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Collaborative inquiry integrated technological pedagogical content knowledge to improve higher-order thinking skills

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Abstract: This study aimed to generate a teaching package in a lesson plan and student worksheet using the TPACK integrated Collaborative Inquiry model, which can improve higher-order thinking skills (HOTS) validly and effectively. The development research design followed the four-D-models development model, consisting of 4 phases: define, design, develop, and disseminate. At define, several observations and literacy studies were carried out. At design, teaching materials were designed. The experts validated the teaching materials in development, namely two lecturers and two teachers as users. Based on the validation results, it is found that the lesson plan and student worksheet were within the good or valid criteria to be used. HOTS was measured using two-tier multiple-choice in the form of 15 questions with good categories and high-reliability categories. The feasibility test was based on expert validation. The results show that the teaching material is in good criteria, so it is suitable for use under several conditions. The implementation results can affect the differences in the results of the pretest and post-test student's HOTS-based observation during learning and increased scores.

Keywords: *collaborative inquiry, higher order thinking skills, TPACK*

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INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) has affected the education sector. Learning activities in the education sector might become an integrated part of the future's cyber-physical manufacturing system of Industry 4.0 (Tvenge & Martinsen, 2018, p 261-266). The world's demand for a more efficient in-class learning system is the 21st-century skills, also known as 4C, which consists of communication, critical thinking, collaboration, and creativity. Technology usage aims to provide more opportunities for the students to think critically using an analytical approach and make learning more efficient (Pouezevara, Mekhael, & Darcy, 2014, p 120-141). The implemented 2013 Curriculum uses an approach that emphasizes on process skills, environmental use, science, technology, and society. This curriculum obliges the students to possess higher-order thinking skills to be further developed as future skills. The ability to produce and process information at a complex level is integral in considering problem-solving choices (Lopes, Mesquita, Río-Rama, & Álvarez-García, 2018, pp. 39-50). Higher-order thinking skills are used to analyze experiment results and accustom the students to utilizing science, technology, and society around them. These skills also focus on developing the student's ability to analyze effectively, evaluate by inferring from available information, and create (synthesize) something new.

However, the student's higher-order thinking skills are relatively low. This is supported by Agustini and Fajriyah's findings that showed that elementary student's higher-order thinking skills fall within the category of low, with an average score of 40 (2018, pp. 1-6). A study focused on the junior high school student thinking competence in answering PISA-standard questions resulted in 18 students and 12 students categorized as average and low, respectively, out of 30 students (Kurniati, Harimukti, & Jamil, 2016, pp. 142-155). Based on the observation and interviews of several teachers in the junior high school Malang, students tend to face difficulties in doing analysis questions requiring higher-order thinking skills. Other developing countries, including Malaysia, seem to be struggling with higher-order thinking skills in education (Chinedu, Olabiyi, & Kamin, 2015, pp. 35-43). The initial observation shows that not all junior high school teachers understand higher-order thinking skills and the related teaching methods. Some teachers have used the learning models recommended by the Ministry of Education and Culture, even though they focus more on syntax functioning instead of developing the student's higher-order thinking skills. Therefore, teachers should be assisted in developing their competence to foster their student's higher order thinking competence.

The development of technology usage in the learning process is crucial to assist the teachers with providing knowledge stimulus to help students comprehend the learning contents (Koehler & Mishra, 2009, pp. 60-70). Teaching is a complex domain in which three components of knowledge (technology, pedagogy, and content) must be integrated to be implemented in a dynamic and diverse classroom (Koehler, Mishra, & Cain, 2013, pp. 13-19). However, Technological Pedagogical Content Knowledge's (TPACK's) framework focuses only on technology, pedagogy, and content, which do not represent the correlation between them (Tanak, 2020, pp. 53-59). Hence, incorporating those three domains in learning activities is pivotal in creating practical learning activities and teaching essential content. TPACK-based learning tools might improve the student's critical thinking skills (Mairisiska, Sutrisno, & Asrial, 2014, pp. 28-37). On the other hand, the implementation of TPACK-based learning is usually hampered by the availability of learning facilities and equipment (Malik, Rohendi, & Widiaty, 2019, p 498-503). Previous studies often found that various learning strategies are used to foster higher-order thinking skills, but there is a diminutive number of learning facilities that utilize technology (Chinedu et al., 2015, p 35-43).

The teacher's role is of paramount importance in the whole learning process (Lopes et al., 2018, p 39-50). The quality of their pedagogical skills directly affects the student's quality. In addition, higher-order thinking skills might be improved using the constructivist approach. Learning that uses a guided inquiry-based module is also fairly effective in developing higher-order thinking skills with moderate criteria. Inquiry-based learning can nurture higher-order thinking skills (Muspawi, Suratno, & Ridwan, 2019, pp. 208-214; Kartika & Noer, 2019, pp. 103-107). Collaborative inquiry (CI) is a part of collaborative learning. The implemented collaborative inquiry learning model has proven to improve the teachers' professionalism in teaching, as well as the student's Higher order thinking skills (Chinedu et al., 2015, p 35-43).

A study by Langgeng, Sajidan, and Prayitno (2017, pp. 1-16) found that collaborative inquiry that is based on local potential can improve the Higher order thinking skills and creativity of the students. A study that focused on the mathematics subject was conducted using the collaborative inquiry learning model, resulting in the improvement of the student's mathematical reflective ability to solve mathematical problems around them and think constructively (Kartika & Noer, 2019, pp. 103-107). In the same vein, a study focusing on the physics subject's impulse, momentum, and collision topic found that a collaborative inquiry learning model improves the student's critical thinking skills and creativity (Sipayung, 2018, p. 10). Another topic that requires the student's higher order thinking skills is optics.

The topic of optics, taught at the junior high school level, is the basic and compulsory knowledge that the students must master. The basic competencies issued by the government are the standard of the student's ability. At the cognitive level, this topic demands the junior high school students to analyze the properties of light, the formation of shadow on flat and concave mirrors, and their implementation to explain the human and animal visual processing and the principles of optics. At the psychomotor level, they have to be able to present the experiment results on shadow formation on mirrors and lenses. Previous studies discovered that misconception is often found in the optics topic, which includes inaccurate predictions about the shadow formation when the light passes through a perforated screen, virtual and real images, and shadow formation on a flat mirror (Sutopo, 2014,; Syarif, Djudin, & Hamdani, 2016; Sheftyawan, Prihandono, & Lesmono, 2018, pp. 147-153). This topic must be developed because it requires technology use in the learning process.

The collaborative inquiry (CI) model applied in web-shaped technology reveals that CI learning positively impacts student learning outcomes. However, the teacher's role in utilizing technology is still not optimal. (Raes & Schellens, 2015, pp. 405- 430). Several activities cannot be done optimally while teaching using a TPACK framework, such as note-taking, debating, developing/constructing a model, in addition to the students who do not ask questions due to low self-esteem (Hayati, Sutrisno, & Lukman, 2014, pp. 53-61). For that reason, it is required to develop learning content that helps the teachers optimize using technology in the learning process and improve higher thinking skills.

METHOD

This study used research and development design with a procedure that follows the development model of 4-D (Four-D Models) (Thiagarajan, 1974, p. 13). This study focused on the development of learning tools that consist of Learning content, a lesson plan that used the TPACK-integrated collaborative inquiry model (CI-TPACK), and a student's worksheet that was developed according to the CI-TPACK learning steps. This learning content used two-tier multiple-choice questions.

There were four stages in developing the learning tools using the TPACK-integrated CI model, namely: Define; Design; Develop; and Disseminate. The elaboration of each stage is as follows.

Define stage. In this stage, an analysis on the curriculum used in grade VIII on properties of light and optical devices was conducted, in addition to students and teachers' need analyses. Curriculum analysis included the compulsory core and basic competencies. Student's need analysis included score analysis prior to optic lesson, and literature review on the difficulties faced by students in the optics topic. Teacher's need analysis included interviews on lessons taught and a literature review on the teachers' methods to make the learning process more efficient and improve the student's higher-order thinking skills.

Design stage. The design was adjusted to the curriculum results and students and teachers' need analyses. In this stage, a lesson plan that used the CI-TPACK model was created, in addition to the content of the student's worksheet that follows CI-TPACK syntax and the two-tier multiple-choice questions' outlines.

D*evelop stage*. In this stage, after the lesson plan, student's worksheet, and two-tier multiple-choice questions were developed, they were validated by the experts comprising one master's programme lecturer, one undergraduate programme lecturer, and two junior high school teachers as the users. It was followed by revision, individual, small-group, field-testing, and another revision.

Disseminate stage. In this stage, the tools were implemented in two classes in one school. Implementation in other schools was not feasible due to the online learning during the COVID-19 pandemic.

There are two types of data in this research which are qualitative and quantitative data. The qualitative data were collected through a validity checklist by a validator (experts from a lecturer or senior teacher). The quantitative data were collected from the item analyses in the form of validity, reliability, discriminating power, and level of difficulty tests. The test consists of 15 items with a reliability value 0.896. Four items have very good discrimination index and the others are good. For the difficulty level, two items were easy, and the others were pretty easy.

The data collection used instruments such as the validation sheets of the lesson plan, student worksheets, and two-tier multiple-choice questions. The collected data were analyzed using descriptive statistics. The results of the questionnaire were described to evaluate the results of development. Meanwhile, the assessment results from the experts, which were the lecturers and teachers, about the lesson plan, student worksheet, and question items were analyzed using a percentage descriptive technique (Purwanto, 2010, p. 32).

The questionnaire results of the limited testing on the two-tier multiple-choice questions were analyzed in the design stage using a percentage descriptive technique. Qualitative and quantitative data were the data obtained from field testing. The qualitative data were collected from the results of the practicality of the lesson plan, student worksheet and two-tier multiple-choice questions. These data were analyzed using a percentage descriptive technique. The quantitative data were collected from testing the two-tier multiple-choice questions, including the validity, reliability, discriminating power, and level of difficulty tests using SPSS 16.0, which were adjusted to the criteria (Arikunto, 2008, p. 38). The result showed that the teaching materials were field-tested at the Disseminate stage in two classes in Jombang Regency. The trial was conducted to determine the effectiveness of teaching materials in improving higher-order thinking skills. High-level thinking skills in this study were tested with 15 two-stage multiple-choice questions, given before (pretest) and after (posttest) learning. The quantitative analysis stage carried out was descriptive statistics, prerequisite tests, differential power statistical tests, normalized gain scores, and effect sizes, and further explained by qualitative analysis.

FINDING AND DISCUSSION

This research generated a learning content that uses the TPACK-integrated collaborative inquiry model to improve the high school student's Higher order thinking skills on the properties of light and optical devices using a 4D model. The first stage is to define, which has five steps: Conducting a front-end analysis that aims to analyze the learning needs from the interview results of students, teachers, and literature review. The researchers discovered that the topic of properties of light and optical devices is deemed difficult, in which the students often have misconceptions due to the lack of learning media to visualize the reflected or biased ray propagation. Hence, the students were unable to correlate the theories with phenomena found in daily life. The 2019 National Exam results for optics topic are in a low category (Puspendik Kemdikbud, 2019). They were analyzing the students, and the researchers found that they were not accustomed to using technology (both computers and the Internet) in teaching and learning.

Consequently, the Higher order thinking skills in analyzing, evaluating, and creating was still considered low; analyzing the tasks, in which the researcher found that efforts to improve the student's Higher order thinking skills were not well-manifested in the tasks given to the students. Furthermore, there was little to no practicum throughout the topic, analyzing the concept, where the researchers arranged the learning contents according to their importance level, focusing on the concepts often misunderstood by the students, and formulating the learning objectives based on the basic competencies required at the junior high school level. The results of analyses done by the researchers became the focus of developing the lesson plan, student's worksheet, and two-tier multiple-choice questions for the Higher order thinking skills test.

The material analysis also takes into account the results of the 2020 national exam, the optical material that has been reported by Puspendikbud states, that the percentage of correct answers from the indicators tested about determining the number of images produced on two angled mirrors is 26.76% and the percentage of indicators tested is about distance comparisons. Objects, shadows, and focus in people with eye defects were 26.91%. From the two indicators of optical material testing, student's knowledge is still in the low category. Some of the obstacles from the interviews conducted by sample students who have received optical material are that they cannot describe abstract beams of light and have complex mathematical calculation skills. This can be a consideration in preparing an RPP when explaining concepts related to calculation.

At the define stage, several alternative solutions have been given, including when learning in the classroom, students need to be trained in multi presentations, including verbal, visual, symbolic, and mathematical, so that students are active (Puspendik Kemdikbud, 2019). Assessment questions are used not only at the level of knowledge/understanding but also applied on an everyday basis so that students easily remember the concepts and lessons that have been taught (Sheftyawan et al., 2018, pp. 147-153). Giving questions in the form of problem-solving can also help students construct various existing problems into new explanations (Rahayu & Laksono, 2015, pp. 29-43). Alternative solutions that have been given become materials for developing the lesson plan and student's worksheet.

The second stage designs, the design of this stage has three steps, namely: Preparing the contents of the lesson plan and student's worksheet according to the essential competencies that must be achieved, Researchers found that at the cognitive level (KI3), students must be able to analyze, and at the psychomotor level (KI4), students must present experimental data. It can be concluded that KD demands students to master the cognitive level C3 (analyze) and conduct experiments (C4/C5) (Anderson & Krathwohl, 2001). In content analysis, the researchers found that student's misconceptions occurred in understanding the concept of the ray diagram forming an image on a flat mirror (Sheftyawan et al., 2018, pp. 147-153).

Misconceptions about the nature and formation of images are caused by incorrect teacher delivery (Sutopo, 2014, pp. 356-368). This becomes the basis for developing teaching materials that help teachers teach correct concepts. This concept can be taught by visualizing the passage of rays until an image is formed. The material analysis results also form the basis for preparing questions to test student's higher-order thinking skills.

Selecting the media and learning models that fit the needs, the researchers use the TPACK-integrated collaborative inquiry model. The researchers have conducted the analysis and found a problem that must be solved. Researchers also consider how teachers can understand students and make learning meaningful. Researchers found several things to help teachers in the learning process assisted by technology. Teachers use technology to help teach complex concepts. Researchers used the collaborative learning model phase consisting of 4 stages: problem framing, collecting evidence, analyzing evidence, celebrating, and sharing (Donohoo, 2013, pp. 1-37). Collaborative inquiry learning helps students review their thought processes and allows individuals to communicate logical ideas and choose appropriate solutions (Kartika & Noer, 2019, p 103-107). Collaborative inquiry based on local potential can improve student's Higher order thinking skills and creativity (Langgeng et al., 2017, pp. 1-16). Learning using the TPACK approach can also train students in observing phenomena, animation, and videos in everyday life (Irmita & Atun, 2017, pp. 84-90). Researchers aim to improve high-level thinking skills supported by the use of technology in the form of teaching materials using the collaborative inquiry model which is integrated with TPACK.

It was choosing the arrangement format and producing a learning step framework such as Table 1. The student's worksheet was developed according to the CI-TPACK learning steps and designed in Microsoft Word. The lesson plan is divided into four meetings: meeting one sub-chapter of the properties of light and reflection on a flat mirror, a meeting of 2 sub-chapters of light reflection on curved (concave and convex) mirrors, and meeting of 3 sub-chapters of refraction on concave and convex lenses and its implementation in insect eyes and meeting four sub-chapters of optical instruments. HOTS questions were developed with a two-stage multiple choice consisting of 15 questions. Researchers developed a cognitive assessment test using a two-tier multiple-choice model. Two-tier multiple choice questions consisting of statements and supporting reasons. Multiple choice with two-tier can measure student's high-level thinking skills with valid quality results according to their achievement indicators (Maulita & Marzuki, 2019, pp. 1-8). Problems with this model can also identify misconceptions that occur in students because it can be seen from the reasons given (Peşman & Eryılmaz, 2010, pp. 208-222).

The third stage is to develop. In this stage, the lesson plan validation test, the student's worksheet, and two-tier multiple-choice questions were carried out. Validation is used to test the feasibility of the teaching materials that have been developed. The feasibility test is carried out by one lecturer in the master's programme, one lecturer in the undergraduate programme, and two teachers who had been teaching junior high school for more than ten years. The results are presented on Tables 2 and 3.

Based on the validator's input, including some of the use of indicators for achieving competence was not quite right, the writing of learning objectives was not correct, the time allocation for the practicum implementation was given additional time. They concluded that the assessment tested by experts is in good criteria and the lesson plan is suitable for use with minor revisions.

Table 1. The syntax of collaborative inquiry model integrated TPACK for the second meeting

Syntax CI	Component of TPACK	Learning Activities
Problem framing	TPACK (Technological Pedagogical Content Knowledge)	The teacher uses videos to facilitate the delivery of lesson, and they help teachers in visualizing the concept of reflection on a convex mirror
Collecting data	TPACK (Technological Pedagogical Content Knowledge)	The teacher uses experimental tools to make it easier to explain the concept of image formation on concave and convex lenses by paying attention to the distance of objects, rarely the image and the focal length of the lens
Analyzing Evidence	TPACK (Technological Pedagogical Content Knowledge)	The teacher uses several tools to experiment and to make it easier to explain the concept of image formation on concave and convex lenses by paying attention to the distance of objects, the length of the shadow, and the focal length of the lens.
Celebrating and Sharing	PCK (Pedagogical Content Knowledge)	The teacher uses classical conditioning in the classroom to observe the explanation of the analysis results from other groups so that there is no misunderstanding

Table 2. Results of the assessment of the feasibility indicators for the lesson plan materials

No	Indication	Score (%)	Criteria
1	Completeness of lesson plans (contains lesson plan components, namely identity, learning objectives, materials, methods, learning activities, learning resources, and assessments)	93.75	Very good
2	Writing lesson plans (numbering, type, and font size)	93.75	Very good
3	Adequacy of learning indicators as a marker of achieving basic competence	81.25	Good
4	The suitability of the prerequisite material with the lesson content that is being taught	93.75	Very good
5	The suitability of learning activities with the syntax of the TPACK-integrated collaborative inquiry model	93.75	Very good
6	Each learning step is displayed	93.75	Very good
7	The suitability of the estimated time allocation with the activities carried out	87.50	Very good
8	The suitability of the use of technical assistance with TPACK components	87.50	Very good
9	The correct use of Indonesian language	100	Very good
10	The language used is short, clear, and does not cause misunderstandings.	100	Very good

Table 3. The results of the assessment of the student's worksheet instrument feasibility indicators

No	Indication	Score (%)	Criteria
1	Completeness of the student's worksheet's structure (chapter title, working instructions, supporting information (illustrations and pictures), exact steps on how to work on questions, steps to conduct experiments and space to write answers)	100	Very good
2	Clarity of student's worksheet format (font type, font size, and numbering system)	93.75	Very good
3	The appearance of the student's worksheet (layout, pictures, tables, and diagrams)	100	Very good
4	Student's worksheet fits in with the indicators	93.75	Very good
5	Suitability of the task and how it is in order with the lesson content	93.75	Very good
6	The tasks are suitable, and it is the TPACK-integrated collaborative inquiry model to increase student HOTS.	93.75	Very good
7	The use of correct Indonesian language	93.75	Very good
8	The language used is short, clear, and does not cause misunderstanding.	93.75	Very good
9	The simplicity of the language used and the suitability of the language with the level of thinking of students	87.50	Very good

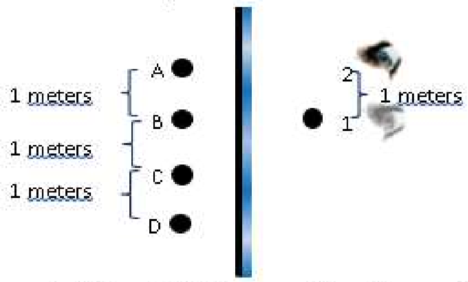
Based on the validator's input, there are still unclear work instructions in the student's worksheet. The conclusion made is that the assessment is in good criteria and the student's worksheet is suitable for use with minor revisions. Minor revisions that have been revised include the clarity of command words in conducting experiments and the use of standard and easy-to-understand Indonesian language. The indicators for assessing the feasibility of two-tier questions include the suitability of the items with the HOTS indicator, the correctness of the questions, the correctness of the answers, using good and correct Indonesian, and The formulation of the questions is easy to understand. It does not cause interpretive signs Based on the results of the assessment, there were several inputs from the validator, including writing the Indonesian spelling that was not correct, there were several indicators that were not yet correct, there was 1 question that did not match the validator's intention, so there was 1 question revision. The conclusion is that the assessment to find out the difference before and after being given a collaborative inquiry of the feasibility test indicators by experts is good criteria. HOTS questions with two-tier multiple-choice is worthy for use with minor revisions (Figure 1). Minor revisions that have been revised include the suitability of the HOTS indicator with the items given, and the error of the answer key with the question.

In the third stage, the multiple-choice HOTS questions were also tested on 33 students who had taken the material to test the questions' validity, reliability, differentiation, and difficulty. After being analyzed using SPSS 16.0, the analysis was validity because the number of respondents was 33 (r_{table} = 0.344 {5%}), so to determine the criteria: $r_{bi} > r_{critical}$ = valid. The conclusion: 15 questions in the valid category, 11 questions have different power in the good category, and four questions have a different power in the very good category, 13

Figure 1. HOTS questions with two-tier multiple choice

1. When it rains, sometimes lightning and thunder occur. What is the sequence of events that occur...
   A. Lightning and thunder sound together..
   B. Lightning then thunder.
   C. Sound of thunder then lightning..
   D. Lightning only.
   Reason.
   A. Lightning is a sound wave that has a speed of 340 m/s, while thunder is an electromagnetic wave that has a speed of $3x10^8$ m/s.
   B. Lightning is an electromagnetic wave that has a speed of $3x10^8$ m/s, while thunder is a sound wave that has a speed of 340 m/s.
   C. Lightning is a sound wave that has a speed of $3x10^8$ m/s, while thunder is an electromagnetic wave that has a speed 340 m/s.
   D. Lightning and thunder are electromagnetic waves that have a speed of $3x10^8$ m/s.

3. When Tiara observes objects from position 1, an image of the object is formed at point B (as shown below).



When the Tiara shifts from position 1 to position 2, a shadow is formed on...
A. Point A (image shifts 1 meter up)
B. Point B (image does not shift)
C. Point C (image shifts 1 meter down)
D. Point D (image shifts 2 meters down)
Reason.
A. The location of the image depends on the position of the object, the location of the mirror and the distance from the observer.
B. The location of the image does not depend on the location of the object, the location of the mirror, and the location of the observer.
C. The location of the image only depends on the position of the object and the location of the observer, not the location of the mirror.
D. The location of the image only depends on the location of the object and the location of the mirror, not the location of the observer.

questions have a difficulty level in the medium category, and two questions have a difficulty level in the easy category. 15 questions had high reliability category (*r = 0.869*). After the students finished working on it, they were asked to rate questions, and an assessment was created, as shown in Table 4.

Table 4. Results of assessment of HOTS question instruments in limited trials

No	Indication	Score (%)	Criteria
1	The sentences are easy to understand	84.09	Good
2	The meaning of the question is understandable	83.33	Good
3	Uses clear terms	82.58	Good
4	The instructions given are clear	81.06	Good
5	Use of punctuation and correct spelling	84.09	Good

The validation results were analyzed using descriptive percentages and concluded that the lesson plan, student's worksheet, and questions were feasible with specific notes. The results of field trials, two-tier multiple-choice questions that have been analyzed by SPSS 16.0, in the calculation of the validity because the number of respondents is 33 ($r_{table}=0.344$ *(5%))* then, to determine the criteria: $r_{bi}>r_{critical}$ = valid. The analysis results concluded that 15 questions were in the correct category and the high-reliability category ($r=0.869$).

At the Develop stage, teaching materials are implemented in two classes of 31 students. The learning is carried out at the teacher's house because it is still in a pandemic. The first meeting with the sub-chapter of the material properties of light and reflection on a flat mirror with an angled mirror practicum, and learning implementation by 94%. The second meeting with sub-material reflections on curved mirrors, practicum on image formation on concave mirrors, and learning implementation by 92%. The third meeting with sub-material on light refraction with refraction practicum on a convex lens, and learning implementation by 94%. The fourth meeting was with sub-material on optical instruments with the manufacture of products in the form of telescopes, 80% of learning outcomes. The assignment of product manufacturing has been given at the first meeting and will be presented at the last meeting.

The results of the interview before the implementation were obtained, students during the Science-Physics learning had never carried out practicum, and the teacher had not used technology in learning, only using worksheets and explaining on the blackboard. After the first learning, interviews were conducted with a sample of students. Students were enthusiastic in learning but still confused in making questions focused on problems and analyzing experimental results. At the third and fourth meetings, it was observed that students were faster in making questions and only needed assistance in analyzing the results of the experiment. Based on interviews with previous teachers who taught in the class, it was found that the average student was weak in mathematical calculations. Research by Winarti, Rahmini, and Almubarak (2019, pp. 172-186), states that mathematical calculation skills can affect student's critical thinking. The ability to think in analyzing is greatly influenced by the arithmetic ability of students.The results of practicum observations at each meeting experienced an increase in speed in completing the analysis and concluding the experimental results.

The implementation of teaching materials also found that teachers' knowledge of technology, pedagogy, and knowledge content (TPACK) was very influential in the teaching process. Supported by Sutopo (2014, pp. 356-368) study of learning optical materials, teachers must facilitate students in exploring students factual knowledge and validating the material taught and double-checking what students say.

Research data analysis for student's high-level thinking skills on optical material after being taught with TPACK integrated Collaborative Inquiry learning was carried out in stages. The analysis phase is descriptive statistics, prerequisite test, difference power statistical test, normalized gain score, and effect size. Descriptive Results Student's higher-order thinking abilities in two classes are presented in Tables 5 and 6.

Table 5. Descriptive results of pretest and posttest higher-order thinking skills of class 9A

	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	16	8.06	7.94	0.00	20.00
Posttest	16	59.69	34.38	0.00	93.00

Table 6. Descriptive results of pretest and posttest higher-order thinking skills of class 9B

	N	Mean	Std. Deviation	Minimum	Maximum
Pretest	15	15.67	12.49	0.00	46.00
Posttest	15	37.40	29.99	0.00	80.00

After obtaining the pretest and posttest data, it was continued with the prerequisite test. The prerequisite test in two classes was carried out in the form of a normality test using Shapiro Wilk with the results shown in Tables 7 and 8.

Table 7. Shapiro wilk normality test results data pretest and posttest higher-order thinking skills of class 9A

	Statistic	df	Sig.	Description
Pretest	0.800	16	0.003	Not Normally Distributed
Posttest	0.855	16	0.016	Not Normally Distributed

Table 8. Shapiro wilk normality test results data pretest and posttest higher-order thinking skills of class 9B

	Statistic	df	Sig.	Description
Pretest	0.916	15	0.170	Normally Distributed
Posttest	0.891	15	0.071	Normally Distributed

The results of the Shapiro Wilk normality test showed that the pretest and posttest data on student's high-level thinking abilities of optical material in class 9A were not normally distributed as in Table 7. The conclusion that shows the pretest and posttest data are not normally distributed is based on the significant value of the pretest and posttest of 0.003 and 0.016, which is smaller than the value of $\alpha=0.05$ (Leech, Barrett, & Morgan, 2005). The results of the Shapiro Wilk normality test in Table 8 indicate that the pretest and posttest data on student's high-level thinking skills in optical material class 9B are normally distributed. Conclusion that shows the pretest and posttest data is normally distributed based on the significant value of the pretest and posttest of 0.170 and 0.071 which is greater than the value of α=0.05 (Leech *et al*., 2005).

In class 9A, pretest and posttest data that were not normally distributed were then analyzed using the nonparametric Wilcoxon Signed Rank Test. Based on the output of the Wilcoxon Signed Rank Test, it is known that Asymp.Sig (2-tailed) has a value of 0.001. The value of *0.001<0.05*, it can be concluded that there is a difference between the pretest score and the posttest value of the high-level thinking ability of optical material in grade 9A students (Hake, 1998, pp. 64-74).

In class 9B, the pretest and posttest data were normally distributed then analyzed by using the parametric test Paired Sample T-Test. Based on the output of the Statistical Test on the Paired Sample T-Test, it is known that Sig (2-tailed) has a value of 0.018. The value of 0.018 <0.05, it can be concluded that there is a difference between the pretest score and the posttest value of the high-level thinking ability of optical material in grade 9B students (Hake, 1998, pp. 64-74).

Furthermore, the pretest and posttest scores in the two classes were statistically tested using the Normalized Gain Score and effect size tests. The pretest and posttest values were analyzed by calculating the normalized average gain score data (N-Gain) to determine the increase in higher-order thinking skills. The results of the statistical Normalized Gain Score and effect size tests are shown in Table 9.

Table 9. Result of the normalized gain score and effect size tests

Classes	Criteria	Score	Category
9A	N-Gain (use mean)	0,56	Medium
	Effect Size	1,39	Strong
9B	N-Gain	0,24	Low
	Effect Size	0,58	Medium

The strength of the difference in the mean pretest and posttest scores was analyzed using the effect size. class 9A shows an N-Gain value <*g*> of 0.56 which is in the medium category, based on the normalized gain value of *0.3 ≤ (<g>) <0.7* (Hake, 1998, pp. 64-74). Based on the calculation of the Normalized Gain Score, it can be concluded that the increase in the pretest to posttest scores of student's high-level thinking skills through integrated collaborative inquiry learning TPACK is included in the medium category. Class 9B shows an N-Gain value <*g*> of 0.24 which is in the low category, based on the normalized gain value *(<g>) <0.7* (Hake, 1998, pp. 64-74). Based on the calculation of the Normalized Gain Score it can be concluded that the increase in the pretest to posttest scores of student's high-level thinking abilities through integrated collaborative inquiry learning TPACK is included in the low category.

In class 9A, shows the results of the calculation of the effect size value of 1.39. This shows that the effect of TPACK integrated collaborative inquiry learning on optical material on student's high-level thinking skills is in a strong category (Cohen, Manion, & Morrison, 2007). Class 9B shows the result of the calculation of the effect size value of 0.58. This shows that the effect of TPACK integrated collaborative inquiry learning on optical material on student's high-level thinking skills is in the medium category (Cohen *et al*., 2007).

The average posttest score is not too significant due to several observed causes, including: students entering the teacher's house cause sometimes many are not serious, taking too long distance schooling so that children lack concentration when explained, many forget how to calculate very simple mathematics, and the most visible is the usual conventional learning makes it difficult for them to think analysts and think at high levels.

Based on the results of the interview after doing the lesson, it was found: students had difficulty in describing the formation of images because they had to adjust to the location of special objects and rays and analysis that calculated the object distance, image distance, focus distance and image distance. Another thing that makes them enthusiastic about learning and participating is the technology the teacher uses in delivering material and active learning in groups. Learning in groups significantly affects the enthusiasm for learning in the classroom and can improve the ability to convey opinions in discussions and complement the heterogeneous abilities of students.

CONCLUSION

Based on the results of development research and discussion in this study, it can be concluded as follows. This study aims to develop a learning content that uses the TPACK-integrated collaborative inquiry model to improve the high school student's Higher order thinking skills on the topic of properties of light and optical consisting of lesson plans, student worksheets and two-stage multiple-choice questions. The results of the assessment of the feasibility of the lesson plan and student worksheet by experts and users are good criteria. They are suitable for use with minor revisions. At the same time, the results of the validation and feasibility test of 15 multiple choice two-stage questions were 15 questions in the valid category with high reliability (r = 0.869). The results of the implementation of the teaching materials that have been developed is that teaching materials with the TPACK integrated Collaborative Inquiry model can affect the differences in the results of the pretest and posttest student's high-level thinking abilities.

The conclusion from the results of the implementation of the teaching materials that have been developed is that teaching materials with the TPACK integrated Collaborative Inquiry model can affect the differences in the results of the pretest and posttest student's high-level thinking abilities. This can be a reference for learning models that link the use of technology in improving higher-order thinking skills, so as to prepare future skills.

Some of the findings obtained in the process of implementing teaching materials include: the role of teachers in using technology greatly influences the enthusiasm of student learning, teacher mastery of the material presented will affect student's thinking abilities, and group learning also has a positive impact on the student learning environment.

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