools. Other researchers can also use Antropi Teach, Kahoot and Socrative tools to help students make connections with the subject, motivate them, and reveal their prior knowledge during the inquiry-based teaching process.

Finally, structured inquiry-based teaching was planned because the students participated in the teaching process for the first time according to the IBL approach. The teacher guided the students at every stage of the inquiry process. Thus, the students did what was expected of them in accordance with the inquiry process. Based on this, it may be recommended to plan the teaching process according to the structured inquiry approach in groups of learners who will gain experience in the IBL process for the first time.

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Acknowledgement

This study was produced from Muzaffer ÖZER's master's thesis and was supported by Giresun University Scientific Research Unit with the project code "EĞT-BAP-C-140316-14".