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Designing Technological Content Curriculum Materials Supported by Logger Pro: An Action Research

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Abstract

This study aimed to develop teacher guide material for students who are uninterested in physics lessons in high schools. In this context, activities in which measurements are made with Logger Pro sensors, which are computer-applied with the innovative technology in 10th-grade optics subjects, have been developed. The study was carried out with 134 students at the school where the researcher taught in the spring semester of the 2019-2020 academic year. In the research, action research method was used. The action researcher personally intervened in the process at every stage of the implementation process to ensure that the teaching material became applicable. Interview, observation and student documents were used to test the hypotheses of the research. The research process was carried out in six stages: Logger pro-supported experimental application, simulation application, analogy application, associating with daily life, modeling and evaluation. Within the scope of action research, qualitative and quantitative methods were used together. Based on research findings; it has been revealed that the developed material is applicable in all types of schools where the 10th-grade physics course is taught, is understandable, overlaps with the content of the curriculum, and has an evaluation competence that can reflect the learning outcomes of the curriculum. As a result of the applications, the students' group success, understanding levels and application skills in the process improved positively in the five observation steps, but the attitudes and motivations of the students with high academic achievement were negatively affected. The reason for this is that it is seen as a waste of time for successful students to devote too much time to students with low academic success and learning together in order to advance group success. It was determined that the motivation and interest of the students reached the highest levels in the stages where the contents of the studies were supported by simulation and video.

Keywords: Education and Technology, Virtual Computing Laboratory, Technological Content Material, Science Education

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INTRODUCTION

Teachers should make effective use of technological developments in order to be able to apply contemporary teaching strategies and to bring their scientificity to the forefront in educational settings. Because the effective use of instructional technologies in the teaching environment helps students to be drawn to the learning center. As a result of this situation, the taught subjects and concepts become interesting and understandable as a part of the students' lives (İşman, Sevinç, & Altık, 1998; Hırça, Çalık & Akdeniz, 2008). Considering that raising individuals in line with the needs of the society is one of the main objectives of education, it is an important need to benefit from educational technologies by designing educational environments that are equipped to meet technological needs and in the quality required by information societies (Aydın, 2003). It is thought that teaching environments designed with contemporary approaches such as computer-aided laboratory applications can support collaborative learning, active learning and individual learning processes (Sultan, 2010).

In the courses within the scope of science, it is seen that many experimental applications that do not coincide with real-life are used in the process of gaining students the acquisitions in the curriculum (Zhao, Wang, Lv & Liu, 2016; Wang, Liu, Lu, Zhang, Ma, Wang, & Sun, 2018). Within the scope of the data obtained from 342 teachers, 7541 students, and 1500 students' parents during the physics curriculum prepared in Turkey in 2011; the lack of teacher guide material that will contribute to the teaching systematically (77%), the inadequacy of the application that will contribute to the measurement and evaluation (52%), the need for experimental application (52%), and the students' difficulties in understanding the working systematic of the technological tools around them (55%), emerged as a major problem (MEB, 2011). This situation, while explaining the importance of the national physics curriculum; in order for meaningful learning to take place in the physics course; it is emphasized that it is necessary to design learning environments where the validity of students' prior knowledge is checked, the contexts they encounter in real life are based, the student is always active mentally, mostly physically, and conceptual change is achieved. In addition, it is pointed out that these learning environments should provide opportunities for students to reinforce the newly learned concept (MEB, 2007; MEB, 2013).

Technology-Assisted Collaborative Learning

Cooperative learning is a process where group members learn together, not competitors, while the learning environment is designed by the teacher. Groups should be designed to consist of 4-6 students in order for effective learning to take place (Bruffee, 1999). In order for the learning process to be completed successfully, all the participants in the group must take active duty and create a learning circle within the division of labor, and all members must reach their learning goals altogether. When a member of the group experiences a lack of learning or performs a wrong learning, this reflects negatively on the evaluation grades of the other group members (Dillenbourg, Järvelä & Fischer, 2009). One for all and all for one is based on interaction. It is essential that interaction is effective in cooperative groups and that this interaction contributes to the course objectives (Bruffee, 1987). The four basic elements of active learning; listening, speaking, writing and communication skills are effectively presented in collaborative groups (Larusson & Alterman, 2009). Technology-assisted learning in collaborative groups is compatible with classic collaborative group learning in terms of the number of members in the group, the quality of the interaction and learning goals. Due to the intriguing effect of technology on high school students, significant problems are experienced in sharing tasks and responsibilities in learning applications with fun technological content (Kitchen & McDougall, 1999). In order to maintain qualified learning systematic in technology-assisted collaborative groups, it is important for teachers to share responsibilities and co-ordinate feedback with group leaders in an effective communication environment (Lee, Tsai, Chai & Koh, 2014). Systematic implementation of technology-assisted teaching practices in collaborative groups significantly limits the distraction and misuse of technological tools in individual practices (Jermann, Soller & Muehlenbrock, 2001). Students who can use technology effectively and efficiently guide students who have less interest and ability in the field of technology in the process, and lead these student groups to use technological applications more effectively in line with instructional goals

(Lipponen, 2002; Higgins, 2012). In this context, the importance of both learning in collaborative groups and using technological applications together in order for active learning to take place in a qualified manner becomes prominent.

Turkey Qualifications Framework (TQF), science and competencies in technology applied as a cooperative among students, has become one of the main objectives of submission within the scope of secondary education programs and lifelong technology education in promoting physics education (MEB 2018). In addition, researchers and action practitioners working in the field of physics education emphasized the need to use physics and technology in coordination among student groups in order to contribute to physics education practices (Karacop, 2017). However, despite the emphasis on the necessity of using physics and technology in cooperation effectively in high schools, it comes to the fore that teacher and student guide materials are not developed at a sufficient level in national and international practices (Kan, 2013; Kilmer & Khrehbiel, 2019).

Logger Pro Supported Applications

Logger Pro technology is an interactive application for data acquisition and analysis, which makes advanced precise measurements with the help of computers and interfaces. It is very easy to install on the computer and can be performed in as little as a minute. Logger Pro interfaces and sensors are important and high-level components of physics course and laboratory applications. It contains sensor measurement tools that can design experiments within the scope of science in high schools. 100 measurements can be made per second, and they can be presented visually in tables and graphs. The data obtained as a result of the measurements can be presented as word or excel (Vernier, 2021). In Logger Pro training technology, eighty sensors can be attached to an interface separately and measurements can be made. The data obtained as a result of the measurements can be adjusted manually or automatically. A relationship can be established between the graphics presented automatically as a result of the measurements and the graphics that are estimated by hand by the people who make the measurements (Milner-Bolotin & Moll, 2008). With the help of Logger Pro technology, which has started to take an important place in experimental measurements in science education, video recordings of the measured data can be created, and the comparative results of the data in desired time intervals can be evaluated by controlling the speed settings of the video recordings (Setiyani, Kristiyanto & Rondonuwu, 2019). Slopes, tangents and integral values in graphs can be found both by calculating and measuring, and the obtained data can be easily printed (Milner-Bolotin, Kotlicki & Rieger, 2007).

Since the individual use of high-tech equipment has recently become popular, the importance of experimental applications that require high-tech applications where measurements based on sensors that incorporate this technology are required has gradually increased in the field of education (Supalo et al., 2007; Supalo et al., 2014; Linn, Slotta & Baumgartner, 2000; Zhang et al., 2019; Zhao, Tong, Chen & Peng, 2019). For example; According to a study conducted at North Carolina State University, educational institutions whose infrastructures have not developed sufficiently can access powerful computing services with an application for educational activities, which was founded in 2004 under the name of Virtual Computing Laboratory (VCL) and equipped with open source codes in 2008. It has been ensured that applications that cannot be installed separately on the computer can be used over a common infrastructure (Averitt et al., 2007; Virtual Computing Lab [VCL], 2020). Therefore, without incurring extra hardware cost in educational institutions, existing and underdeveloped technological infrastructure and applications requiring performance can be run on a common infrastructure without installing separately on each student's computer. Such applications provide information sharing, functionality and cooperation in electronic environment as well as traditional education (Dong, Zheng, Quiao, Shu, & Yang, 2009; Supalo et al, 2007).

In experiments with VCL applications, a significant reduction in errors in measurement data is achieved and an excellent learning experience is provided for students in physics, biology, science and chemistry (Kilmer & Khrehbiel, 2019). VCL technology allows the course instructor to collect experimental data using electronic probes and displays this data in a spreadsheet or graphical form when paired with Logger Pro software. Thanks to VCL, every student has a copy of the Logger Pro software and can analyze data outside of the classroom while working in small groups or alone (Erickson & Cooley, 2007). Traditionally, Logger Pro or similar technologies can be used effectively in laboratories or in small groups that require collaboration that each group of students can access and experiment independently (Milner-Bolotion & Moll, 2008).

Simulation Applications

Studies are carried out to enrich the content of the subjects with computer-assisted activities in order to present abstract subjects within the scope of science effectively in the classroom environment. In this context, one of the applications carried out in classrooms is simulations. Simulations are expressed as models of structures that exist in daily life and cannot be observed (Okuda et. Al., 2009). Physics, chemistry and biology courses within the scope of science courses have content that requires physical and mental application. In this context, many methods have been used in researches in order to provide effective teaching. Effective and successful results have been obtained from simulation applications especially in the teaching of abstract subjects (Vogel et. al., 2009). By using simulation applications, science subjects with abstract content are taught in a shorter time, in a more qualified way and student success increases significantly (Hofstein & Lunetta, 2004). Simulation applications can be used effectively in science subjects that cannot be experimented, as well as as a support to better understand the subject in experimental subjects. It is possible to carry out variable measurements, instant feedback content and low cost activities in simulations (Windschitl & Andre, 1998).

Science education in which computer-aided measurements are made; since it is a free application that includes communication and cooperation applications designed for students in all types of schools, it contributes to the school budget since it does not have expenses such as renovating the technological infrastructure, stationery, printing and photocopying costs. Technological tools, in which measurements are made with sensors, have been used effectively within the scope of the research, as they have great potential in terms of educational activities, together with teaching, learning, social sharing, professional development, keeping records and more. Realization of being able to win universities in Turkey through multiple-choice questions, for experimental applications, because of the lack of sufficient physical equipment in schools and the crowded classes, simulations were used in a short time and in order to support experimental applications. Interactive learning in cooperative groups, which is the most effective way of active and collaborative learning, because of the sufficient number of experimental sets and Logger Pro measurement sets for the groups, interactive cooperative learning groups were formed and the process was carried out in order to reach all students in a short time.

The Aim of the Research

Developing alternative and interesting materials for students who have a negative attitude towards abstract subjects and who fail to solve problems in physics course will make significant contributions to the physics teaching process. In this context, the aim of the study is to develop an experimental applied teacher guide material, in which measurements are made with computer-applied Logger Pro-supported sensors, which are supported by innovative technology in secondary education physics 10th grade optic topic, for students who are not interested in the lessons in the process of experimental applications in the classroom in science teaching. Within the scope of the purpose of the research, answers to the following questions were sought:

- Technology supported teacher guide material developed and applied by an action researcher on optics, which is one of the abstract topics in physics course; is it at a sufficient level in terms of applicability, understandability, overlapping with the content of the curriculum and evaluation categories according to the teachers' opinions?

- Are the students' active interactions with the course content and sharing of responsibilities at a sufficient level during the implementation of the action research based teacher guide material supported by Logger Pro technology supported tools?

- After the application of the action research based teacher guide material supported by Logger Pro technology-supported tools, how does the level of students' associating daily life with contexts develop?

- What is the effect of action research-based teacher guide material, supported by Logger Pro technology-supported tools, on students' academic success?

METHOD

Research Strategy

In this study, liberating / developing / critical action research method which is one of the action research types was used. The action researcher personally intervened in the process at every stage of the implementation process to ensure that the teaching material became applicable. The purposes of this kind of action researches are to discipline the practitioner to gain new knowledge, skills and experiences, as well as to develop a critical perspective towards practices. Action researcher will perceive his in-class systematic studies as a chain of the problem-solving processes and shape the next steps according to this systematic. The main thing in this type of research is to find the right point between theory and practice with the questioning and critical point of view and to present the material suitable for the class level to the service of students and material practitioners (Yıldırım & Şimşek, 2008). In this type of research, the action researcher should also give the application material its final form by performing data collection in classroom observation and application processes by using different techniques (Berg, 2001).

Within the scope of this research type; the theoretical point of view was systematized and planned and implemented as a process in which the researcher was personally involved in the process, developed a critical and questioning perspective at every step of the process, and gave the final form to the teacher guidance material by obtaining the data himself and acting on his analysis.

With the implementation of new physics curriculum in Turkey, instead of teachers teaching lesson subjects with classical methods in classrooms; they are asked to teach courses supported by using local opportunities and innovative technologies (MEB, 2018). In this context, due to the nature of the research, it was thought that action research was appropriate because it is aimed to develop systematic solutions with local resources for the problems faced by a teacher in a classroom where he is working and to create solutions for students to learn better. Hendrics (2006), suggests that parameters such as teaching situations, researcher's characteristics and research questions should be taken into account when deciding which quantitative and qualitative data will be used in action research. Within the scope of the study, both data sets were used in flexible conditions, considering that the researcher has sufficient academic skills in the interpretation and analysis of quantitative and qualitative findings, and that using quantitative and qualitative findings in the content of the teaching will contribute positively to the teaching process.

Participants

In action research, the sample can be expressed as students who are in the teachers' own classes (Palaganas, Sanchez, Molintas & Caricativo, 2017). In this study, the sample group was determined as five classes from the 10th grade at Turkey Trabzon Araklı Mehmet Akif Ersoy Anatolian High School, which is the teacher's own student group. The sample data has been presented in detail in table 1.

Table 1. Detailed representation of the sample group within the scope of the study

Gender	Rate (%)	Departments		Interviews
		Science	Maths	Teacher
Male (N=62)	46	35	27	13
Female (N=72)	54	39	33	2
Total (134)	100	74	60	15

Data Collection Tools

Observation

In the research, structured field work, one of the types of observation, was used. In this type of observation, the researcher, as an external observer, observes the process with the help of a structured measurement tool (Yıldırım & Şimşek, 2008). In the research, the researcher made observations by participating as an external observer in order to evaluate the development and implementation process of the Logger Pro supported guide material. As a data collection tool (M-SCOPS, 2003), it was used as the "Structured Observation Form (SOF)", matching the research content. With the SOF, the positive and negative aspects of the application of the guide material in the classroom were coded on the observation form prepared in advance for the purposes. The observation data obtained from the teachers were classified systematically and associated and combined with the findings obtained from the interview data according to their meaning integrity, grouped according to the content status and evaluated.

Open Ended Questions

Open-ended questions are used in international exams such as PIRLS, TIMSS, PISA and ICILS. Given the failure of Turkey in the international exams, their teaching practices in order to eliminate this deficiency and benefiting from open-ended questions as a measurement tool to detect learning qualifications in activities related to education should be preferred (Cangüven, Oya & Sürmeli, 2017). Although creating and evaluating open-ended questions is difficult and takes a long time, it also enables the measurement of advanced cognitive skills, performance and ability by providing the respondents with the opportunity to express themselves freely and comprehensively (Ozuru, Briner, Kurby & McNamara, 2013). The most important problem of open-ended questions is objectivity in evaluation (Schonlau & Couper, 2016). In the scope of the research; In order to determine the competencies of students in learning activities at a high level, students' knowledge, skills, performance and abilities were measured with the help of open-ended questions at all stages of the application. Collaboration was made with two physics teachers who are experts in their fields while determining and structuring open-ended questions.

Semi-Structured Interview

Semi-structured interviews are the continuation of the process with a flexible interview form by reconfiguring the questions according to the answers given by the participants. In the process of obtaining data, the mimics and behaviors of the participants can also guide the process (Schmidt, 2004). Within the scope of the study, the effectiveness and quality of the technology supported teacher guide material was increased by benefiting from the opinions of physics teachers who taught the subject of optics in their classrooms. Statistical data were obtained by evaluating the opinions of the participating teachers. The difficulties experienced in the applications and the solutions developed were categorized and interpreted. Throughout the process, different questions were asked according to the answers of the participants and the process was tried to be described completely.

Five open-ended questions were prepared for the semi-structured interview. Interview questions were submitted to a total of three expert opinions, one academic and two teachers in the field of science. After the expert opinion was obtained, one question was removed from the items and the interview questions were reduced to four. A pilot study was conducted with a participant in order to determine the functionality of the interview questions. In the pilot application, it was concluded that there was no problem regarding the functionality of the questions and it was a data collection tool that served the purpose of the research. Semi-structured interview questions are shown below.

What do you think about the applicability of this teaching material in classrooms where you taught optics?

When you apply this teaching material in your classroom, what do you think about the students' understanding of the instructions and practices?

What do you think about the compatibility of the material with the learning outcomes in the curriculum?

What do you think about the contribution of the material to students' problem solving?

Validity and Reliability

Interview transcripts were presented to the opinion of two educators who were experts in their fields, and the findings were analyzed together. The codes created by the researcher were gathered under themes that will provide meaning integrity and presented in tables by combining them. Within the scope of the study, various measures have been taken to ensure credibility and transferability. In this context, some parts of the answers given by the participants in the interviews were presented in the findings section in order to provide both validity and reliability as well as the reliability and transferability of the study. Long-term interaction, depth-focused data collection, diversification, expert review, and participant confirmation were made in order to ensure the internal validity of the research, namely its credibility (Onwuegbuzie & Leech, 2007). In addition, the stages followed in the study were reported in detail. However, consistency analysis was used to ensure internal reliability, and confirmation analysis was used to ensure external reliability (Whittemore, Chase & Mandle, 2001). However, one month after the study was completed, the tables were re-examined and Miles and Huberman (1994) calculated the percentage of compliance. According to Miles and Huberman (2015), the compliance percentage value of a study should be at least 70%. As a result of the investigations carried out within the scope of this study, Miles and Huberman compliance percentage value was found to be 88%. “What do you think about the applicability of this teaching material in classrooms where you taught optics?” 91% for the question, “When you apply this teaching material in your classroom, what do you think about the students' understanding of the instructions and practices?” 85% for the question, “What do you think about the compatibility of the material with the learning outcomes in the curriculum?” 89% for the question and “What do you think about the contribution of the material to students' problem solving?” for the question data, it was found to be 90%. Considering all the processes mentioned above, it can be stated that validity, reliability, credibility and transferability measures are provided at a sufficient level in the analysis of the data.

In the evaluation phase of open-ended questions, the names of the students who were cross, unaware of each other and scored were closed and scoring was performed, and objectivity was achieved by eliminating the effects of halo effect, orientation towards the center, range effect and inconsistency in the evaluation, and scorer bias was tried to be minimized.

Analysis of Data

Analysis of semi-structured interview transcripts was done by content analysis. In addition, some of the comprehensive, original and prominent answers were directly presented as an example. Some abbreviations were made while giving the interview findings. These; T1: first teacher, T2: second teacher. In content analysis, the data obtained through interviews and observations are analyzed in four stages: (1) coding the data, (2) finding codes, categories and themes, (3) organizing codes, categories and themes, (4) defining and interpreting the findings (Eysenbach & Köhler, 2002; Miles & Huberman, 1994). These four stages were followed within the scope of the research.

Descriptive analysis and analytical scoring key were used in the observation findings. In this context, in line with Merriam (2002) suggestions, the behaviors to be observed before starting the classroom applications of the Logger Pro supported guide material were determined and a checklist and rubric was developed according to these behaviors. The Findings section was interpreted by establishing cause-effect relationships in line with the researcher's experience. The data in the observation findings obtained from (M-SCOPS, 2003) within the scope of the study were interpreted and presented. The observation stages consist of five steps in total. Each stage; It was evaluated as "1 = very unsatisfactory, 2 = unsatisfactory, 3 = moderate, 4 = sufficient, 5 = advanced". Competence levels are made by taking into account the behaviors in the evaluation processes in table 3.

Before analyzing the open-ended questions, three physics teachers together with the researcher prepared draft answer keys and score scale. The scores that can be given to each stage are noted in detail. Hiding identity and mixed question evaluation methods were used for scoring teachers to be able to evaluate them regardless of the difficulties of the items and the characteristics of the students. As a result of the One-sample t test analysis over 100 points for the upper score of open-ended questions, it was determined whether there was a significant difference according to the passing grade, which is 50 points.

Development Process of Teacher Guide Material

There are five 10th grade classes in the school where the researcher teaches. Each of these classes has two hours of physics lessons per week. Students learn physics lessons by coming to the physics laboratory. Since the school is a school that accepts students with success ranking, there are high-level students as academic success. In the last fifteen years, the rate of students who graduated from school and qualified to study at universities has been 92% on average. In the physics laboratory; there are ten long experiment tables, teacher's desk central experiment control panel, smart board, Logger Pro experiment sets, Nova experiment sets, mechanical, optical, electrical and magnetism experiment sets and advanced technology computer aided sensor measurement devices. Physics laboratory is an educational environment that is equipped to provide education to 40 students and is only used by the researcher teacher.

Since the learning environment is the physics laboratory, students are ready for the course in the laboratory by taking the course materials related to the physics course before the lesson starts. There is no specific seating arrangement in the physics laboratory, students can sit wherever they prefer. When students come to class, they usually come as a group of friends, their speaking tone is low, and they have a respectful and affectionate approach to communication. They use body language and communication language that are respectful to physics teachers; often a finger is raised when asking for the right to speak. While the theoretical part of the physics course is covered, students rarely ask questions and ask for a say. The teacher's allowance of partial flexibility while forming the groups caused a short-term chaos in the classroom. After the teacher intervened and gave the groups their final form, the groups started to merge within themselves. Intensive discussions took place among the group members in the selection of the group president and group spokesperson. There were problems in combining different ideas in solving the questions in the guide material distributed to the students. Due to the willingness of each student in the use of Logger Pro supported sensors, there were intense discussions among the group members. Intense support was requested from the teacher in drawing and interpreting the graphics. The effect level of the group scores to be obtained as a result of the activities on the lecture grades was frequently questioned, and the reflection of group scores to all students as individual scores was criticized by the students.

Within the scope of Logger-Pro supported applications, logger-pro sensors and interfaces that can make accurate measurements at the level of 100 measurements per second while making measurements in laboratory experiments and which can be displayed graphically by establishing a relationship between the measurements made, and that can present the obtained data with tables and graphics on the computer screen have been used effectively. The sensors and interfaces used within the scope of the research are accepted as the most advanced version of the sensors and interfaces used in technological equipment in daily life in the laboratory environment. A section of the light sensor and interface used within the scope of the research is shown in figure 2.

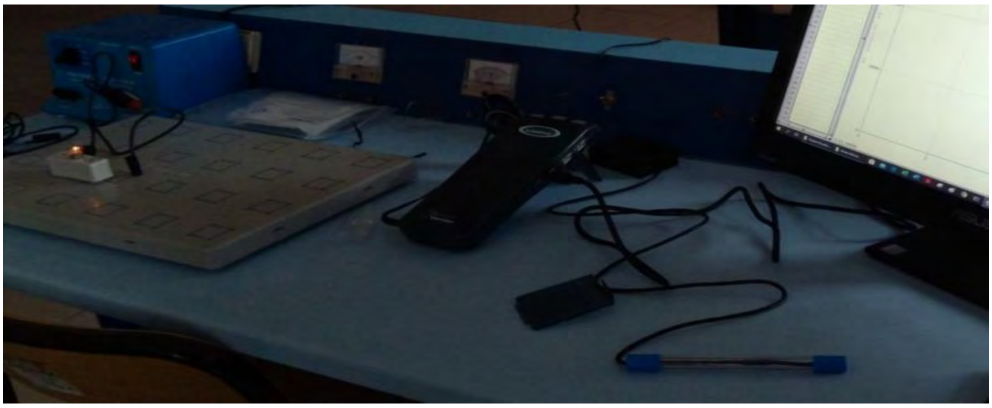


Figure 1. Logger-pro interface and light sensor used in measurements

Basic optical concepts within the scope of the research; 2018 in Turkey physics curriculum content and descriptions are shown in table2.

Table 2. Logger-pro interface and light sensor used in measurements

Teaching application	Detailed information on the purpose and application process
Goal	Establishing a relationship between the concepts of luminous intensity, luminous flux and enlightenment.
Sub goals	- By doing experiments or simulations, a relationship is established between the concepts of enlightenment intensity, light intensity, luminous flux. - Mathematical models related to the concepts of luminous intensity, luminous flux and enlightenment are utilized.
Explanation	Mathematical calculations are not made.
Conceptual teaching objectives	Luminous intensity: It is an indicator of the amount of light emitted from the source per unit time.
	Enlightenment intensity: The unit is the indicator of the light intensity on the surface.
	Luminous flux: The light energy that a light source drops on a certain surface per unit time.

While preparing the teacher guide material, the information in table 1 was taken into consideration. Within the scope of this research, Mills (2003) action research was applied by shaping the cyclical structure of the environment according to the physical and academic readiness of the students. This process has been implemented as in figure 1.

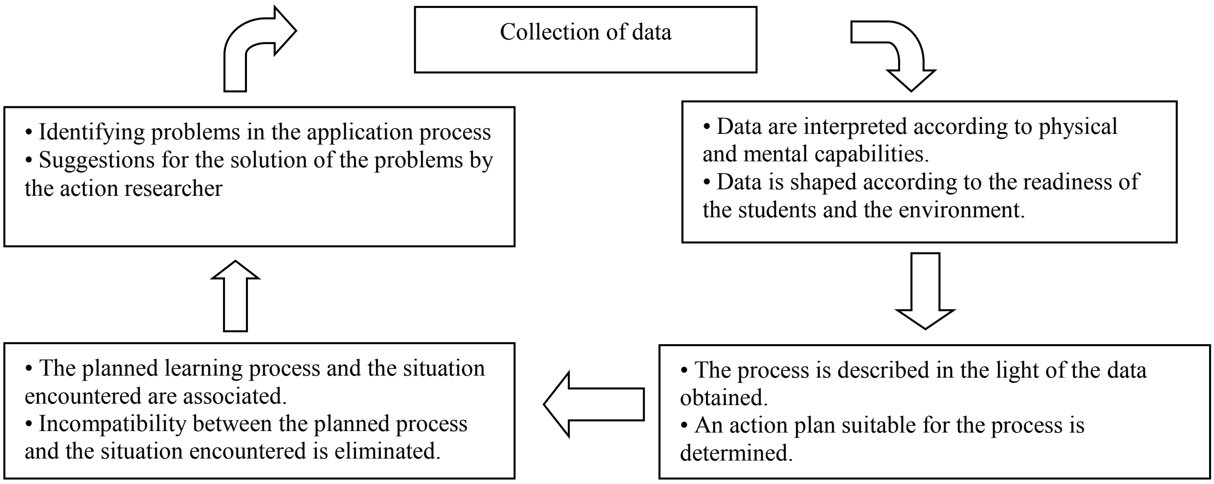


Figure 2. Action research application steps applied within the scope of the research

The research carried out in Turkey; in the 2019-2020 academic years, it was applied to 134 students in the 10th grade for sixteen class hours. In the process of teaching the basic concepts of optics, the activities to be applied in the teaching material were decided based on three different teaching systematic developed by Rogers (1995), Gladhart (2001) and Russell (1996). These stages and the developed teaching material are shown in table 3.

Table 3. The development process of teacher guidance material

Stage	Rogers (1995)	Russell (1996)	Gladhart (2001)	Application in Teaching Material
1	Awareness of innovation	Preliminary information	Preliminary information	Analogy application
2	Attitude to new knowledge	Teaching the process	Adoption	Experimental application with Logger Pro support
3	Prediction of new knowledge	Making sense of the process	Adaptation	Simulation applications
4	Application of new knowledge	Remembering the concept and a sense of competence	Identification with yourself	Relating activity with daily life
5	Evaluation of applications	Application in new situations	Ability to apply in a new situation	Modeling applications
6		Context-based innovative applications		Evaluation questions

In Table 3, alternative representations of the stages that can be applied in new teaching systematics in the literature are presented. Within the scope of this research; Using these three teaching systematics, activities were developed with the direction of the action researcher and a new teaching material that could be applied in the classroom was introduced.

While developing an experimental applied teacher guidance material for the 10th grade in high school physics, which is supported by innovative technology in optics, and where measurements are made with the computer-applied Logger Pro supported sensors; The teaching systematics developed based on three different teaching systematics developed by Rogers (1995), Gladhart (2001) and Russell (1996) is shown in table 4 in four stages.

Table 4. Experimental application stages where measurements are made with Logger Pro supported sensors

Application stages	Evaluation process
Logger Pro	By setting up a Logger pro supported setup, making measurements and drawing graphics by processing them on the table. Interpretation of the values and graphics
Simulation	Interpreting the studies obtained with experimental applications supported by simulation activities
Analogy	Determining the situation of demonstrating the concrete resemblance of the information learned with the help of analogy map
Associating with Everyday Life	Interpretation of the results obtained with three application steps
Modeling	Questioning applications by developing mathematical and mental models
Evaluation	To reveal the level of association of daily life problems with the gains in the activity processes in the application stages

As seen in table 4, it is aimed to carry out activities that are at the center of the learning process of students and that can contribute to the learning competencies of all students.

FINDINGS

Observation Findings

The process was observed by the action researcher in order to determine whether the teacher guidance material developed as a result of the six-stage applications meets the teaching competencies and the observation findings in a classroom are shown in Table 5.

Table 5. Observation findings obtained during the six-stage action research-based laboratory implementation process.

School: Turkey Araklı Mehmet Akif Ersoy Anatolian High School Teacher: Action Researcher Class: 10 / A Date: (05.11-19.11.2019)
Time: Four lesson hours

Observed Behaviors	Groups and Ratings						Average Score
	1	2	3	4	5	6	
Collaboration and interaction in the experimental implementation phase with Logger Pro support	4	4	5	4	4	5	4,3
Cooperation and interaction during the simulation implementation phase	5	5	4	5	5	4	4,7
Cooperation and interaction at the technology-supported analogy implementation phase	4	3	3	4	3	4	3,5
Cooperation and interaction at the stage of relating to everyday life	3	3	3	4	3	3	3,2
Collaboration and interaction in the modeling phase	3	4	3	4	3	4	3,5
Collaboration and interaction in the evaluation phase	4	4	5	4	3	4	4,0

Student behaviors during the lesson process	Since it was reminded that group and individual evaluations will be taken into consideration from the first week, the division of labor within the group was carefully done There is intense pressure on the desire to use mobile phones. There are difficulties in interpreting analogy. There are discussions in the group about the quality of the appropriate video. Everyone was actively forced to take responsibility in groups There are serious problems and discussions about model building. During the simulation phase, students have fun.

As can be seen in Table 8, during the six-stage action research-based laboratory applications process, the cooperation and interaction competencies of the students in experimental applications and simulation applications supported by Logger Pro are very good, and in the process of cooperation and interaction at the stage of associating with daily life, partial inadequacies have been observed.

In the first stage; all groups showed an advanced level of performance in the stages of setting up Logger pro supported setup, making measurements, drawing graphics by processing on the table, and interpreting the values and graphics. Because the interaction of the 3rd group and the 6th group members was shared among all group members homogeneously, they got full points. Other group members could not share their duties and responsibilities homogeneously. It was observed that some group members were very active while others remained passive.

The second stage, "Cooperation and interaction in the simulation application stage", was carried out in the computer-technology laboratory classroom of the school for one class hour for each branch. It was observed that all student groups took active responsibilities throughout the applications and carried out their duties sincerely and questioning. It was observed that one student each in the third and sixth groups tried to open other programs on the computer during the simulation applications and negatively affected the motivation of the other group members.

The third stage, "Cooperation and interaction in the analogy application stage" was a stage that students encountered for the first time and had difficulties in understanding and interpreting. Groups of students, who had to fill in the analogy map within a period of 20 minutes, sometimes moved away from the context and applied to different practices. Although the members of the 2nd, 3rd and 5th groups, who got 3 points, were very interested in the beginning of the activity, after the seventh minute, they started to be interested in the next parts of the worksheet, and some group members were observed to have discussions and communication with other group members on different topics. Although the 1st, 4th and 6th group members, who got 4 points each, followed the process very well, they chose to produce individual solutions instead of interaction within the group.

The fourth stage, "Cooperation and interaction in the stage of relating with everyday life" is the stage in which the student groups have the lowest average score. This stage includes the URL addresses of the students previously determined by the teacher; it is the stage that they should follow and interpret by taking into account the concepts of light intensity, illumination intensity and luminous flux. 4th group members carefully followed the light events in both video images and took notes under three subheadings. It was observed that the students in the other five groups made comments about the off-topic visuals while watching the video recordings and moved away from the context.

In the fifth stage, "Cooperation and interaction in the modeling stage", it was aimed to question the applications in the previous stages by developing mathematical and mental models of the student groups. Group 1 and group 3 members acted individually and filled in the blanks on the worksheet. Fifth group members disrupted the integrity among themselves by interacting with other group members. Although the students in the second, fourth, and sixth groups acted effectively in sharing responsibilities, they could not fully ensure the internal integrity of the group throughout the entire time. Sixth group members had active discussions to solve the meaning pattern of the concepts of luminous intensity, illumination intensity and luminous flux during the 20-minute activity period. The sixth question of this stage, the figure drawing stage, revealed that the relationship in expressing mental modeling as physical modeling was not sufficiently developed.

It was aimed to reveal the level of association of daily life problems with the acquisitions in the activity processes in the application stages from student groups in the stage of "cooperation and interaction in the evaluation stage”. It was observed from the group discussions that the awareness states in the applications of the examples of increase or decrease of light intensity, enlightenment intensity and luminous flux in daily life were expressed by all groups except the fifth group. Fifth group members humorously compared the concept of enlightenment violence with the enlightenment subjects in other lessons and moved away from the context in their discussions. Third group members were found to be effective in both task sharing and taking responsibility, researching and concluding. In other groups, it was observed that the tasks were fulfilled by taking effective responsibility, although sometimes they went out of the subject.

Open-Ended Questions Findings

The scores obtained by the student groups as a result of the evaluations made by considering all the stages in the worksheets are shown in Table 6.

Table 6. The scores of student groups from open-ended questions in technology-supported applications

Activity Evaluation Process	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Logger Pro Supported Experimental Application (24 points)	15	21	15	18	21	18
Simulation Practice (12 points)	12	12	12	9	12	12
Analogy Practice (12 points)	6	6	9	9	12	9
Everyday Life Practice (12 points)	8	8	12	12	12	8
Model Development (24 points)	16	16	12	20	20	16
Evaluation Process (16 points)	12	12	12	16	12	16
Total Points (100 points)	69	75	72	84	89	79

As can be seen in Table 6, the student groups are quite successful in the experimental process, simulation process and evaluation processes in the six-step action research-based laboratory application process; it is seen that they show moderate success in analogy, model development and video finding and interpretation processes.

In the experimental application phase supported by Logger Pro, the students were evaluated with eight questions. In the experimental application phase supported by Logger Pro, the students were evaluated with eight questions. Each correct answer was evaluated on a total of "24 points", with "3 points". All groups gave correct answers to the questions "relationship between light intensity and potential difference change", "evaluation of light intensity", "value of light intensity measured with distance from the light source" and "evaluation of light intensity". Group 2 and group 5 students simply plotted the potential difference-light intensity graph incorrectly. The 4th group and the 6th group members made the display and graphic drawing incorrectly with the model in the first measurement, and the 1st group and 3rd group members made the representation and graphic drawing with the model in the first and second measurements incomplete. It has been observed that a "direct proportional graph" was drawn as a general mistake in the graphical drawings. Failure to make the appropriate association in drawing the model draws attention as the most important error in the representation with the model.

When the group responses were examined, it was determined that only the 4th group gave the wrong answer "The intensity of illumination on the object will not change as a result of increasing the intensity of the light source". Other groups gave correct answers to all questions.

At the analogy stage, each correct answer was "3 points", and the groups were evaluated with four questions, with a total of "12 points". The first question, "the comparison of the number of arrows shot", was written incorrectly as the "intensity of enlightenment" by the first, second and sixth groups. The question of “the number of arrows fired at the target in one minute” was answered incorrectly by all groups except the fifth group. Other questions were answered correctly by all groups.

In the "daily life practice" phase, the groups included six questions in total; each correct answer was scored with "2 points" and a total of "12 points". The first and sixth groups incorrectly answered the change in light intensity in the sunset video as “decreasing”. The first and second groups incorrectly answered the change in light flux in the sunset video as "unchanging". All other questions were answered correctly by the groups.

In the "model development" application, the groups were evaluated with six questions. Each correct answer was evaluated with "4 points", with a total of "24 points". While defining the luminous flux in the first, second and sixth groups, it was seen that they confused it with the intensity of illumination by expressing "the amount of light emitted from the light source as the amount of illumination of a surface". All group members made “the representation of the relationship between illumination, light intensity, and luminous flux by drawing” incomplete or incorrect. The third, fourth and sixth groups used the concepts of luminous flux and enlightenment intensity interchangeably; the first, second and fifth groups mixed the concepts of light intensity and luminous flux with each other and made a drawing by mixing them.

During the evaluation process, the groups were evaluated with four questions. Each correct answer was evaluated with "4 points", with a total of "16 points". Four groups expressed the concepts of luminous intensity, enlightenment and luminous flux as incomplete or incorrect by mixing them with each other while explaining the concepts.

Table 7. One-sample t-test analysis data during the six-step action research-based laboratory implementation process

N	X	S	sd	t	p
134	72,22	13.28	133	19.37	.000

As seen in table 7, the level of learning optical concepts as a result of action research-based applications during the implementation of the six-stage Logger Pro supported teacher guidance material was evaluated with a grade. As a result of these evaluations, it shows that there is a significant difference according to the 50 points expected from students as success. t (133) = 19.37, p <.01, it was determined that the average score of the students as a result of the activities was approximately 72 scores.

Interview Findings

The teacher guidance material was evaluated by fifteen teachers who are experts in their fields before the application. The evaluations of teachers working in different school types are shown in table 8.

Table 8. Evaluation of the instructional material according to the teachers' opinions

Teacher Opinion	Participants															f	%
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
It can be applied in different school and classroom settings.	+	+	+	+	+	-	+	+	+	+	+	+	-	+	-	12	80
It is understandable regardless of their readiness to learn.	+	+	+	+	-	+	+	-	-	+	+	+	+	+	+	12	80
There are enough activities that coincide with the learning goals.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	15	100
It contributes sufficiently to the problem solving process.	+	+	-	+	+	-	+	+	-	+	+	+	+	+	-	11	73

As can be seen in Table 8, the answers given by the teachers to the interview questions regarding the application process of the developed teaching material in the classroom environment have been categorized and shown. The applicability of the teaching material in different school and classroom environments, the students 'ability to perceive the activities and application stages according to different readiness levels, the competencies of the activities to coincide with the acquisitions and the contribution of the material to students' problem solving were shown.

The interview questions asked to teachers within the scope of the evaluation of the teaching material and some answers overlapping with the evaluation category are shown below.

Question 1: What do you think about the applicability of this teaching material in classes where you teach physics? As an example of the answers given in the positivity category: T2: “I think that the students at the school where I work will be very productive, especially in the experimental and analogical application stages, as they deal with skill-based applications. This will contribute to students' being more eager in evaluation questions”. T8: “I think it is neither too challenging nor too simple since I work at a middle level Anatolian high school. The physical and technological competence of the school also meets the requirements of the material”. T14: “Absolutely yes. I think it will be very successful and effective”. As an example of the answers given in the negativity category: T13: “I think that students in science high school type schools will benefit partially because they concentrate more on problem solving”. T15: “I work in a school where students with exam anxiety are concentrated. I am concerned that it can be applied effectively”.

Question 2: When you apply this teaching material in your classroom, what do you think about the students' understanding of the instructions and practices? As an example of the answers given in the category of positivity: T10: “I think it is neither too challenging nor too simple since I am in a middle level Anatolian high school. The physical and technological competence of the school also meets the requirements of the material”. T15: “There are students at different academic levels in the classes I teach. In the teaching material, there are clear instructions and questions that students at all levels can understand”. T11: “The directives and other practices in the material are quite clear. It can be easily understood by students”. T3: “The instructions are quite clear and understandable. I think the instructions and questions are more understandable especially for intermediate students”. As an example of the answers given in the negativity category: T5: “I think the students are unwilling to the academic courses, they will harm the equipment and sensors”.

Question 3: What do you think about the compatibility of the material with the goals of the curriculum? All of the teachers stated that the material developed overlaps with the curriculum objectives. Some of the teacher's views are as follows: T3: “There are applications that will fully teach the concepts of luminous intensity and enlightenment, more concrete examples related to the concept of luminous flux could be emphasized”. T7: “Establishing the relationship between the first sub-goals, the intensity of illumination, luminous intensity and luminous flux through experiment and simulation applications, was handled quite appropriately. Achievement goals are fully felt in the activities”. T11: “The second sub-target was applied without being felt by the teaching activities. Activities that can be taught to students through activities in a clear and understandable way are available in the teacher's guide material”. T14: “The teaching material is fully compatible with the goals”. T15: “Application of analogy; He explained the abstract concepts of luminous intensity, luminous flux and enlightenment very well”.

Question 4: To what extent do you think the material will contribute to students' problem solving? As an example of the answers given in the category of positivity: T5: “I think that it will contribute a lot to the solution of real life problems especially”. T7: "I think that after the material is fully applied, students will be able to easily solve the questions in the central exams in recent years”. T12: "It will partially contribute to the problem solving of students in science high schools, and will contribute a lot to the problem solving of students in other types of schools". As an example of the answers given in the negativity category: T6: “I think they can solve all verbal questions. I don't think it will make much contribution to numerical and operative questions”.

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

The research provides an example of how to create applications that test higher-order thinking skills such as data analysis and evaluation by applying the concepts learned in the classroom to real-life situations in modern technology science teaching.

In physics subjects where innovative technology-supported measurements are made, students' interactions with each other, their efforts to reach results by making research and questioning are quite advanced. In physics experiments and applications in which measurements are made with technology-supported sensors, when the sharing of duties and responsibilities between group members is done effectively, the group interaction and success of the students are much more advanced. Since Logger Pro supported measurements are entertaining for students, all students in the group are volunteers to take measurements and fulfill their responsibilities regarding measurements. It is stated in the literature that technology-supported science teaching has a positive effect on students' attitudes and achievements, as well as contributing to attitude, behavior and interaction processes (Yeh, Tsai, Tsai & Chang, 2019).

After performing experimental measurements with sensors in the physics laboratory, performing simulation applications in the computer and technology laboratory was perceived as a new and exciting environment for students, and developed positive pre-attitudes in learning new physics concepts. The technology-aided implementation of the first three stages ensured the active participation of all group members and made a significant contribution to learning the subject. As a result of the meta-analysis conducted among 42 studies by (Wang et. al., 2014); In most of the studies, it is in line with the findings that experimental applications in the applications within the scope of science courses are supported with advanced technology tools and computer-aided enriched content, making a significant positive contribution to students' attitudes. It has been stated by that student groups who cannot actively participate in a poorly planned process will isolate themselves from the groups and lesson subjects as a result of technology-supported activities and their learning processes will be damaged (Keller & Cernerud, 2002). This finding coincides with the importance of the active participation prerequisite for each group member in the study.

Technology-aided analogy practices created significant support for students to participate in the lesson more effectively. The fact that the first two stages of the teacher's guideline material is technology supported has formed integrity with the fact that the third stage is technology supported. The first encounter of the student groups with the application of analogy created a problem at the beginning of the process. In the following processes, the development of analogy map by integrating the computer game with the analogies enabled the students to be more active towards the lesson. Teaching abstract physics subjects with technology supported analogy applications has made a positive contribution to the students' attitudes towards physics subjects. The effectiveness of computer-aided analogy applications towards the academic achievement of 7th grade students in science classes, their attitudes towards the course and the permanence of knowledge is in accordance with the researches determined by (Celik, Kirindi & Kotaman, 2020).

The most important problem encountered in the teaching of physics subjects is that the subjects learned in the classroom cannot be associated with daily life situations. Although we use technology at the highest level in the tools and equipment we use in daily life, the experiments in the physics laboratory are carried out with classical experimental materials. As a result of the effective application of technology supported teacher guidance material in the classroom environment, it makes a significant contribution to the relationship between students' experimental practices and daily life practices. As a result of the studies in which technology-supported science teaching was analyzed taking into account teachers' views (Namdar & Salih, 2017; Babacan & Ören, 2017) and student views (Haron, Othman & Awang, 2019; Yıldırım & Sensoy, 2018), it was significantly shows a supportive feature with the findings it contributes.

Teaching abstract physics topics through mental and physical models has an important place in active learning. Teaching abstract physics topics by making measurements with Logger Pro supported sensors, using technology-supported simulations and informatics-supported analogies contributes positively to students' effective participation in the processes of physical and mental modeling, to adopt the process by discussing, and to model development attitudes in interaction with other group peers. The reason for this is that the daily life applications of students in this age group are generally equipped with technological tools such as smart phones, tablets and computers, and that such applications come to the fore as an important motivation tool when used as a learning tool in the classroom. (Ring, Dare, Crotty & Roehrig, 2017; Windschitl, Thompson & Braaten, 2020) emphasized in their study that in addition to the development of science, technology and mathematics skills of students in science teaching based on innovative technology, modeling competencies will also be advanced. (Retnawati, Arlinwibowo, Wulandari & Pradani, 2018) emphasizes that physics teachers have serious difficulties in presenting mathematical models to students, and that technology and other active learning strategies should be used in a way that coincides with student interests and attitudes in order to overcome these problems.

It is known that the concepts of luminous intensity, illumination intensity and luminous flux are abstract and complex concepts that are intertwined for high school students and that there are important problems in the solutions of daily life problems related to these concepts. Developing solutions by organizing and discussing technology-supported activities with other peers who have similar problems in order to assimilate and solve abstract optics by students make a significant contribution to the solution of these problems. (Ramma, Bholoa, Watts & Nadal, 2018; Sunal et. al., 2019) in their research, it is stated that the application of technological applications that attract the attention of students to the groups within the scope of the physics course, contributes positively to the development of students' responsibilities and to the development of their skills through active knowledge sharing.

One of the most important problems in active teaching practices is the evaluation of the result with different question models after the applications are completed, not the learning process. In this context, the evaluation of desired behaviors in the process is ignored. As a result, students focus on being successful as a result, not in the learning process. Neglecting the process also makes the result unsuccessful. In this context, in all processes of this study, observation, open-ended questions and interview findings were used to evaluate at the end of each stage, and as a result of the description of the whole process together with the result, the students were enabled to take active responsibility in all stages of learning practices. Considering that ensuring group integrity creates group success and consequently contributes to the scores of all members in the group, all group members take active responsibility at every stage of technology-supported learning practices, and students actively participate in the content of the subject. (van Leeuwen & Janssen, 2019) reveals that the learning process will be successfully completed in all individuals of the groups as long as teachers in secondary and high schools can effectively follow the process and encourage groups to cooperate under auto-control systematically.

One of the important problems encountered in technology supported action research applications is the use of technological tools outside of the course contents during the course applications. Considering that the group scores will be shared among all group members within the scope of the study, effective group work and the evaluation of the process by describing it with observations make a positive contribution to the success and responsibilities of the students. In particular, game-based analogy applications cause students to go out of context to a significant extent. The evaluation of the process with open-ended questions at all application stages contributes to the prevention of out-of-context applications. Despite the fact that one of the drawbacks of using game-based technology in teaching practices in the literature is out-of-context activities (Mayer, 2019; Papadakis, 2018; Zhonggen, 2019), solutions for out-of-context activities have not been presented.

The presence of evaluation activities at all stages of the applications where abstract content physics subjects are supported with technological measurements and applications and taught with teacher guidance material contributes to the students to remain active at every stage of the lesson. The guide material, which provides active participation at every stage of the teaching practices, provides a significant academic success increase as a result of the process. Although it is stated that evaluating students with their positive behaviors at every stage of the course will contribute positively to the learning process and students' learning attitudes (Moss, & Brookhart, 2012; Made et. Al., 2019); there are no practical examples in the literature regarding what kind of activities to achieve this situation.

In Virtual Logger Pro technology-supported application systematic, presenting measurements with desired precision, graphic support and different variables together contributes to the formation of an effective and holistic teaching systematic and to enable students to construct graphical applications at analysis-synthesis level in the later stages of the process. (Oktaviyanti & Pramudya, 2019), in their studies where they evaluate the angular velocity and angular acceleration by placing the logger pro magnetic sensor on the upper part of the propeller, they confirm that the use of such advanced technology tools contributes to the learning activities at the analysis synthesis level. In addition, as a result of measurements with Logger Pro supported sensors, it is very easy to construct, interpret and associate mathematical models in optics with daily life based on graphic representations. As a result, holistic learning in physics course subjects takes place at a significant level. It also increases the quality of the teaching process in heterogeneous school types where students 'academic readiness levels differ, and contributes to students' comparative knowledge about variables in abstract concepts.

In the study, an experimental applied teacher guide material, which is based on innovative technology-supported computer-applied Logger Pro-supported sensors, was developed and examined for students who are not interested in abstract physics in science teaching. The focus was on the active use of computer and technology content by students at all stages of the study. In Turkey, the first time through analogies in science teaching has benefited from computer-aided applications. The fact that measurement tools are extraordinary in technology supported applications and that they perform highly sensitive measurements contribute significantly to the teaching of abstract physics subjects that are desired to be taught. Teaching course contents by using technological equipment and computer technology together has an important effect on the development of professional attitudes in students. In future research, it is important to consider three important situations. First, presenting the problems of daily life in abstract physics to the students before the lesson, and listing the solution suggestions of the students. Second, planning activities by integrating physics-technology-computer interaction with abstract physics topics. Third, collaborative learning groups, where each student can be at the center of the learning process, are professionally designed in the classroom environment and there are assessment activities in all learning stages.

We hope that this study will provide researchers interested in science education in developing countries with an important perspective on the use of technology and science together. In addition, we believe that it will contribute as an important resource material to teachers who try to maximize students' interests, attitudes and motivations while teaching physics subjects.

REFERENCES

Averitt, S., Bugaev, M., Peeler, A., Shaffer, H., Sills, E., Stein, S. at all. (2007). Virtual computing laboratory (VCL). *Proceedings of the International Conference on Virtual Computing Initiative* (1-16). NC: IBM Corp., Research Triangle Park.

Aydın, B. (2003). Bilgi toplumu oluşumunda bireylerin yetiştirilmesi. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi*, *14*(14), 183-190.

Babacan, T., & Ören, F. Ş. (2017). Teknoloji destekli mikro öğretim uygulamalarinin fen bilimleri öğretmen adaylarinin teknoloji kullanim algilari üzerine etkisi. Eğitim Teknolojisi Kuram ve Uygulama, 7(2), 193-214. https://doi.org/10.17943/etku.300412

Berg, B.L. (2001). Qualitative research methods for the social sciences (4. baskı). Boston: Allyn and Bacon.

Bruffee, K. A. (1987). The art of collaborative learning. Change: The Magazine of Higher Learning, 19(2), 42-47.

Bruffee, K. A. (1999). Collaborative learning: Higher education, interdependence, and the authority of knowledge. Johns Hopkins University Press, 2715 North Charles Street, Baltimore, MD 21218-4363.

Cangüven, H. D., Oya, Ö. Z., & Sürmeli, H. (2017). Türkiye Hong Kong Fen Eğitimi Karşılaştırılması. International Journal of Eurasian Education and Culture, 2(2), 21-41.

Celik, H., Kirindi, T., & Kotaman, Y. A. (2020). The Effect of the Computer-Based Analogy Used in Science Teaching on Learning Outcomes. Journal of Turkish Science Education, 17(1), 73-93. doi: 10.36681/tused.2020.14

Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning. In Technology-enhanced learning (pp. 3-19). Springer, Dordrecht.

Dong, B., Zheng, Q., Quiao, M., Shu, J. and Yang, J. (2009). BlueSky cloud framework: an e-learning framework embracing cloud computing. *Lecture Notes in Computer Science, 5931*, 577-582.

Erickson, T., & Cooley, B. (2007). *A Den of Inquiry: Data-Rich Labs for Introductory Physics (Volume 2, Mechanics with Sensors)*. eeps media.

Eysenbach, G., & Köhler, C. (2002). How do consumers search for and appraise health information on the world wide web? Qualitative study using focus groups, usability tests, and in-depth interviews. BMJ, 324(7337), 573–577. https://doi.org/10.1136/bmj.324.7337.573.

Game of Archery (2020). Rekor oyun archery game. Turkey.

Gladhart, M. A. (2001). A model for integrating technology to meet accreditation standards for teacher education programs. Kansas State University.

Haron, M. Z., Othman, M. K. H., & Awang, M. I. (2019). Technology-assisted teaching aids in teaching and learning: Evidence from the Malaysian Tahfiz Ulul Albab Model (TMUA). International Journal of Innovative Technology and Exploring Engineering, 8(12), 4401-4404. DOI: 10.35940/ijitee.L3915.1081219

Hendricks, V. F. (2006). Mainstream and formal epistemology. Cambridge University Press. DOI:10.5860/choice.44-1457

Hırça, N., Çalık, M. ve Akdeniz, F. (2008). Investigating grade 8 students' conceptions of 'energy' and related concepts. *Türk Fen Eğitimi Dergisi*, 5(1), 77-89.

Higgins, S., Mercier, E., Burd, L., & Joyce-Gibbons, A. (2012). Multi-touch tables and collaborative learning. British Journal of Educational Technology, 43(6), 1041-1054. doi:10.1111/j.1467-8535.2011.01259.x

Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. Science education, 88(1), 28-54. https://doi.org/10.1002/sce.10106

İşman, A., Sevinç, V. ve Altığ, E. (1998). Fen bilgisi öğretiminde eğitim teknolojilerinin uygulamaları. 2. Fen Bilgisi Öğretimi Konferansı, Karadeniz Teknik Üniversitesi, Trabzon.

Jermann, P., Soller, A., & Muehlenbrock, M. (2001). From mirroring to guiding: A review of the state of art technology for supporting collaborative learning. In *European Perspectives on Computer-Supported Collaborative Learning* (No. CONF, pp. 324-331).

Kan, S. (2013). Fizik öğretiminde proje tabanlı ve probleme dayalı öğrenme uygulamalarının değerlendirilmesi. Yayımlanmamış Doktora Tezi, Karadeniz Teknik Üniversitesi, Trabzon.

Karacop, A. (2017). The Effects of Using Jigsaw Method Based on Cooperative Learning Model in the Undergraduate Science Laboratory Practices. Universal Journal of Educational Research, 5(3), 420-434. DOI: 10.13189/ujer.2017.050314

Keller, C., & Cernerud, L. (2002). Students' perceptions of e-learning in university education. Journal of Educational Media, 27(1-2), 55-67. https://doi.org/10.1080/1358165020270105

Kilmer, M. & Khrehbiel, J.D. (2019).. The Physics Teacher 57(1), 21. DOI: https://doi.org/10.1119/1.5084921

Kitchen, D., & McDougall, D. (1999). Collaborative learning on the Internet. Journal of Educational technology systems, 27(3), 245-258. https://doi.org/10.2190/5H41-K8VU-NRFJ-PDYK

Larusson, J. A., & Alterman, R. (2009). Wikis to support the "collaborative" part of collaborative learning. International Journal of Computer-Supported Collaborative Learning, 4(4), 371-402.

Lee, K., Tsai, P. S., Chai, C. S., & Koh, J. H. L. (2014). Students' perceptions of self-directed learning and collaborative learning with and without technology. Journal of Computer *Assisted Learning*, *30*(5), 425-437. doi: 10.1111/jcal.12055

Linn, M. C., Slotta, J. D., & Baumgartner, E. (2000). Teaching high school science in the information age: A review of courses and technology for inquiry-based learning. *Milken Family Foundation.*

Lipponen, L. (2002). Exploring foundations for computer-supported collaborative learning.

Made, A. F., Hasan, A., Tuttle, S., & Tuttle, D. (2019). Less is more: assessment and student learning in computer science education. *Journal* of Computing Sciences in Colleges, 34(4), 142-148.

Mayer, R. E. (2019). Computer games in education. Annual review of psychology, 70, 531-549. https://doi.org/10.1146/annurev-psych-010418-102744

MEB (2007). Orta öğretim 9. sınıf fizik dersi öğretim programı, Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı, Ankara.

MEB (2011). Orta öğretim 9. sınıf fizik dersi öğretim programı, Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı, Ankara.

MEB (2013). Orta öğretim fizik dersi öğretim programı, Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı, Ankara.

MEB (2018). Orta öğretim fizik dersi öğretim programı, Milli Eğitim Bakanlığı Talim ve Terbiye Kurulu Başkanlığı, Ankara.

Merriam, S. B. (2002). Introduction to qualitative research. Qualitative research in practice: Examples for discussion and analysis, 1(1), 1-17.

Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook. sage.

Miles, M. B., & Huberman, A. M. (2015). Nitel veri analizi: Genişletilmiş bir kaynak kitap (Çev. Ed. S. Akbaba-Altun & A. Ersoy). Ankara: Pegem Akademi.

Milner-Bolotin, M., Kotlicki, A., & Rieger, G. (2007). Can students learn from lecture demonstrations. J Coll Sci Teach, 36, 45-49.

Milner-Bolotin, M., & Moll, R. (2008). Physics exam problems reconsidered: Using Logger Pro to evaluate student understanding of physics. The Physics Teacher, 46(8), 494-500. https://doi.org/10.1119/1.2999067

Mills, G. E. (2003). Action Research: A Guide For the Teachers Researcher. Upper Saddle River, NJ: Merrill/Prentice Hall.

Moss, C. M., & Brookhart, S. M. (2012). Learning targets: Helping students aim for understanding in today's lesson. ASCD.

Namdar, B., & Salih, E. (2017). Fen Bilgisi Öğretmen Adaylarının Teknoloji Destekli Argümantasyona Yönelik Görüşleri. Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 17(3), 1384-1410. https://doi.org/10.17240/aibuefd.2017.17.31178-338837

Oktaviyanti, D., & Pramudya, Y. (2019, November). Angular Velocity and Acceleration Using Logger Pro magnetic Sensor. In Journal of Physics: Conference Series (Vol. 1254, No. 1, p. 012068). IOP Publishing. doi:10.1088/1742-6596/1254/1/012068

Okuda, Y., Bryson, E. O., DeMaria Jr, S., Jacobson, L., Quinones, J., Shen, B., & Levine, A. I. (2009). The utility of simulation in medical education: what is the evidence?. Mount Sinai Journal of Medicine: A Journal of Translational and Personalized Medicine: A Journal of Translational and Personalized Medicine, 76(4), 330-343. https://doi.org/10.1002/msj.20127

Onwuegbuzie, A. J., & Leech, N. L. (2007). Validity and qualitative research: An oxymoron?. Quality & quantity, 41(2), 233-249. DOI 10.1007/s11135-006-9000-3

Ozuru, Y., Briner, S., Kurby, C. A., & McNamara, D. S. (2013). Comparing comprehension measured by multiple-choice and open-ended questions. Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale, 67(3), 215. DOI: 10.1037/a0032918

Palaganas, E. C., Sanchez, M. C., Molintas, V. P., & Caricativo, R. D. (2017). Reflexivity in qualitative research: A journey of learning. Qualitative Report, 22(2). https://doi.org/10.46743/2160-3715/2017.2552

Papadakis, S. (2018). The use of computer games in classroom environment. International Journal of Teaching and Case Studies, 9(1), 1-25. https://doi.org/10.1504/IJTCS.2018.090191

Ramma, Y., Bholoa, A., Watts, M., & Nadal, P. S. (2018). Teaching and learning physics using technology: Making a case for the affective domain. Education Inquiry, 9(2), 210-236. https://doi.org/10.1080/20004508.2017.1343606

Retnawati, H., Arlinwibowo, J., Wulandari, N. F., & Pradani, R. G. (2018). Teachers' difficulties and strategies in physics teaching and learning that applying mathematics. *Journal of Baltic Science Education*, *17*(1), 120. http://www.scientiasocialis.lt/jbse/files/pdf/vol17/120-135.Retnawati_JBSE_Vol.17_No.1.pdf

Ring, E. A., Dare, E. A., Crotty, E. A., & Roehrig, G. H. (2017). The evolution of teacher conceptions of STEM education throughout an intensive professional development experience. Journal of Science Teacher Education, 28(5), 444-467. https://doi.org/10.1080/1046560X.2017.1356671

Rogers, E. M. (1995). Diffusion of innovation. New York: Free Press.

Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): Reliability, validity, and factor structure. Journal of personality assessment, 66(1), 20-40. https://doi.org/10.1207/s15327752jpa6601_2

Schmidt, C. (2004). The analysis of semi-structured interviews. *A companion to qualitative research*, *253*, 258.

Schonlau, M., & Couper, M. P. (2016, August). Semi-automated categorization of open-ended questions. In Survey Research Methods (Vol. 10, No. 2, pp. 143-152). https://doi.org/10.18148/srm/2016.v10i2.6213

Setiyani, A., Kristiyanto, W. H., & Rondonuwu, F. S. (2019). Development of Motion Learning Media and Energy Conservation Law Through Coaster Tracks Based on Logger Pro Analysis. Jurnal Pendidikan Fisika Indonesia, 15(1), 24-28. DOI: 10.15294/jpfi.v15i1.17253

Stuessy, C. L., Parrott, J. A. & Foster, A. S. (2003). Mathematics and Science Classroom Observation Profile System (M-SCOPS): Using Classroom Observation to Analyze the How and What of Mathematics.

Sultan, N. (2010). Cloud computing for education: a new dawn?. *International Journal of Information Management, 30*(2), 109–116. doi:10.1016/j.ijinfomgt.2009.09.004

Sunal, D. W., Shemwell, J. T., Harrell, J. W., & Sunal, C. S. (Eds.). (2019). *Physics Teaching and Learning: Challenging the Paradigm*. IAP.

Supalo, C. A., Mallouk, T. E., Amorosi, C., Rankel, L., Wohlers, H. D., Roth, A., & Greenberg, A. (2007). Talking Tools to Assist Students Who Are Blind in Laboratory Courses. *Journal of Science Education for Students with Disabilities*, *12*(1), 27-32.

Supalo, C. A., Mallouk, T. E., Dwyer, D., Eberhart, H. L., & Bunnag, N. W. (2014). Teacher training workshop for educators of students who are blind or low vision. *Journal of Science Education for Students with Disabilities*, *13*(1), 3.

Van Leeuwen, A., & Janssen, J. (2019). A systematic review of teacher guidance during collaborative learning in primary and secondary education. Educational Research Review, 27, 71-89. https://doi.org/10.1016/j.edurev.2019.02.001

VCL (2013). Virtual Computing lab. 16.06.2019

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. Journal of Educational Computing Research, 34(3), 229-243. https://doi.org/10.2190/FLHV-K4WA-WPVQ-H0YM

Wang, C. Y., Wu, H. K., Lee, S. W. Y., Hwang, F. K., Chang, H. Y., Wu, Y. T., ... & Tsai, C. C. (2014). A review of research on technology-assisted school science laboratories. Journal of Educational Technology & Society, 17(2), 307-320.

Wang, F., Liu, Y., Lu, Y., Zhang, L., Ma, J., Wang, L., & Sun, W. (2018). High-sensitivity Fabry–Perot interferometer temperature sensor probe based on liquid crystal and the Vernier effect. Optics letters, 43(21), 5355-5358. https://doi.org/10.1364/OL.43.005355

Vernier (2021). Vernier Computer Interface Logger Pro, 18 January 2021.

Whittemore, R., Chase, S. K., & Mandle, C. L. (2001). Validity in qualitative research. Qualitative health research, 11(4), 522-537. https://doi.org/10.1177/104973201129119299

Windschitl, M., & Andre, T. (1998). Using computer simulations to enhance conceptual change: The roles of constructivist instruction and student epistemological beliefs. Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 35(2), 145-160. https://doi.org/10.1002/(SICI)1098-2736(199802)35:2<145::AID-TEA5>3.0.CO;2-S

Windschitl, M., Thompson, J., & Braaten, M. (2020). *Ambitious science teaching*. Harvard Education Press.

Yeh, H. Y., Tsai, Y. H., Tsai, C. C., & Chang, H. Y. (2019). Investigating students' conceptions of technology-assisted science learning: a drawing analysis. Journal of Science Education and Technology, 28(4), 329-340. https://doi.org/10.1007/s10956-019-9769-1

Yıldırım, A. ve Şimşek, H. (2008). Sosyal Bilimlerde Nitel Araştırma Yöntemleri. Ankara: Seçkin Yayıncılık.

Yildirim, H. I., & Sensoy, O. (2018). Effect of *Science Teaching Enriched with Technological Practices on Attitudes of Secondary School 7th Grade Students towards Science Course. Universal Journal of Educational Research, 6(5), 947-959.* DOI: 10.13189/ujer.2018.060516

Zhang, G., Wu, X., Zhang, W., Li, S., Shi, J., Zuo, C., ... & Yu, B. (2019). High temperature Vernier probe utilizing photonic crystal fiber–based Fabry-Perot interferometers. Optics Express, 27(26), 37308-37317. https://doi.org/10.1364/OE.27.037308

Zhao, Y., Wang, P., Lv, R., & Liu, X. (2016). Highly sensitive airflow sensor based on Fabry–Perot interferometer and Vernier effect. *Journal of Lightwave Technology*, *34*(23), 5351-5356.

Zhao, Y., Tong, R. J., Chen, M. Q., & Peng, Y. (2019). Relative humidity sensor based on Vernier effect with GQDs-PVA un-fully filled in hollow core fiber. Sensors and Actuators A: Physical, 285, 329-337. https://doi.org/10.1016/j.sna.2018.11.042

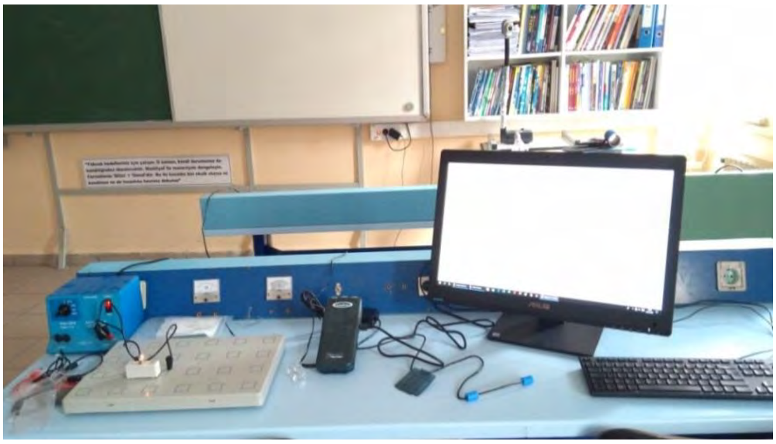
Zhonggen, Y. (2019). A meta-analysis of use of serious games in education over a decade. International Journal of Computer Games Technology, 2019. https://doi.org/10.1155/2019/4797032

URL-1: Sunset on Mount Nemrut. (date of access: 17.10.2019)

URL-2: Sunrise on Mount Nemrut, (date of access: 17.10.2019)

Appendix A. Technology supported teacher guide material with Logger Pro content

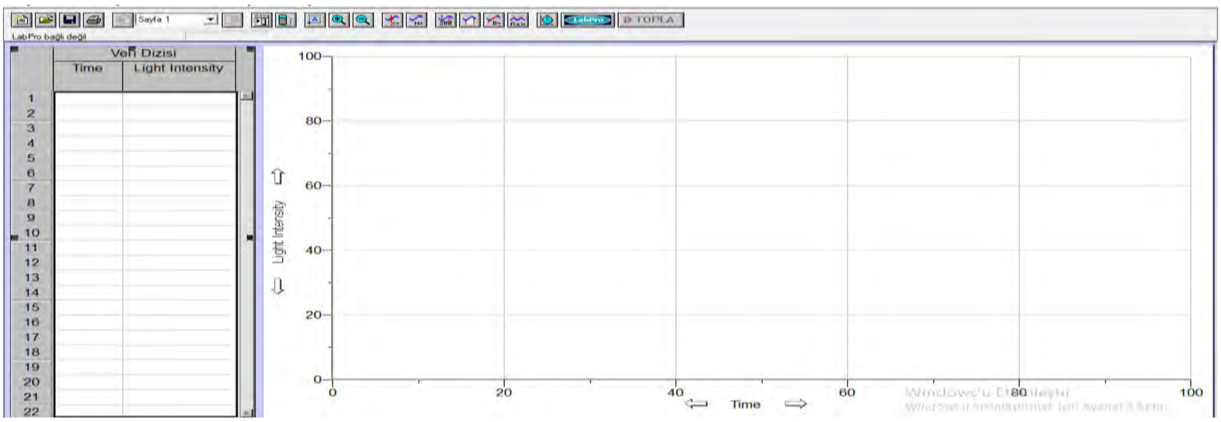
1. Experimental application with Logger Pro support



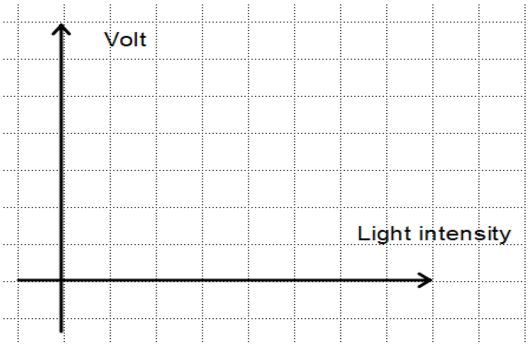
- Set up the simple electrical circuit experiment setup shown in the figure.
- Install the Logger Pro interface and light sensor together with the computer hardware.
- Increase the volt value in the power supply regularly as indicated in the table and write the measured values in the table.
- Show the modeling for light intensity by drawing your figures on the table.
- Write your verbal evaluations about light intensity on the table.

Power supply voltage (Volt)	Light intensity value measured at the light sensor (5 cm distance)	Demonstrate with model	Evaluation of light intensity
0			
1.5			
3.0			
4.5			
6.0			

• Show your estimated drawings that can be obtained with the Logger Pro program and sensors on the figure, after measuring, compare the measurement results with your drawing results.



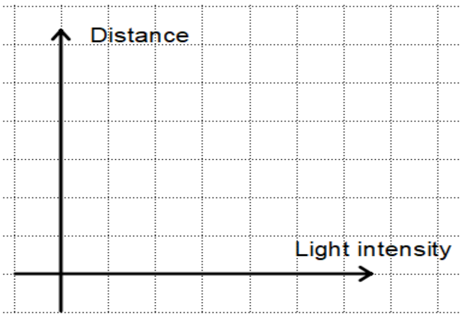
• Show the relationship between volt-light intensity on the graph, taking into account the data you measure.



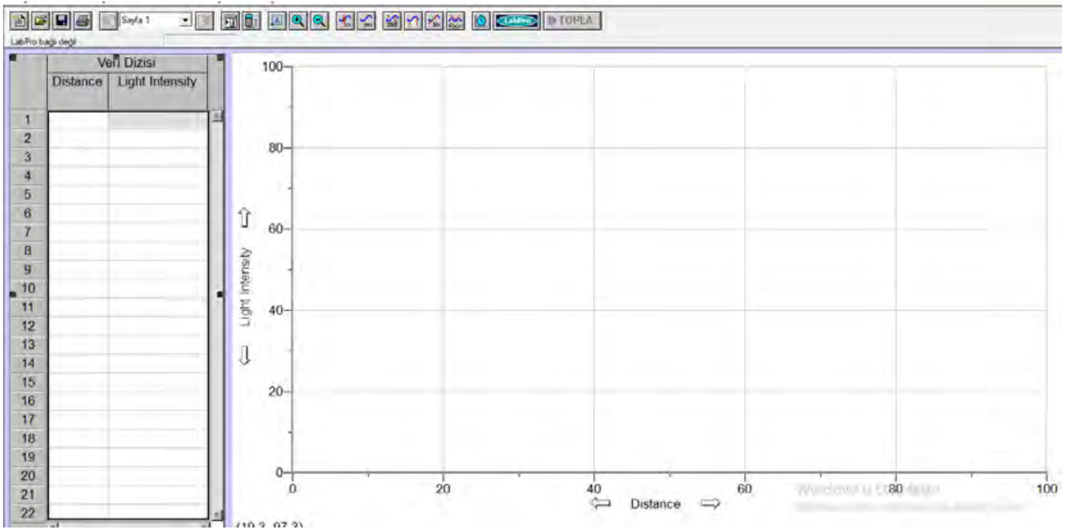
• Without changing the voltage value of the power source, move the light sensor away from the light source and show the light intensity values measured on the curtain in the table.

Distance from light source (cm)	Light intensity value measured at the light sensor (4,5 Volt)	Demonstrate with model	Evaluation of light intensity
5			
4			
3			
2			
1			

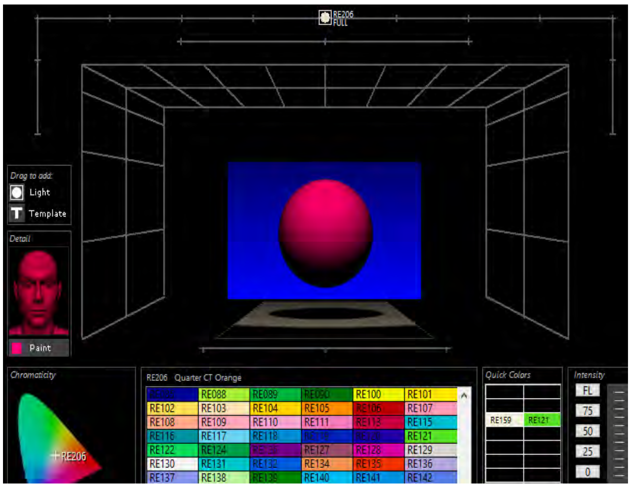
• Show the relationship between distance-light intensity on the graph, taking into account the data you measure.



• Show your estimated drawings that can be obtained with the Logger Pro program and sensors on the figure, after measuring, compare the measurement results with your drawing results (4,5 volt).



2. Simulations



Run the virtual-light-lab application.

- Using the simulation application program, answer the questions below with applications.

a. When you bring the light source closer to the object, the amount of enlightenment on the curtain ………… …………………………………..

b. The intensity of illumination on the curtain when you move the light source away from the object ……… ……… ………… ………

c. When you increase the intensity of the light source, the intensity of illumination on the curtain ………… ……… .. ………………………………

d. When you reduce the intensity of the light source, the light intensity on the curtain …… …………. ……………………………….

3. Analogy With the Computer Game

(Archery game) Enter this web page.

- In the archery game application, make five shots to the target. All group members shoot five arrows to the target and write down your results on the worksheet. Keep time during the shooting of all members of the group, determine the number of arrows hit on the target and create a success ranking according to the time.
- Using the analogy application, fill in the blank spaces in the analogy map appropriately.

Similarity	*Comparison*	*Simulated feature*
Number of arrows shot	Comparable	Light intensity
Number of arrows hitting the target	Comparable	Illumination intensity
Number of arrows reaching the target in one minute	Comparable	Luminous flux
Arrows	Incomparable	Light

4. Daily Life Practice

The video about sunrise and sunset in the link below; Watch by considering the concepts of light intensity, illumination and luminous flux.

(URL-1) Sunset video; Watch and discuss with your group friends, taking into account the concepts of luminous intensity, illumination and luminous flux.

(URL-2) Watch the sunrise video taking into account the concepts of light intensity, illumination intensity and luminous flux and discuss with your group friends.

Fill in the blanks below according to the changes in the videos you watch.

Optics concept	Change in the sunset	Change in Sunrise
Light intensity	Constant	Constant
Illumination	Decreases	Increases
Luminous flux	Decreases	Increases

5. Model development application

• How can you express the light intensity? ……..

• How can you define the concept of illumination? ………..

• How can the luminous flux best be defined? ……

• By which optical concept can the better observation of things in an environment be expressed?………………………………………………………………………………………………………

• Write down the variables that affect illumination.

• Show the relationship between illumination, luminous intensity and luminous flux by drawing a figure.

6. Evaluation process

(a) (b)

• Explain the pictures in case (a) and (b), taking into account the concepts of light intensity, illumination and luminous flux.

• How can it be achieved to increase the light intensity in the pictures above?

• How to increase the illumination in the pictures above?

• How to increase the luminous flux in the pictures above?