Original Research Article:
full paper

(2023), «EUREKA: Physics and Engineering»
Number 2

DEVELOPMENT OF SIMPLE KITS (SK) REFRACTION OF LIGHT USING PHOTODIODE SENSORS FOR STUDENT UNDERSTANDING

Firmanul Catur Wibowo✉
Department of Physics Education[1]
fcwibowo@unj.ac.id

Ade Nur Maemunah
Department of Physics Education[1]

Hadi Nasbey
Department of Physics Education[1]

Bayram Costu
Department of Science Education
Yildiz Technical University
Beşiktaş, İstanbul, Turki, 34349

Binar Kurnia Prahani
Department of Physics Education
Universitas Negeri Surabaya
1 Lidah Wetan, Surabaya, Indonesia, 60231

Niki Dian Permana
Departement of Science Education
Universitas Islam Negeri Sultan Syarif Kasim Riau
15 HR. Soebrantas Simpang Baru, Pekanbaru, Indonesia, 28293

Dina Rahmi Darman
Department of Physics Education
Universitas Sultan Ageng Tirtayasa
27 Ciwaru Raya Cipare, Serang, Indonesia, 42117

Achmad Samsudin
Department of Physics Education
Universitas Pendidikan Indonesia
229 Dr. Setiabudi Isola, Bandung, Indonesia, 40154

[1]*Universitas Negeri Jakarta*
11 Rawamangun Muka, Jakarta Timur, Indonesia, 13220

✉**Corresponding author**

Abstract

Students' understanding to learn science on the concept of light refraction is experiencing serious problems because of the unobservable of light particles. The research object to be resolved in this study is to improve the concept of light refraction using a photodiode sensor. The problem to be solved in this research is to develop a Simple Kit (SK) Refraction of Light (RoL) using a photodiode sensor for students' understanding of concepts. The research method for making SK RoL using photodiode sensors using ADDIE, which consists of the first stage, analysis by analyzing the needs of SK RoL products using photodiode sensors to be developed. Second, the SK RoL design uses a photodiode sensor. Third, Development is developing SK RoL Using Photodiode Sensors. Implementation of the Fourth RoL Decree Using Photodiode Sensors to see student understanding of 74 students from tertiary institutions in one of the provinces in Indonesia. Fifth, Evaluation by revising the product at each stage of SK RoL development. SK RoL product research results include Green Laser, Photodiode sensor, Angle Arc, Display Module and Displayed Data, Arduino Uno R3 Atmega 328, Medium Container and Programs Using Arduino Software. The characteristics of the SK ROL results show that the SK RoL based on the Photodiode Sensor developed can be used as a physics learning medium because it can visualize the unobservable concept of light refraction and increase students' understanding of the concept of light refraction because of the nature of the particles which are difficult to understand by using a green laser which is passed through a photodiode sensor medium and Arduino can be visualized in a real way. SK RoL can work optimally in a room where the light is not too bright or requires a room that is a bit dark so it is possible to observe the laser beam. SK RoL, as a physics learning medium, can be used to increase students' understanding of the concept of light refraction. The implications of developing SK RoL can be used as a learning medium to attract students' interest in learning, support the learning process, and help make it easier for students to understand abstract physics concepts.

Keywords: Simple Kits (SK), Refraction of Light (RoL), Photodiode Sensors, Student Understanding.

DOI: 10.21303/2461-4262.2023.002728

1. Introduction

Physics is a branch of science that studies about all-natural phenomena [1]. Physics is the study of science that studies the properties and symptoms of objects in nature [2]. These symptoms are initially felt by the five senses example, the eye can see, vision is related to optics or light, hearing finds the study of sound, and the five senses of touch which can feel hot or cold [3]. Physics is essential because the analysis of science is fundamental, dealing with all the behavior and structure of objects, especially inanimate objects, starting with observing the movement of heavenly bodies the [4, 5]. The phenomena physics is that occurs in the universe [6]; however, students often find learning physics boring because, generally teachers present physics material only in the form of formulas which causes students to need help understanding concepts [7].

The practicum learning method can create active students so that students not only memorize formulas but also understand the physics concepts being studied [8]. Physics is a lesson based on scientific observation, so learning physics will be more appropriate if using practical learning methods [9]. This is also supported by the competency demands that must be achieved in university level students in learning physics, one of which is conducting experiments or practicum [10]. Therefore, using the practicum learning method, student learning outcomes are hoped to increase.

The students' physics learning outcomes can be increased using practical learning methods [11, 12]. Then this is also in line with the results of cognitive tests, both pre-test, and post-test, the significant differences from the physics learning outcomes of students who follow the practicum learning method. The results of student physics learning with practical learning methods are more effective in achieving three domains together, namely:

1) cognitive, namely understanding and applying theory to real problems;
2) affective: planning activities independently, working together, and communicating information;
3) psychomotor, namely learning to install the equipment, so it runs, uses specific equipment and instruments. Learning outcomes achieved using practicum learning methods certainly need to be supported by teaching media in the form of kits [13, 14].

The research found that the group of students who experimented benefited more than those who did not, acquiring science process skills and basic practical performance skills, one of which was light refraction [15]. Kits are a learning media that can visualize abstract or non-concrete physics material [16]. Physics materials that cannot be seen directly by the five senses require learning media in the form of kits so that they can help explain concepts, symptoms, events, or natural laws [17–19].

Unresolved problems regarding the optical kit include that most students still need help with using the optical kit [17]. Schools already have optical kits, but these optical kits are rarely used because their use is rather complicated [20]. The light refraction experiment activities carried out by students showed that most students still needed to be more skilled in using kit tools. The acquisition of the average value of student learning outcomes in the experimental class using a kit the low category [21]. This problem still needs to be resolved because of the unobservable nature of light or optic matter so that the eye cannot observe it directly (Unobservable). This problem still needs to be resolved because the eye cannot directly observe the nature of light, so it is difficult for students to understand the nature of light travel or light refraction.

Furthermore, based on research, most students needed help applying the principle of light refraction to explain real-world situations. One of the abstract materials of physics is the refraction of light. The presentation of misconceptions about lightweight refraction material is 53.33 %. In line with the results of the needs analysis conducted, it showed that 95 % of students stated that light refraction material was material that was difficult and too abstract to understand, and 100 % of students agreed to use light refraction kits as learning support media for learning media is needed in the form of kits on light refraction material.

The development of light refraction practicum sets for physics Learning. Weaknesses that need to be corrected are that the liquid and solid substances used do not vary, namely in liquids used only water and solids used only glass. In addition, the light source used is a diode laser whose light is less able to focus and less visible when it enters the medium. Furthermore, the Light Refraction Kits Design to Help Improve Students' Problem-Solving Ability also has the same drawbacks as previous research: still using a manual protractor. Therefore, this research was conducted to correct the deficiencies that still exist in previous studies. The purpose of the research is to develop a Simple Kit (SK) Refraction of Light (RoL) using a photodiode sensor for students' understanding of concepts.

2. Materials and methods of research

2. 1. The research steps

This research is a Research and Development study using the Analysis, Design, Development, Implementation and Evaluation (ADDIE) development model [22, 23], which consists of the Analyze stage, the Design stage, the Development stage, the Implement stage, and the Evaluate Simple Kits (SK) for Refraction of Light (RoL) Using Photodiode Sensors for student understanding stage. The research steps used in the light refraction kits research are shown in **Fig. 1**:

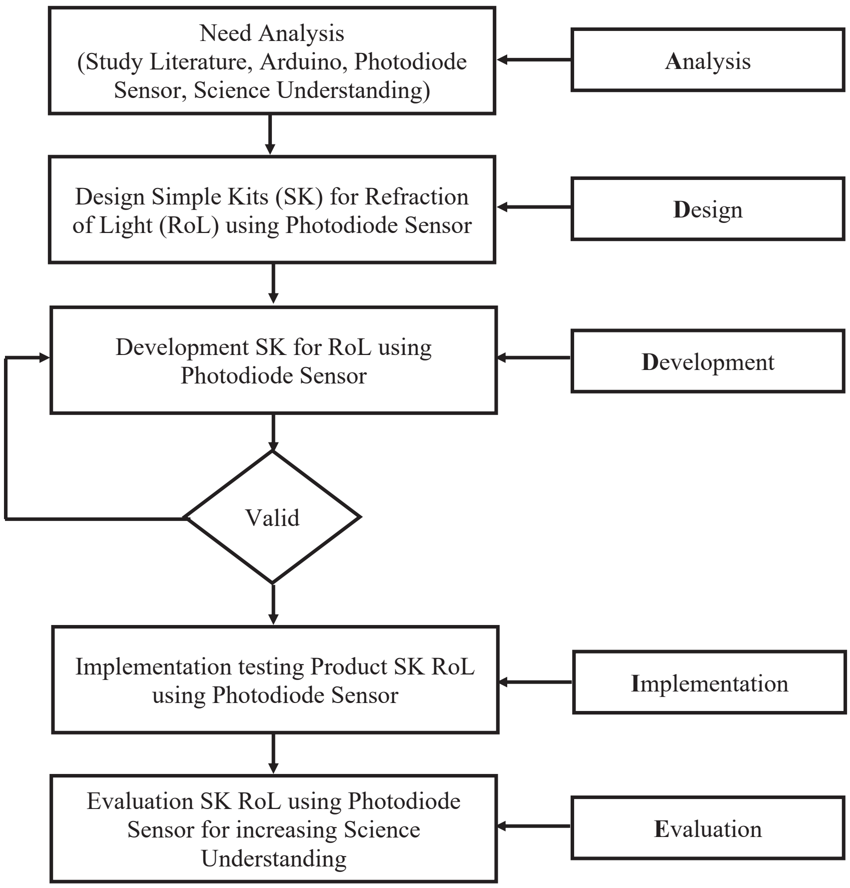

Fig. 1. Research of method of analysis, design, development, implementation and evaluation for development Simple Kits (SK) for refraction of light

The **Fig. 1**, information is obtained that the research design used in this Study uses the ADDIE model. Therefore, the stages of this research consist of, stages of this research consist of:

1) analysis by conducting a needs analysis on SK RoL Using Photodiode Sensors products to be developed;

2) design of SK RoL Using Photodiode Sensors;

3) development developing SK RoL Using Photodiode Sensors;

4) implementation by implementing SK RoL Using Photodiode Sensors to see student understanding of 74 from department of physics education in one of the provinces in Indonesia;

5) evaluation by revising the final SK RoL product.

2. 2. Phase analyze

What was done at the analysis stage was conducting a needs analysis and literature studies related to the light refraction kits that would be developed:

a. Needs Analysis.

The needs analysis was carried out at one of the from department of physics education in the Province of Jakarta, Indonesia, which was carried out randomly and got 80 respondents to see the needs analysis.

b. Study of Literature.

The literature study was carried out to find information from similar research that others had done before. The Development of a Light Refraction Practicum Set for Physics Learning in from student form department of physics education. In this research, a practicum set has been successfully developed for the sub-material of light refraction with laser beams and adjusting the angle of incidence. The results obtained from the lecturer and teacher validation of this practicum set show that the light refraction practicum set is feasible to be a practicum set for learning physics in from student department of physics education.

The design of light refraction kits to help improve students' problem-solving ability. Based on the study results, students were assisted in doing light refraction practicums, and using light refraction kits increased students' problem-solving abilities.

Based on the needs analysis and literature study results, it was shown that it was necessary to develop light refraction kits as a medium for teaching physics in university. Therefore, the research to be carried out is to develop light refraction kits using photodiode sensors as physics learning media.

2. 3. Design stage

The thing that was done at the design stage was to do the design to develop the Light Refraction Kits. Design planning aims to determine the material and series of kits to be developed. This stage is carried out to design Light Refraction Kits that are adjusted to the competency standards and essential competencies of the applicable curriculum. The design of the Side View Light Refracting Kit is shown in **Fig. 2** [24]:

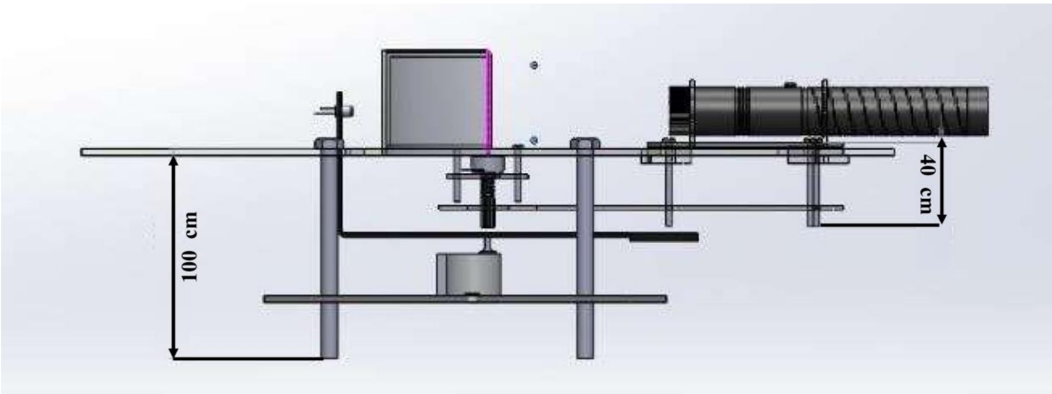

Fig. 2. Design of side view light refracting kits

Based on **Fig. 2**, information is obtained from the Side View Light Refraction Design Kits. The pallet distance of 100 cm and 40 cm is shown in the picture. In addition, there are blue laser light components, photodiode sensors, unipolar stepper motors, potentiometers, Arduino Uno R3 Atmega 328, containers, upper support boards, and lower support boards.

2. 4. Development stage

The thing to do at the development stage is to collect the tools and materials used to develop the light refraction kits according to the development design that has been designed. At this stage also developed Student Worksheets and manual books as supporting media for the developed light refraction kits. The next step is validating the light refraction kits by material and media experts.

2. 5. Implementation stage

After validating the light refraction kits by material experts and media experts, the next step is at the implementation stage, namely applying the results of the development of light refraction kits to students in the learning process. The Implementation of 74 students from university in one of the provinces in Indonesia.

2. 6. Evaluation stage

What was done at the evaluation stage was to evaluate the developed light refraction kits. The evaluation results are used as the basis for determining decisions regarding the light refraction kits that are developed.

3. Results

3. 1. Simple Kits (SK) products for (refraction of light ROL) using photodiode sensors

The research product is in the form of physics learning media in the form of light refraction kits using photodiode sensors for light refraction. The development of learning media in the form of light refraction kits using photodiode sensors can attract students' interest in learning and help make it easier for students to understand abstract physics material to become more accurate. Product specifications of light refraction research development kits:

1. The product developed from this research is learning media in the form of light refraction kits using a photodiode sensor.
2. The physics learning material that will be carried out in this study is light waves about light refraction.
3. Design of Light Refraction Kits using Solid Works software.
4. The resulting kits are light refraction kits equipped with a photodiode sensor to calculate the refractive index of a medium.

Based on the objectives and specifications of natural products for light refraction practicum, Light Refraction Kits Using Photodiode Sensors are designed. At the design stage, the process of designing light refraction kits using a photodiode sensor is carried out. Design planning aims to determine the materials and series of kits to be developed. This stage aims to design light refraction kits that are adjusted to the competency standards and essential competencies of the applicable curriculum. The design of light refraction kits using a photodiode sensor is as follows. The **Fig. 3** shows the design of light refraction kits using photodiode sensors [24].

This research also develops student worksheets and manual books. The developed Student Worksheet contains the steps of activities carried out by students in carrying out practicums using light refraction kits using photodiode sensors. The developed manual book contains information about the components of the light refraction kits using a photodiode sensor. In addition, there are instructions for using the kits and observation tables in the manual book. Below are some of the pages on the developed Student Worksheet. The results of simple kits development carried out by researchers in the form of Student worksheets & Manual Book Simple Kits Refraction of Light are shown in **Fig. 4**.

A manual book for this product is provided to complement and make it easier for students to use SK RoL. The kits manufacturing stage is carried out after carrying out the data collection stage and the design stage. Then, light refraction kits using photodiode sensors are developed based on the design designs made at the design stage. The following is a display of light refraction kits using a photodiode sensor that has been developed along with the components that make it. The results of simple kits development carried out by researchers in the Simple Kits for Refraction of Light are showing **Fig. 5**.

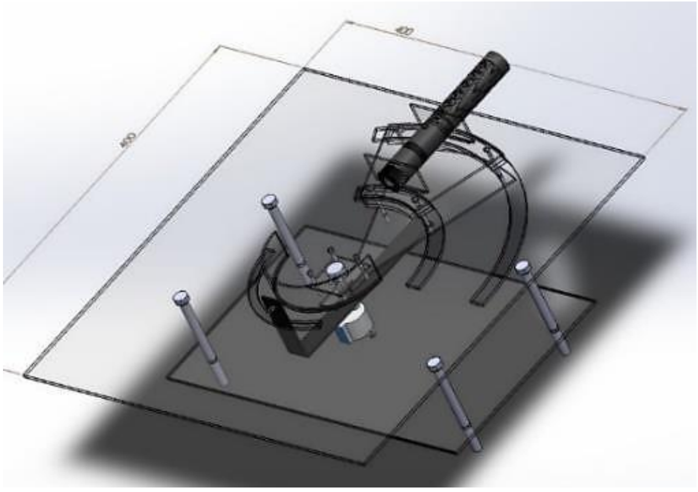

Fig. 3. Design of light refraction kits using photodiode sensors

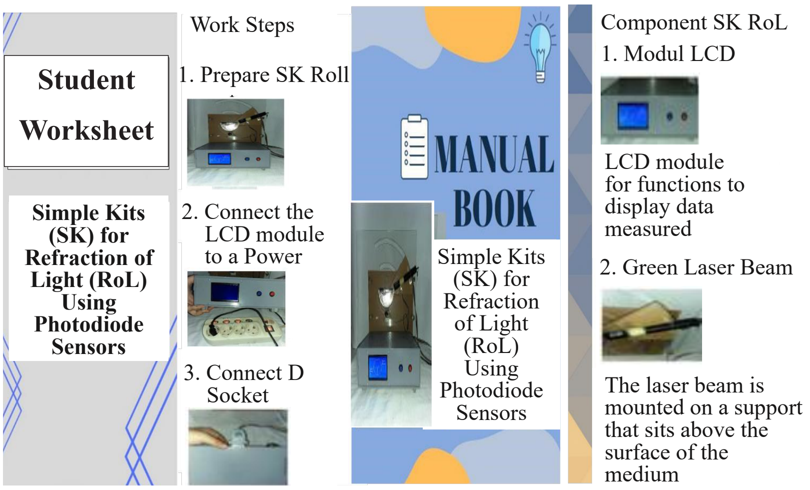

Fig. 4. Student worksheets & Manual Book Simple Kits Refraction of Light

Fig. 5. Kits Simple Kits for Refraction of Light

The components that make up the refraction kits using the photodiode sensor that has been developed are as follows:

1. Green Laser Beam.

The green laser beam serves as a light source. The laser beam is mounted on a support that sits above the surface of the medium and can be shifted 80° from positive y to positive x. The position of the laser beam determines the angle of incidence of the light. The results of simple kits development carried out by researchers in the Green Laser are shows **Fig. 6**:

Fig. 6. Green Laser

2. Photodiode sensor.

The photodiode sensor functions to receive light stimuli that experience refraction after passing through the medium. The photodiode sensor is installed at the bottom of the medium container to detect Refractive rays with the help of a stepper motor. A stepper motor assists the moving photodiode sensor in detecting the Refractive beam. The photodiode sensor holder is located on the same axis as the stepper motor and potentiometer, precisely with the zero-point position on the arc angle.

The results of simple kits development carried out by researchers in the Photodiode sensor are shows the **Fig. 7**:

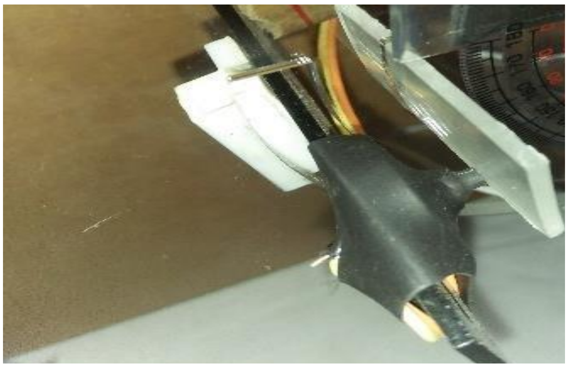

Fig. 7. Photodiode sensor [24]

3. Angle Arc.

The angle arc measures the angle of Refractive manually and as a reference for the surface boundaries of the medium used. The corner arcs are located between the supports on which the medium is placed. The zero point on the angular arc is located on a shaft with a potentiometer, stepper motor, and photodiode sensor support. Therefore, at the time of measurement, the surface boundary of the medium being tested must be precisely at the zero point of the arc to get accurate results.

The results of simple kits development carried out by researchers in Angle Arc are show **Fig. 8**:

Fig. 8. Angle Arc [24]

4. LCD module.

A box-shaped LCD module that functions to display data measured by potentiometers, photodiode sensors, and stepper motors. The data displayed is the angle of incidence and the angle of refraction. In using the LCD module, a source of electrical energy is needed. The red button on the LCD module functions as the power button. Furthermore, the blue button on the LCD module calibrates and measures the Refractive angle.

The results of simple kits development carried out by researchers in the display module and displayed data are shown in **Fig. 9**:

Fig. 9. Display module and displayed data

5. Potentiometer.

The potentiometer functions to calibrate the initial angle and measure the angle of incidence. The angle of incidence measured by the potentiometer is displayed on the LCD module. The potentiometer is on the back of the sectional board and mounted on a shaft with a stepper motor. A photodiode sensor support is located precisely at the arc angle's zero-point position.

6. Stepper motors.

The stepper motor measures the angle of refraction by moving the photodiode sensor to detect the Refractive light in the tested medium. The stepper motor is located on the back of the cross-section board. It is mounted on a shaft with a photodiode sensor support and potentiometer and is located precisely in the zero-angle arc position. The Refractive angle measured by the stepper motor is displayed on the LCD module.

7. Arduino.

Arduino serves as the control center of the kits. The Arduino used is the Arduino Uno R3 Atmega 328.

The results of simple kits development carried out by researchers in the Arduino Uno R3 Atmega 328 are show **Fig. 10**:

Fig. 10. Arduino Uno R3 Atmega 328 [24]

8. Cable box.

The cable box stores Arduino and cables, so they are arranged orderly. The cable box is attached to the back-support board.9. Medium and media containers.

The container for holding the medium in the shape of semicircle functions as a medium. The medium used in the light refraction kits using a photodiode sensor consists of two liquid media, namely water and glycerin, and a solid medium, acrylic, and resin. The results of simple kits development carried out by researchers in the Medium container are show **Fig. 11**:

Fig. 11. Medium container

The photodiode sensor in the light refraction kit is connected to Arduino Uno. Arduino UNO is programmed to display the incident angle and Refractive angle data on the Display module. The results of simple kits development carried out by researchers in the Making Programs Using Arduino Software are shown in **Fig. 12**:

Fig. 12. Making programs using Arduino Software

3. 2. Simple Kits (SK) for refraction of light (RoL)

Light refraction kits use photodiode sensors to show the phenomenon of light refraction. The data generated by the light refraction kits using a photodiode sensor are the angle of incidence and the angle of refraction. Light refraction kits using a photodiode sensor can show the effect of the angle of incidence on the angle of refraction and determine the refractive index of each medium being tested.

The medium to be tested is placed in a container containing the medium and then on support, where the medium is placed under the laser beam. The green laser beam is turned on as a light source and shifts the position of the laser beam to get the desired angle of incidence. Then press the blue button on the LCD module to run the stepper motor. The stepper motor is mounted on a single axis with a photodiode sensor support. After the blue button is pressed, the stepper motor will run to measure the Refractive angle and stop when the photodiode sensor detects the Refractive beam. The angle of incidence is determined by the position of the laser beam as the light source, measured by the potentiometer. In measuring the angle of refraction, the photodiode sensor detects the Refractive beam by being assisted by a stepper motor until the photodiode sensor finds the point where the Refractive beam is.

Trials of the light refraction practicum tool using a photodiode sensor were carried out to determine that the product being developed can function as it should in testing the light refraction practicum tool using a photodiode sensor varying the medium and angle of incidence. There are two types of medium used: liquid medium in the form of water and glycerin and solid medium in the form of acrylic and resin. The angle of incidence was varied from 15° to 60° with a difference of 5° for each trial. The light refraction practicum using a photodiode sensor displays experimental data in the form of the angle of incidence and the angle of refraction. Then based on the data displayed, the refractive index of each medium can be calculated.

Understanding concept for Measurement of Refractive Angle by Varying Medium and Incident Angle Measurements are made by varying the medium and angle of incidence. The medium used for measurement was water, glycerin, acrylic, and resin. The angle of incidence varies from 15° to 60° with a difference of 5° for each experiment. The results of the measurement results on water medium research conducted by researchers with 10 trials obtained the data shown in **Fig. 13**:

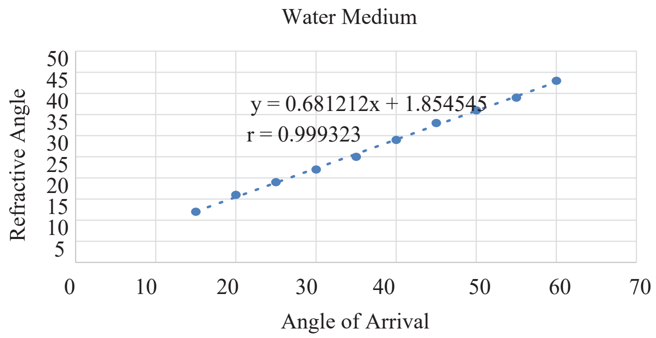

Fig. 13. Measurement results on water medium [24]

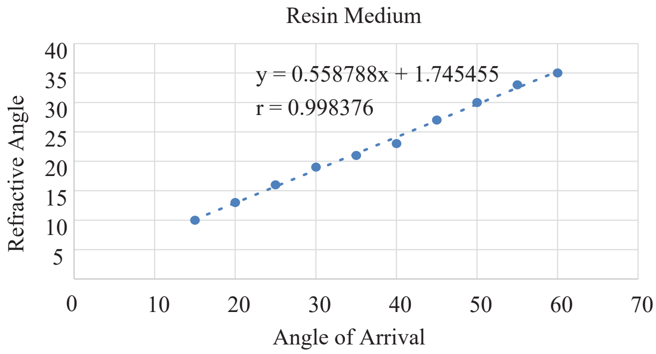

Fig. 14. Measurement Results on Resin Medium

Based on trials on the four media that have been carried out, it can be concluded that the four media tested to show the value of the angle of refraction increases when the angle of incidence also increases. The increase in the angle of refraction when the angle of incidence also increases because the four tested mediums have denser properties than the first medium, namely air.

4. Discussion

The measurement results from SK RoL on water Medium obtained results $y = 0.68x+1.85$. Angle of Arrive is formed at 15 degrees and forms a refractive angle at 10 degrees. In contrast, the largest angle of Measurement Results SK RoL on Water Medium Angle of Arrive is formed at 60 degrees and forms a refractive angle at 45 degrees to form a gradient that meets the good criteria with $y = 0.68x+1.85$ and $r = 0.99$. The measurement results from SK RoL on resin medium were $y = 0.56x+1.75$. Angle of Arrive is formed at 14 degrees and forms a refractive angle at 10 degrees. Meanwhile, the largest angle of Measurement Results SK RoL on Water Medium Angle of Arrive is formed at 60 degrees and forms a refractive angle at 5 degrees to form a gradient that meets the good criteria with $y = 0.56x+1.75$ and $r = 0.99$.

Measurement Results on Water Medium of $y = 0.68x+1.85$ & $r = 0.99$ and Measurement Results SK RoL on resin medium obtained results of $y = 0.56x+1.75$ & $r = 0.99$. This figure shows the gradient as a tangent line that passes through the abscissa point. This gradient is in the normal category because it is perpendicular to the tangent line. These results indicate that SK RoL has good accuracy as a physics learning medium on the refraction of light using photodiode sensors. This accuracy is due to the measurement accuracy of the fired green laser.

This research and development aim to develop and produce a product as a light refraction practicum tool using a photodiode sensor equipped with a student worksheet and manual book. The development model used in this study is the ADDIE development model [22, 23]. The ADDIE development model can be used for various forms of product development, such as learning strategies, learning methods, learning media, and teaching materials. Furthermore, the stages in the ADDIE development model are systematic, so this development model is a development model that is simple and easy to implement.

The group of students who experimented benefited more than those who did not, acquiring science process skills and basic practical performance skills, one of which was light refraction. Furthermore, most students need help applying the principle of light refraction to explain real-world situations. Development of Light Refraction Practicum Sets for Physics Learning, Weaknesses that need to be corrected are that the liquid and solid substances used do not vary, namely in liquids used only water and solids used only glass [25]. In addition, the light source used is a diode laser whose light is less able to focus and less visible when it enters the medium. Finally, the Design of a Light Refraction Practicum Tool to Help Improve Students' Problem-Solving Ability also has the same drawbacks as previous studies: still using a manual protractor [26]. Therefore, this research was conducted to correct the deficiencies that still exist in previous studies.

The product produced in this research and development is a light refraction practicum tool using a photodiode sensor. In addition to developing a light refraction practicum tool, this research also develops student worksheets and manual books. The components that make up the light refraction practicum tool using photodiode sensors that have been developed are green laser light, photodiode sensors, potentiometers, stepper motors, Arduino, angle arcs, LCD modules, cable boxes, medium containers, liquid mediums in the form of water and glycerin, and medium solids such as acrylic and resin.

Student worksheets that have been developed are composed of essential competencies, learning objectives, theoretical basis, experimental procedures, observation tables, and questions. Furthermore, the manual book that has been developed is composed of components of practicum tools, instructions for using practicum tools, and observation tables. The practicum tool for light refraction using a photodiode sensor that has been developed is also being tested by students. The trial by students was carried out online and was attended by 74 students from universities in one of the provinces in Indonesia.

The testing of the light refraction practicum tool using a photodiode sensor varying the medium and angle of incidence. There are two types of medium used: liquid medium in the form of water and glycerin and solid medium in the form of acrylic and resin. The angle of incidence was varied from 15° to 60° with a difference of 5° for each experiment. Based on the calculation of the refractive index of each medium that has been carried out, it can be concluded that the average value of the refractive index error for each medium is 3 % in the water medium, 2.7 % in the glycerin medium, 0.7 % in acrylic medium, and 2.7 % in glycerin medium, and 0.7 % in acrylic medium. Resins by 1.3 %.

The results showed that the developed SK RoL Using Photodiode Sensors could be used as a physics learning medium because it can visualize the concept of light refraction. In addition, SK RoL can also increase student understanding. It was concluded from this study that the SK RoL design as SK for RoL can be used as a physics learning medium to improve students' understanding. The advantage of the light refraction practicum using a photodiode sensor is that the laser beam used as a light source is green. The green laser beam has a sharp beam so that the photodiode sensor can detect the refractive beam precisely. The medium measured may vary because the container in which the medium is placed can be removed from the support and reassembled. Disadvantages of light refractieon practicum tools using photodiode sensors are. The surface of the tested medium must be precisely at the zero point on the angular arc so that the measurements made get the correct data [27, 28]. The Suggestion of SK and results of the research and discussion that has been done, the researchers suggest the following: 1) the container in which the medium is placed has boundary markings for the surface of the medium being measured; 2) the light refraction practicum developed is portable; 3) the support board on the light refraction practicum tool is thick.

5. Conclusions

The results showed that the developed SK RoL Using Photodiode Sensors could be used in physics learning because it can visualize the concept of light refraction and increase student understanding. The concept of light, which is microscopic and unobservable, makes it difficult for students to understand, so with the SK RoL tone, it is easy to demonstrate the nature of light, which is invisible to the eye. Furthermore, based on the results of the validation test by material and media experts, as well as the field test responses by physics teachers and students that have been carried out, the average value of the validation test results by material experts is 88 %. By media, experts are 87.82 %, and the results of field trials by physics teachers at 89.58 % and by students at 93.33 %. So, the Practicum Tool for Light Refraction Using Photodiode Sensors that has been developed meets the very feasible criteria so that it can be used as a physics learning medium for light refraction. The implications of developing a light refraction practicum tool using a photodiode sensor can be used as a learning medium to attract students' interest in learning, support the learning process, and help make it easier for students to understand abstract physics material to become more accurate.

Conflict of interest

The authors declare no conflict of interest.

Financing

This study was carried out with financial support from research and community service grants Faculty of Mathematics and Natural Sciences LPPM Universitas Negeri Jakarta, Directorate General of Higher Education, Research and Technology Ministry of Education, Culture, Research and Technology Indonesia.

Data availability

Manuscript has no associated data.

Acknowledgement

The authors would like to thank FMIPA and LPPM, Universitas Negeri Jakarta, and Directorate General of Higher Education, Research and Technology Ministry of Education, Culture, Research and Technology Indonesia in 2023 for support for research fund the 2023.

References

[1] Kaluza, Th. (2018). On the Unification Problem in Physics. International Journal of Modern Physics D, 27 (14), 1870001. doi: https://doi.org/10.1142/s0218271818700017

[2] Gholampour, A., Ozbakkaloglu, T. (2019). A review of natural fiber composites: properties, modification and processing techniques, characterization, applications. Journal of Materials Science, 55 (3), 829–892. doi: https://doi.org/10.1007/s10853-019-03990-y

[3] Cavazzana, A., Röhrborn, A., Garthus-Niegel, S., Larsson, M., Hummel, T., Croy, I. (2018). Sensory-specific impairment among older people. An investigation using both sensory thresholds and subjective measures across the five senses. PLOS ONE, 13 (8), e0202969. doi: https://doi.org/10.1371/journal.pone.0202969

[4] Xu, Y., Liu, X., Cao, X., Huang, C., Liu, E., Qian, S. et al. (2021). Artificial intelligence: A powerful paradigm for scientific research. The Innovation, 2 (4), 100179. doi: https://doi.org/10.1016/j.xinn.2021.100179

[5] Sirajudin, N., Suratno, J., Pamuti. (2021). Developing creativity through STEM education. Journal of Physics: Conference Series, 1806 (1), 012211. doi: https://doi.org/10.1088/1742-6596/1806/1/012211

[6] Jan, H. U., Uddin, M., Shah, I. A., Khan, S. U. (2022). On the eventual periodicity of fractional order dispersive wave equations using RBFS and transform. EUREKA: Physics and Engineering, 3, 133–148. doi: https://doi.org/10.21303/2461-4262.2022.002394

[7] Holly, M., Pirker, J., Resch, S., Brettschuh, S., Gütl, C. (2021). Designing VR Experiences-Expectations for Teaching and Learning in VR. Educational Technology & Society, 24 (2), 107–119. Available at: https://www.jstor.org/stable/27004935

[8] Miller, D. (2021). The Best Practice of Teach Computer Science Students to Use Paper Prototyping. International Journal of Technology, Innovation and Management (IJTIM), 1 (2), 42–63. doi: https://doi.org/10.54489/ijtim.v1i2.17

[9] Willcox, K. E., Ghattas, O., Heimbach, P. (2021). The imperative of physics-based modeling and inverse theory in computational science. Nature Computational Science, 1 (3), 166–168. doi: https://doi.org/10.1038/s43588-021-00040-z

[10] Rashidov, A. (2020). Development of creative and working with information competences of students in mathematics. European Journal of Research and Reflection in Educational Sciences, 8 (3), 10–15.

[11] Magana, A. J., Hwang, J., Feng, S., Rebello, S., Zu, T., Kao, D. (2022). Emotional and cognitive effects of learning with computer simulations and computer videogames. Journal of Computer Assisted Learning, 38 (3), 875–891. doi: https://doi.org/10.1111/jcal.12654

[12] Riyan Rizaldi, D., Doyan, A., Makhrus, Muh., Fatimah, Z., Nurhayati, E. (2021). Adaptation to New Normal Conditions. International Journal of Asian Education, 2 (3), 369–376. doi: https://doi.org/10.46966/ijae.v2i3.171

[13] Sefriani, R., Sepriana, R., Wijaya, I., Radyuli, P., Menrisal, M. (2021). Blended learning with Edmodo: The effectiveness of statistical learning during the COVID-19 pandemic. International Journal of Evaluation and Research in Education (IJERE), 10 (1), 293–299. doi: https://doi.org/10.11591/ijere.v10i1.20826

[14] Cheng, L., Ritzhaupt, A. D., Antonenko, P. (2018). Effects of the flipped classroom instructional strategy on students' learning outcomes: a meta-analysis. Educational Technology Research and Development, 67 (4), 793–824. doi: https://doi.org/10.1007/s11423-018-9633-7

[15] Chiarello, F. (2018). Playing With Light: A Game Based Approach to Learn Photonics in FabLabs. ECGBL 2018 12th European Conference on Game-Based Learning. Academic Conferences and publishing limited, 31. Available at: https://books.google.co.id/books?id=3n91DwAAQBAJ&printsec=frontcover&hl=id#v=onepage&q&f=false

[16] Baifeto, E. P. F., Aulia, M., Hasbi, J. E., Sundari, R., Rusdiana, D. (2021). Development of Mixed Learning Media (MLM) Assisted by Student Worksheet on The Topic of The Effect of Molarity on Light Index. Indonesian Journal of Science and Mathematics Education, 4 (2), 204–213. doi: https://doi.org/10.24042/ijsme.v4i2.9124

[17] Jaafar, R., Mat Daud, A. N. (2022). EM-FOR: simple and low-cost force on a straight current-carrying conductor in a magnetic field experimental kit. Physics Education, 58 (1), 015001. doi: https://doi.org/10.1088/1361-6552/ac987c

[18] Wye, S. (2022). Teaching remote laboratories using smart phone sensors: determining the density of air. Physics Education, 58 (1), 015002. doi: https://doi.org/10.1088/1361-6552/ac9816

[19] Monteiro, M., Stari, C., Martí, A. C. (2022). A home-lab experiment: resonance and sound speed using telescopic vacuum cleaner pipes. Physics Education, 58 (1), 013003. https://doi.org/10.1088/1361-6552/ac9ae1

[20] Widayanto, W. (2009). Development of process skills and understanding of class X students through optical kits. Jurnal Pendidikan Fisika Indonesia, 5 (1), 1–7. Available at: https://journal.unnes.ac.id/nju/index.php/JPFI/article/view/991

[21] Kadir, N. S., Yaacob, M. I. H. (2022). The Development and Usability of Optics Kit as a Teaching Aid among Physics Trainee Teachers. Journal of Physics: Conference Series, 2309 (1), 012040. doi: https://doi.org/10.1088/1742-6596/2309/1/012040

[22] Spatioti, A. G., Kazanidis, I., Pange, J. (2022). A Comparative Study of the ADDIE Instructional Design Model in Distance Education. Information, 13 (9), 402. doi: https://doi.org/10.3390/info13090402

[23] Branch, R. M. (2009). Instructional design: The ADDIE approach. Vol. 722. Springer Science & Business Media. doi: https://doi.org/10.1007/978-0-387-09506-6

[24] Maemunah, A. N., Siswoyo, S., Wibowo, F. C. (2020). Pengembangan Alat Praktikum Pembiasan Cahaya Menggunakan Sensor Photodioda Sebagai Media Pembelajaran Fisika. Prosiding Seminar Nasional Fisika (E-Journal), 9 (1), 163–168. doi: https://doi.org/10.21009/03.snf2020.02.pf.24

[25] Astuti, N. H., Sudjito, D. N., Noviandini, D. (2018). Applying venn diagram to present bloom's cognitive level of students of a physics learning about light refraction using developed independent lab work module and PhET simulation «bending light». Journal of Science and Science Education, 2 (1), 21–28. doi: https://doi.org/10.24246/josse.v2i1p21-28

[26] Dasilva, B. E., Kuswanto, H., Wilujeng, I., Jumadi. (2019). SSP Development with a Scaffolding Approach Assisted by PhET Simulation on Light Refraction to Improve Students' Critical Thinking Skills and Achievement of Science Process Skills. Journal of Physics: Conference Series, 1233 (1), 012044. doi: https://doi.org/10.1088/1742-6596/1233/1/012044

[27] Kobasko, N. (2017). Investigation of transient nucleate boiling processes and their practical use in heat treating industry. EUREKA: Physics and Engineering, 5, 39–48. doi: https://doi.org/10.21303/2461-4262.2017.00409

[28] Susilawati, S., Satriawan, M., Rizal, R., Sutarno, S. (2020). Fluid experiment design using video tracker and ultrasonic sensor devices to improve understanding of viscosity concept. Journal of Physics: Conference Series, 1521 (2), 022039. doi: https://doi.org/10.1088/1742-6596/1521/2/022039

Received date 19.12.2022
Accepted date 09.03.2023
Published date 22.03.2023

***How to cite:** Wibowo, F. C., Maemunah, A. N., Nasbey, H., Costu, B., Prahani, B. K., Permana, N. D., Darman, D. R., Samsudin, A. (2023). Development of simple kits (SK) refraction of light using photodiode sensors for student understanding. EUREKA: Physics and Engineering, 2, 3–16. doi: https://doi.org/10.21303/2461-4262.2023.002728*