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DEVELOPMENT OF PROBLEM-BASED LEARNING-BASED INDEPENDENT CURRICULUM LKPD TO IMPROVE STUDENTS' HOTS

Arezqi Tunggal Asmana[1*], Abdur Rohim[2], Khafidhoh Nurul Aini[3], Vina Pandu Winata[4]
[1,2,3,4]Mathematics Education Study Program, Universitas Islam Darul 'Ulum, East Java Province, Indonesia

*Correspondence: arezqitunggal@unisda.ac.id

ABSTRACT
This research is a development research that aims to develop Problem Based Learning Independent Curriculum Worksheets (LKPD) on Trigonometry material that are valid, practical, and effective to improve students' Higher Order Thinking Skills (HOTS). The LKPD developed is part of the teaching module of the Independent Curriculum. This study uses the 4D development model, which consists of the Defining, Designing, Developing, and Deployment stages. However, the Deployment stage is not carried out. The trial was carried out on Class X students of SMA Negeri 1 Sekaran, Lamongan City. The analysis techniques used in this study were grouped into three, namely analysis of LKPD validity data, analysis of LKPD practicality data, and analysis of LKPD effectiveness data. The results showed that the LKPD Independent Curriculum based on Problem Based Learning on Trigonometry material that was developed met the valid, practical, and effective categories to improve students' HOTS. Validity is shown by the average percentage of LKPD validation results is 91%. Practicality is indicated by (1) the average percentage of LKPD implementation is 92%, (2) the percentage of teacher responses is 94%, and (3) the percentage of student responses is 88%. Effectiveness is shown by (1) the average percentage of student activity is 87% and (2) the HOTS increase of students from written assessments is 96%.
Keywords: LKPD, Independent Curriculum, Problem Based Learning, HOTS

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PRELIMINARY

The industrial revolution 4.0 is directed at developing mathematical abilities that refer to the 21st century. In 21st century learning there is communication, critical thinking, creativity, and collaboration which is called 4C, these are very important and necessary skills (Ariyana et al., 2018). According to Purwasi & Fitriyana (2020), these four skills are part of higher order thinking skills (HOTS). Thomas et al. (Hamidah, 2018) stated that thinking at a higher level places thinking activities at a higher level than simply stating facts. However, the ability of Indonesian students to solve questions that require higher-order thinking processes is still lacking (Megawati et al., 2020).

The independent curriculum is disseminated and implemented in all educational units with the aim of renewing the learning process which has been constrained by the pandemic (Maulinda, 2022). Then the 21st century educational features based on independent learning hold the principles of efficiency, effectiveness, and are student-oriented and think about the readiness, interest, and learning needs of students in class so they can achieve learning goals optimally (Wijoyo, 2018). Teachers understand that the Independent Curriculum must be able to develop HOTS in learning activities and develop assessment instruments. However, they experienced difficulties in formulating the indicators in HOTS to become assessment instruments (Hanifah, 2019). Apart from that, in reality the teaching material facilities provided by schools in the form of textbooks and Student Worksheets (LKPD) do not support higher level thinking activities. Existing teaching materials use more closed questions that emphasize the end result rather than the process of how students find answers. Where teaching materials are an important part of the learning process (Magdalena et al., 2020).

Based on the results of interviews and observations with mathematics teachers and several students at SMA Negeri 1 Sekaran, Lamongan Regency, information was obtained that there were still very few HOTS-based LKPD provisions that were developed independently by teachers. Moreover, LKPD on the relatively new Independent Curriculum. In the learning process, it is only based on one textbook. According to Hersandi et al. (2017), books do not immediately become the most preferred teaching materials for students because a lot of material in books makes students less interested in reading. In addition, the implementation of the Independent Curriculum must be supported by various learning tools that can actively develop students' skills (Umbaryati, 2016). Prastowo (2013) said that in order to achieve targets according to indicators of success in learning, teaching materials used by teachers should be accompanied by LKPD.

LKPD is one of the learning resources in the Independent Curriculum which is used to assist teachers in training students' skills in discovering concepts through work steps and problems provided along with assessment techniques. The use of LKPD as a tool to help students in the learning process at school, because it contains material, namely summaries of various relevant book sources so that the learning process is effective when needed and there are practice questions and instructions for learning activities (Sari & Wulandari, 2020). Through the development of Problem Based Learning (PBL)-based worksheets, it is hoped that students' HOTS can be increased. Especially in the subject of geometry where it is one of the subjects of mathematics which is very important given to students because of

its application in everyday life (Manalu & Zanthy, 2020). One of the sub-topics of geometry is trigonometry. Based on research by Fajri & Nida (2019) it shows that most students do not understand the definition of trigonometry (sine, cosine, tangent), students have difficulty performing arithmetic operations and cannot determine trigonometry ratio values at special angles, and students are unable to show elements what is known and asked in the form of a story.

The relevant research that has been conducted related to the development of teaching materials and worksheets, namely research by Saraswati et al. (2021) demonstrated that the HOTS-oriented PBL-based worksheets developed were valid, practical, and effective for improving students' problem-solving abilities. Then Khairunisa et al. (2020) stated that the LKPD with the Problem Based Learning model based on HOTS on the Sine and Cosine Rules material in Trigonometry that was developed met the valid criteria so that the LKPD that was developed was feasible to use. Furthermore, Purwasi & Fitriyana (2020) showed that HOTS-based LKPDs that fulfill valid, practical, and effective aspects can increase students' HOTS where the average pre-test result is 30.76, while the post-test is 74.09. In addition, several related research titles of researchers, for example the development of an analytic rubric for assessment of written mathematics communication in solving mathematical problems (Asmana, 2018) as well as profiles of written mathematics communication of MA students in problem solving based on gender and mathematical ability (Asmana & Rohim, 2019). The test questions used in both studies were HOTS questions. In connection with several research results that have been carried out previously, it is necessary to develop the HOTS-based Independent Curriculum LKPD on trigonometry material.

Based on the description above, the researcher intends to conduct research on "Development of PBL-Based Independent Curriculum LKPD to Improve Students' HOTS. The purpose of this study was to develop Problem-Based Learning-based Independent Curriculum LKPD on Trigonometry material that is valid, practical, and effective to improve students' HOTS. The LKPD developed is part of the teaching module of the Independent Curriculum which can increase students' HOTS by 90%.

METHODS

The type of research used is Research and Development (R&D). R&D is a research method used to produce certain products, and test the effectiveness of these products (Sugiyono, 2016). The product development carried out was the development of Problem-

Based Learning-based Independent Curriculum Worksheets to increase students' HOTS. This development research refers to the 4-D model according to Thiagarajan et al. (1974). This model consists of 4 stages of development, namely: (1) Define, (2) Design, (3) Develop, and (4) Deployment (Thiagarajan et al., 1974). In this study, the authors only conducted research up to the Development stage, while at the Deployment stage it was not carried out. The choice of this model is because each development step is directly related to revision activities and this model is specifically for the development of learning tools including Student Worksheets (LKPD). The product in this research is the Problem-Based Learning Independent Curriculum LKPD which is valid, practical, and effective for increasing students' HOTS. The trial was carried out at SMA Negeri 1 Sekaran, Lamongan Regency and was carried out in Class X in the even semester of the 2022/2023 academic year.

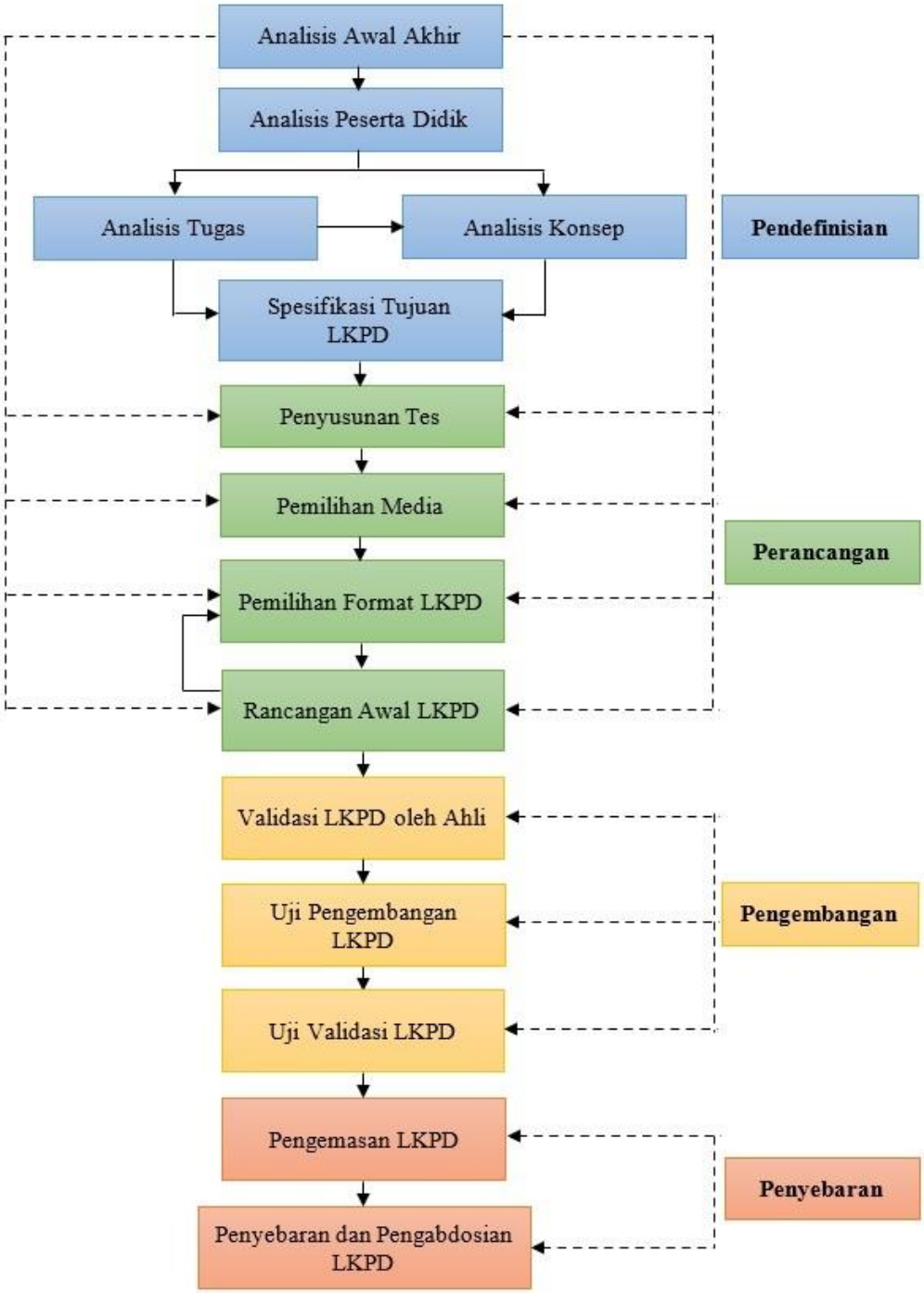
Data collection techniques were carried out using: 1) validity instruments, namely the LKPD validation sheet; 2) practical instruments, namely PBL-based Independent Curriculum LKPD implementation sheets, student response questionnaire sheets and teacher responses; and 3) effectiveness instruments, namely student activity observation sheets and written assessments in the form of HOTS questions. The analysis techniques used in this study were grouped into three, namely analysis of LKPD validity data, analysis of LKPD practicality data, and analysis of LKPD effectiveness data.

The Defining stage aims to define and define learning needs through analysis of material objectives and boundaries. At this stage interviews and direct observations were conducted with the mathematics teacher. The steps are initial-finish analysis, student analysis, concept/material analysis, and finally formulation of learning objectives. The design phase aims to design PBL-based Independent Curriculum LKPD. The activities carried out included the preparation of PBL-based Independent Curriculum LKPD teaching materials, format selection, and initial design. At this stage, in addition to making PBL-based Independent Curriculum LKPD, supporting instruments were also made, namely teaching modules and written assessments. Then the revised knowledge dimension of Bloom's Taxonomy adapted from Anderson et al. (2001) as a reference for making HOTS questions in written assessments as well as questions in LKPD are presented in the table below.

Table 1. Revised Dimensions of Bloom's and KKO's Taxonomy for HOTS

The Knowladge Dimension	**The Cognitive Process Dimension**		
	C4 Analyze	**C5 Evaluate**	**C6 Create**
Factual Knowledge (FK)	C4 FK Grouping	C5 FK Compare Connect	C6 FK Merge
Conceptual Knowledge (CK)	C4 CK Explain Analyze	C5 CK Review Interpret	C6 CK Plan
Procedural Knowledge (PK)	C4 PK Differentiate	C5 PK Conclude Summarize	C6 PK Combine Formulate
Metacognition Knowledge (MK)	C4 MK Embody Find	C5 MK Create a sequence Evaluate	C6 MK Realize

In addition, instruments were also made to assess the quality of the developed learning tools including three types, namely validity instruments, practical instruments, and effectiveness instruments. Development Stage (Develop), the activities carried out at this stage are the validation of the learning tools and all the practicality and effectiveness of the learning tools. In addition to validation, a trial phase was also carried out to find out whether the developed LKPD was practical and effective. In detail, the steps for developing the PBL-based Independent Curriculum LKPD with the 4-D model are presented in the figure below.


Analisis Awal Akhir
Analisis Peserta Didik
Analisis Tugas
Analisis Konsep
Pendefinisian
Spesifikasi Tujuan LKPD
Penyusunan Tes
Pemilihan Media
Perancangan
Pemilihan Format LKPD
Rancangan Awal LKPD
Validasi LKPD oleh Ahli
Uji Pengembangan LKPD
Pengembangan
Uji Validasi LKPD
Pengemasan LKPD
Penyebaran
Penyebaran dan Pengabdosian LKPD

English Version

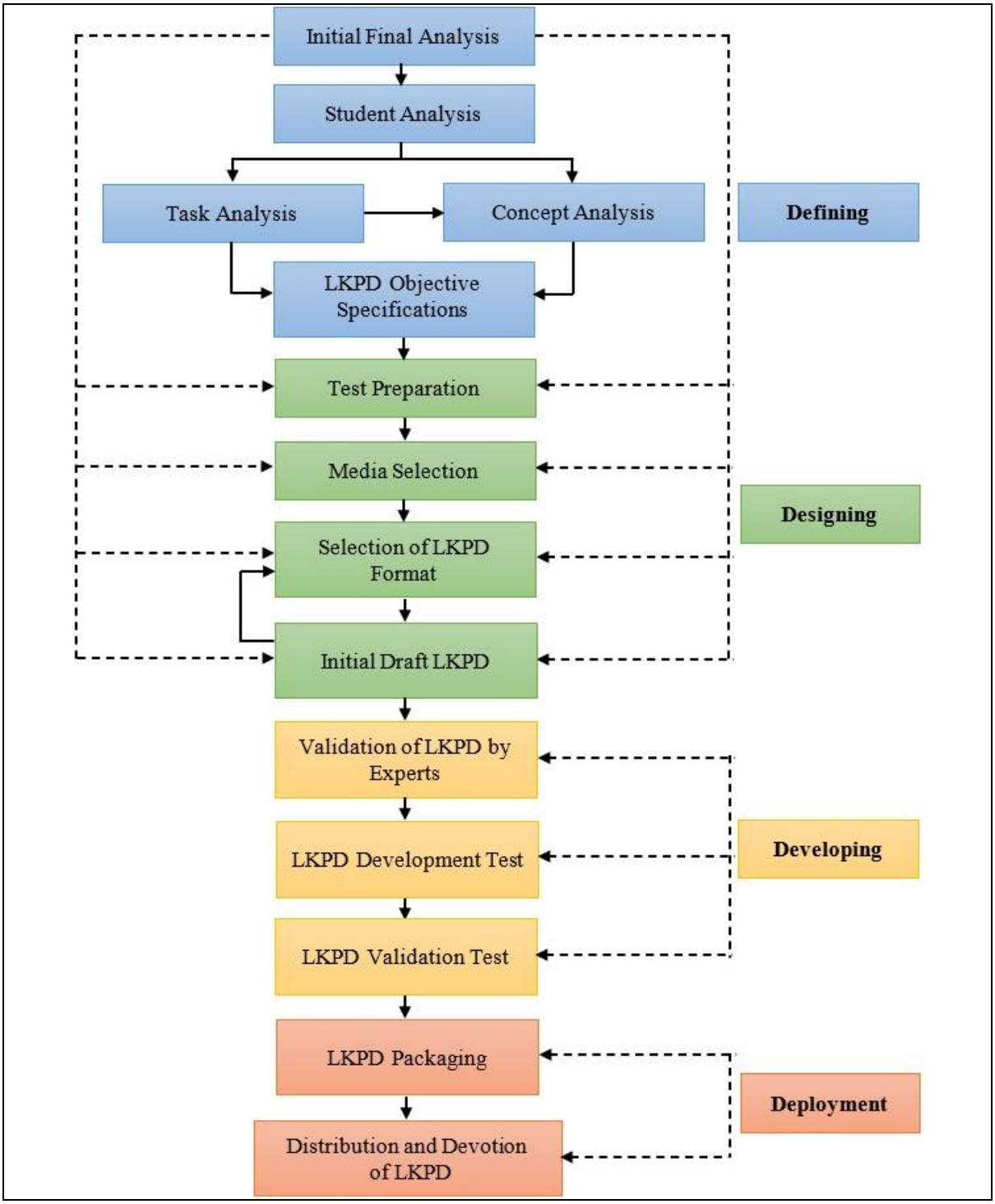


Figure 1. LKPD Development Steps with 4-D Model

The expert validation stage aims to produce valid PBL-based Independent Curriculum Worksheets. This validation aims to assess the quality of learning tools that have been developed. In addition to the device, the practicality and effectiveness of the instrument to be used will also be validated. Validation of the learning tools developed is

carried out by mathematics lecturers who are experts in their field. The basis for revising learning tools based on the validation results.

The revision results that have been carried out after the validation process are then called prototype II. Prototype II was then used for a limited trial with the aim of knowing whether the LKPD that had been developed really met the user's needs. In addition, this stage is also to determine the level of practicality and effectiveness of the developed LKPD. Implementation of this trial was carried out by carrying out a learning process of 4 meetings as well as meetings for written assessments (Pre Test and Post Test). The results of the Pre Test and Post Test are used to test the effectiveness of the LKPD by calculating the gain index (N-Gain). For the N-Gain calculation as follows (Oktapia & Siregar, 2023).

N-Gain (g) = (Score Post Test-Score Pre Test)/(Score Ideal-Score Pre Test)

Table 2. N-Gain Categories (g)

No	N-Gain Score	N-Gain Interpretation
1	$0,00 < g < 0,30$	Low
2	$0,30 \leq g \leq 0,70$	Keep
3	$0,70 < g < 1,00$	Tall

Based on the trial phase carried out, practicality and effectiveness data were obtained from the developed LKPD.

RESULT AND DISCUSSION

Defining Stage

At the Defining stage, information was collected about learning needs through analysis of the objectives and limitations of the material. The collection of this information was carried out by interviewing the mathematics teacher of class X SMA Negeri 1 Sekaran and observing students in class learning with the steps namely initial-end analysis, student analysis, concept/material analysis, then formulation of learning objectives.

Based on the results of interviews conducted with a class X math teacher at SMA Negeri 1 Sekaran, the researchers obtained some information. First, some of the obstacles encountered by teachers in learning, namely the abilities possessed by students vary so that teaching materials are needed that are suitable for all students. Second, the textbooks used contain little subject matter related to real life and worksheets are not available (Atika & MZ, 2016). Third, there is still very little provision of HOTS-based LKPDs which are developed independently by teachers, especially LKPDs in the relatively new Independent Curriculum. Finally, the teacher agrees with the development of LKPD which is expected to help increase students' HOTS. Then the teacher who taught mathematics in class X

SMA Negeri 1 Sekaran chose trigonometry material on geometric elements as material with low student learning outcomes.

From the interview results, it was also obtained a curriculum review of the Independent Curriculum used in SMA Negeri 1 Sekaran. The analysis of the curriculum in question is an analysis of the formulation of learning achievement indicators on geometric elements for trigonometry material. However, in the curriculum analysis there were no changes to the CP, TP or indicators, the reason being that the indicators contained in the curriculum were appropriate. Learning Outcomes (CP) used in LKPD, namely at the end of phase E, students can solve right-angled triangle problems involving trigonometry comparisons and their applications.

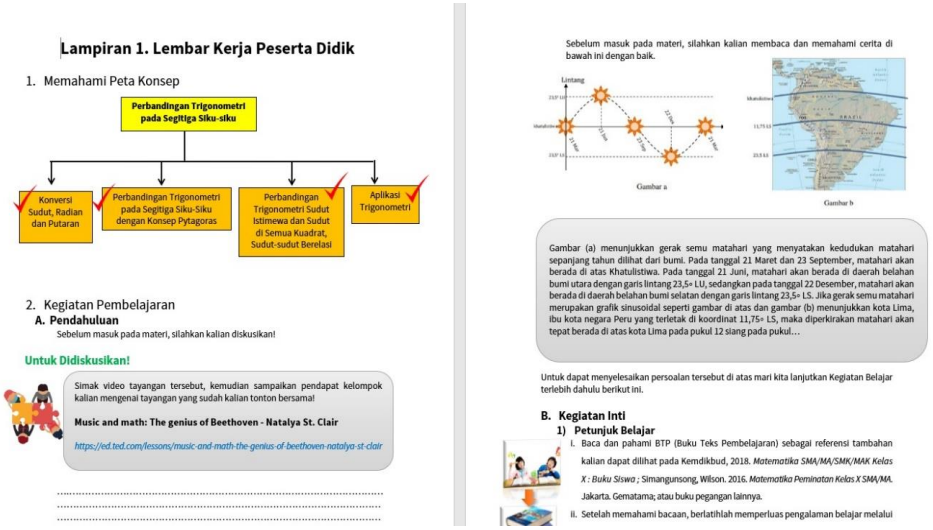
Learning Objectives (TP) used are: (1) students are able to solve problems on right triangles, (2) students are able to solve problems on trigonometry comparisons. Then the Learning Objectives Achievement Indicators (IKTP) used are: (1) students are able to explain the concepts of converting angles, radians, and rotations, (2) students are able to explain the definition of trigonometry ratios in right triangles by connecting them to the Pythagorean concept, (3) students are able to identify Trigonometry in quadrants and relate to the concept of related angles and special angles in Trigonometry, (4) students are able to solve Contextual problems related to Trigonometry comparisons in right triangles.

The results of observations on the way teachers teach are obtained from some information. First, the learning activities carried out by the teacher have led to efforts to teach students but the role of the teacher is still dominant so that students do not have the opportunity to be active. In the learning process, students are only considered as learning objects (Gustin et al., 2020). Second, the learning carried out by the teacher has not accustomed students to think for themselves using the knowledge they have in learning new material. In addition, learning activities also do not facilitate students in training themselves so they can make conclusions from the material that has been studied.

Design Stage

At the design stage, PBL-based LKPD Independent Curriculum was designed with the steps namely preparing PBL-based Independent Curriculum LKPD teaching materials, format selection, and initial design. The LKPD design is based on information from the Defining stage. In addition to making PBL-based Independent Curriculum LKPD, supporting instruments were also made, namely teaching modules and written assessments. The written assessment in the form of Pre Test and Post Test was made referring to the revised knowledge dimension of Bloom's Taxonomy adapted from Anderson et al. (2001).

The Pre Test and Post Test each consist of 4 questions. Then the initial draft of the LKPD is presented in the following figure.



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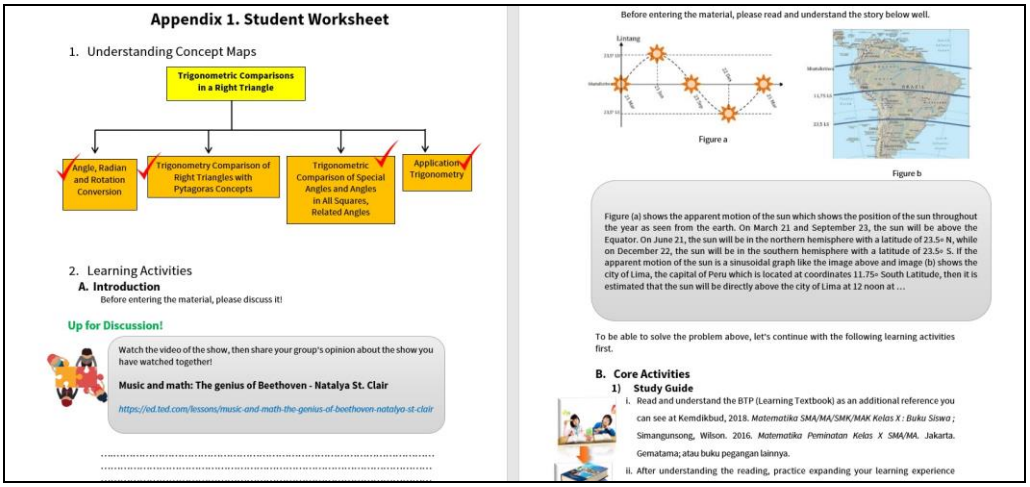


Figure 2. Preliminary Design of PBL-Based Independent Curriculum LKPD

Development Stage

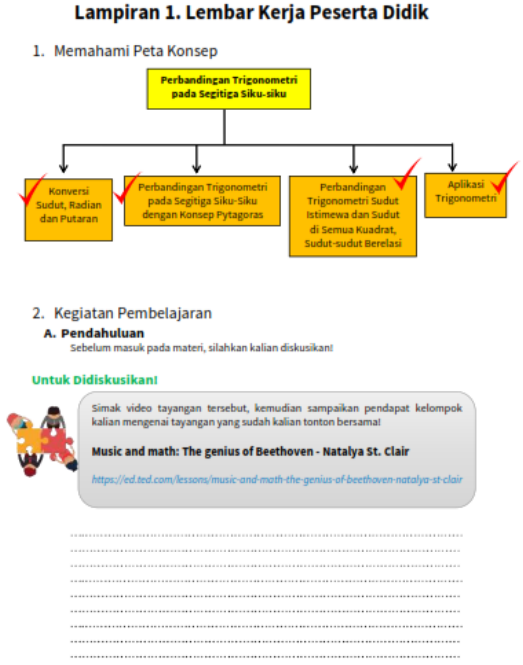
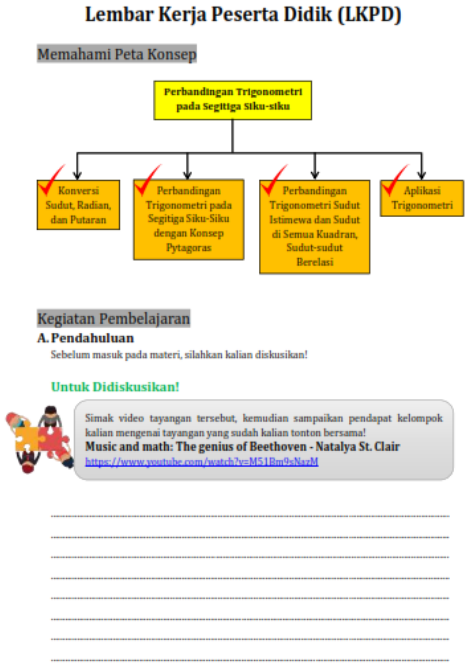
At the Development stage, validation of the learning tools and all the practicality and effectiveness of the learning tools has been carried out. PBL-based Independent Curriculum LKPD validation was carried out by 2 validators, namely 1 mathematics education lecturer and 1 mathematics teacher for material expert validation and by 2 validators, namely 2 mathematics education lecturers for media expert validation. Analysis of the data that has been collected from the material expert validation test and media expert validation test to assess whether the LKPD product is valid or invalid using a questionnaire data instrument (Agustina et al., 2019). The validation sheet that has been filled in by the expert is then converted as in the table below.

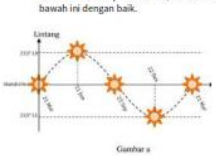
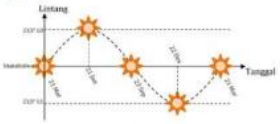
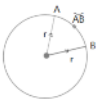
Table 3. PBL-Based Independent Curriculum LKPD Validation Results

No	Information	Average Percentage	Criteria
1	Material expert validation	88%	Highly Valid
2	Media expert validation	94%	Highly Valid
	Conclusion	91%	Highly Valid

Based on Table 3, the average percentage of material expert validation test results obtained is 88% with very valid qualifications and does not need to be revised so that the material prepared is suitable to be taught to students. Then proceed with the assessment of the media expert validation test which gets an average percentage of 94% with very valid information so it doesn't need to be revised and is suitable for use. Then the validator provides suggestions for multiplying pictures and reducing words that are ambiguous or unclear in their placement and adjusting the form of the questions whether the questions include fields or essays. In general, the average percentage of validation results is 91% with a very valid category so that it can be recommended for use in the learning process, especially in Trigonometry material. After being validated, several parts of the LKPD have undergone improvements or revisions according to the suggestions from the validator. Some of the changes after the repairs were made can be seen in Table 4.

Table 4. Differences Before and After Revision

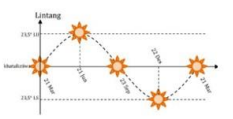
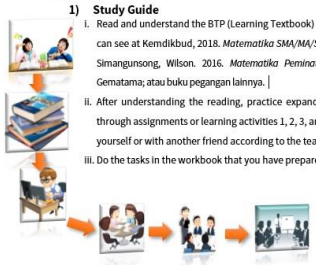
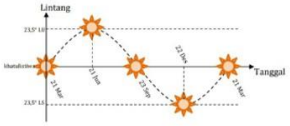
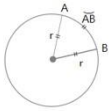
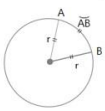
No	Before Revision	After Revision
1		

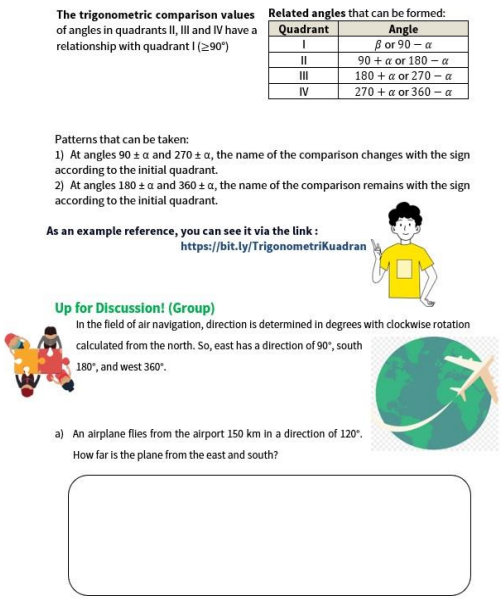
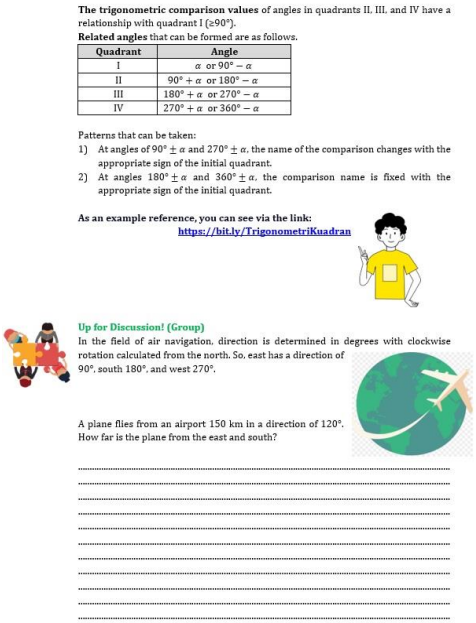
No	Before Revision	After Revision
2	Sebelum masuk pada materi, silahkan kalian membaca dan memahami cerita di bawah ini dengan baik.  Gambar a  Gambar b Gambar (a) menunjukkan gerak semu matahari yang menyatakan kedudukan matahari sepanjang tahun dilihat dari bumi. Pada tanggal 21 Maret dan 23 September, matahari akan berada di atas Khatulistiwa. Pada tanggal 21 Juni, matahari akan berada di daerah belahan bumi utara dengan garis lintang 23,5◦ LU, sedangkan pada tanggal 22 Desember, matahari akan berada di daerah belahan bumi selatan dengan garis lintang 23,5◦ LS. Jika gerak semu matahari merupakan grafik sinusoidal seperti gambar di atas dan gambar (b) menunjukkan kota Lima, ibu kota negara Peru yang terletak di koordinat 11,75◦ LS, maka diperkirakan matahari akan tepat berada di atas kota Lima pada pukul 12 siang pada pukul… Untuk dapat menyelesaikan persoalan tersebut di atas mari kita lanjutkan Kegiatan Belajar terlebih dahulu berikut ini. **B. Kegiatan Inti** **1) Petunjuk Belajar**    i. Baca dan pahami BTP (Buku Teks Pembelajaran) sebagai referensi tambahan kalian dapat dilihat pada Kemdikbud, 2018. *Matematika SMA/MA/SMK/MAK Kelas X : Buku Siswa* ; Simangunsong, Wilson. 2016. *Matematika Peminatan Kelas X SMA/MA*. Jakarta. Gematama; atau buku pegangan lainnya. ii. Setelah memahami bacaan, berlatihlah memperluas pengalaman belajar melalui tugas-tugas atau kegiatan-kegiatan belajar 1, 2, 3, dan 4 baik yang harus kalian kerjakan sendiri atau teman lainnya sesuai instruksi guru. iii. Kerjakan tugas-tugas di buku kerja yang sudah kalian siapkan sebelumnya. 	Sebelum masuk pada materi, silahkan kalian membaca dan memahami cerita di bawah ini dengan baik.  Gambar a  Gambar b Gambar (a) menunjukkan gerak semu matahari yang menyatakan kedudukan matahari sepanjang tahun dilihat dari bumi. Pada tanggal 21 Maret dan 23 September, matahari akan berada di atas Khatulistiwa. Pada tanggal 21 Juni, matahari akan berada di daerah belahan bumi utara dengan garis lintang 23,5◦ LU, sedangkan pada tanggal 22 Desember, matahari akan berada di daerah belahan bumi selatan dengan garis lintang 23,5◦ LS. Jika gerak semu matahari merupakan grafik sinusoidal seperti gambar di atas dan gambar (b) menunjukkan kota Lima, ibu kota negara Peru yang terletak di koordinat 11,75◦ LS, maka diperkirakan matahari akan tepat berada di atas kota Lima pada pukul 12 siang pada …. Untuk dapat menyelesaikan persoalan tersebut di atas mari kita lanjutkan Kegiatan Belajar terlebih dahulu berikut ini.
3	**Kegiatan Belajar 1** Pada kegiatan belajar 1 ini, siswa mampu menjelaskan konsep konversi sudut, radian dan putaran. Alokasi waktu kegiatan ini 2 JP **Definisi :** **Besar sudut dalam satu lingkaran penuh adalah 360°**, atau dengan kata lain 360° didefinisikan sebagai ukuran sudut yang disapu oleh jari-jari lingkaran dalam jarak 1 kali keliling lingkaran. 1° di definisikan sebagai ukuran sudut yang diperoleh dari jari-jari lingkaran dalam jarak putar sejauh $\frac{1}{360}$ keliling lingkaran. Sudut dapat dinyatakan dalam berbagai macam satuan, yaitu: 1) **Derajat (°)** : Satu derajat didefinisikan sebagai $\frac{1}{360}$ putaran penuh satu lingkaran. $1° = \frac{1}{360}$ putaran penuh lingkaran 2) **Menit (')** : Satu menit didefinisikan sebagai $\frac{1}{60}$ derajat, sehingga 1° bernilai 60'. 3) **Detik (")** : Satu $1' = \frac{1}{60}°$ $1° = 60'$ menit atau $\frac{1}{3600}°$ sehingga 1° bernilai 3600" dan 1' bernilai 60". $1' = \frac{1}{60}°$ $1° = 3600"$ 4) **Radian (rad)** : Satu radian didefinisikan sebagai ukuran sudut yang dibentuk oleh suatu juring lingkaran yang busurnya bernilai sama dengan jari-jari lingkaran.  Nilai satu radian adalah: $1 \text{ rad} = \frac{180}{\pi}°$ $1° = \frac{\pi}{180}$ rad	**Kegiatan Belajar 1** Pada kegiatan Belajar 1 ini, peserta didik mampu menjelaskan konsep konversi sudut, radian, dan putaran. Alokasi waktu kegiatan ini 2 JP. **Definisi:** **Besar sudut dalam satu lingkaran penuh adalah 360°**, atau dengan kata lain 360° didefinisikan sebagai ukuran sudut yang diperoleh dari jari-jari lingkaran dalam jarak 1 kali keliling lingkaran. 1° di definisikan sebagai ukuran sudut yang diperoleh dari jari-jari lingkaran dalam jarak putar sejauh $\frac{1}{360}$ keliling lingkaran. Sudut dapat dinyatakan dalam berbagai macam satuan, yaitu: 1) **Derajat (°)**: Satu derajat didefinisikan sebagai $\frac{1}{360}$ putaran penuh satu lingkaran. $1° = \frac{1}{360}$ putaran penuh lingkaran 2) **Menit (')**: Satu menit didefinisikan sebagai $\frac{1}{60}$ derajat, sehingga 1° bernilai 60'. $1' = \frac{1}{60}°$ $1° = 60'$ 3) **Detik (")**: Satu detik didefinisikan sebagai $\frac{1}{60}$ menit atau $\frac{1}{3600}°$ sehingga 1° bernilai 3600" dan 1' bernilai 60". $1' = \frac{1}{60}°$ $1° = 3600"$ 4) **Radian (rad)**: Satu radian didefinisikan sebagai ukuran sudut yang dibentuk oleh suatu juring lingkaran yang busurnya bernilai sama dengan jari-jari lingkaran.  Nilai satu radian adalah: $1 \text{ rad} = \frac{180}{\pi}°$ $1° = \frac{\pi}{180}$ rad **Sebagai referensi contoh, kamu bisa melihat melalui link:** http://bit.ly/KonversiSudut 

No	Before Revision	After Revision
4	**Nilai perbandingan trigonometri** sudut pada kuadran II, III dan IV memiliki suatu hubungan atau relasi dengan kuadran I (≥90°). **Sudut berelasi** yang dapat dibentuk: Kuadran | Sudut: I: β atau 90 − α; II: 90 + α atau 180 − α; III: 180 + α atau 270 − α; IV: 270 + α atau 360 − α Pola yang dapat diambil: 1) Pada sudut 90±α dan 270± α, nama perbandingan berubah dengan tanda sesuai kuadran awal. 2) Pada sudut 180±α dan 360± α, nama perbandingan tetap dengan tanda sesuai kuadran awal. **Sebagai referensi contoh, kamu bisa dilihat melalui link :** **https://bit.ly/TrigonometriKuadran** **Untuk Didiskusikan! (Berkelompok)** Dalam bidang navigasi penerbangan udara, arah ditentukan dalam satuan derajat dengan perputaran searah jarum jam di hitung dari arah utara. Sehingga, timur memiliki arah 90°, selatan 180°, dan barat 360°. a) Sebuah pesawat, terbang dari bandara sejauh 150 km dengan arah 120°. Berapakah jarak pesawat tersebut dari arah timur dan selatan?	**Nilai perbandingan trigonometri** sudut pada kuadran II, III, dan IV memiliki suatu hubungan atau relasi dengan kuadran I (≥ 90°). **Sudut berelasi** yang dapat dibentuk sebagai berikut. Kuadran | Sudut: I: α atau $90° - \alpha$; II: $90° + \alpha$ atau $180° - \alpha$; III: $180° + \alpha$ atau $270° - \alpha$; IV: $270° + \alpha$ atau $360° - \alpha$ Pola yang dapat diambil: 1) Pada sudut $90° \pm \alpha$ dan $270° \pm \alpha$, nama perbandingan berubah dengan tanda sesuai kuadran awal. 2) Pada sudut $180° \pm \alpha$ dan $360° \pm \alpha$, nama perbandingan tetap dengan tanda sesuai kuadran awal. **Sebagai referensi contoh, kamu bisa melihat melalui link:** https://bit.ly/TrigonometriKuadran **Untuk Diditskusikan! (Berkelompok)** Dalam bidang navigasi penerbangan udara, arah ditentukan dalam satuan derajat dengan perputaran searah jarum jam dihitung dari arah utara. Sehingga, timur memiliki arah 90°, selatan 180°, dan barat 270°. Sebuah pesawat, terbang dari bandara sejauh 150 km dengan arah 120°. Berapakah jarak pesawat tersebut dari arah timur dan selatan?

English Version

No	Before Revision	After Revision
1	**Appendix 1. Student Worksheet** 1. Understanding Concept Maps Trigonometric Comparisons in a Right Triangle Angle, Radian and Rotation Conversion Trigonometry Comparison of Right Triangles with Pytagoras Concepts Trigonometric Comparison of Special Angles and Angles in All Squares, Related Angles Application Trigonometry 2. Learning Activities **A. Introduction** Before entering the material, please discuss it! **Up for Discussion!** Watch the video of the show, then share your group's opinion about the show you have watched together! **Music and math: The genius of Beethoven - Natalya St. Clair** *https://ed.ted.com/lessons/music-and-math-the-genius-of-beethoven-natalya-st-clair*	**Student Worksheet (LKPD)** Understanding Concept Maps Trigonometric Comparisons in a Right Triangle Angle, Radian and Rotation Conversion Trigonometry Comparison of Right Triangles with Pytagoras Concepts Trigonometric Comparison of Special Angles and Angles in All Quadrants, Related Angles Application Trigonometry Learning Activities **A. Introduction** Before entering the material, please discuss it! **Up for Discussion!** Watch the video of the show, then share your group's opinion about the show you have watched together! **Music and math: The genius of Beethoven - Natalya St. Clair** https://www.youtube.com/watch?v=M51Bm9sNazM

No	Before Revision	After Revision
2	Before entering the material, please read and understand the story below well.  Figure a  Figure b Figure (a) shows the apparent motion of the sun which shows the position of the sun throughout the year as seen from the earth. On March 21 and September 23, the sun will be above the Equator. On June 21, the sun will be in the northern hemisphere with a latitude of 23.5◦ N, while on December 22, the sun will be in the southern hemisphere with a latitude of 23.5◦ S. If the apparent motion of the sun is a sinusoidal graph like the image above and image (b) shows the city of Lima, the capital of Peru which is located at coordinates 11.75◦ South Latitude, then it is estimated that the sun will be directly above the city of Lima at 12 noon at … To be able to solve the problem above, let's continue with the following learning activities first. **B. Core Activities** **1) Study Guide** i. Read and understand the BTP (Learning Textbook) as an additional reference you can see at Kemdikbud, 2018. *Matematika SMA/MA/SMK/MAK Kelas X : Buku Siswa ;* Simangunsong, Wilson. 2016. *Matematika Peminatan Kelas X SMA/MA.* Jakarta. Gematama; atau buku pegangan lainnya. ii. After understanding the reading, practice expanding your learning experience through assignments or learning activities 1, 2, 3, and 4, whether you have to do it yourself or with another friend according to the teacher's instructions. iii. Do the tasks in the workbook that you have prepared beforehand. 	Before entering the material, please read and understand the story below well.  Figure a  Figure b Figure (a) shows the apparent motion of the sun which shows the position of the sun throughout the year as seen from the earth. On March 21 and September 23, the sun will be above the Equator. On June 21, the sun will be in the northern hemisphere with a latitude of 23.5° N, while on December 22, the sun will be in the southern hemisphere with a latitude of 23.5° S. If the apparent motion of the sun is a sinusoidal graph like the image above and image (b) shows the city of Lima, the capital of Peru which is located at coordinates 11.75° South Latitude, then it is estimated that the sun will be directly above the city of Lima at 12 noon on …. To be able to solve the problem above, let's continue with the following learning activities first.
3	**Learning Activities 1** In learning activity 1, students are able to explain the concept of angle, radian and rotation conversions. The time allocation for this activity is 2 JP **Definition :** **The size of an angle in a full circle is 360°**, or in other words 360° is defined as the measurement of the angle swept by the radius of the circle in a distance of 1 times the circumference of the circle. 1° is defined as the angle measure obtained from the radius of a circle within a rotation distance of $\frac{1}{360}$ of the circle's circumference. Angles can be expressed in various units, namely: 1) **Degrees (°) :** One degree is defined as $\frac{1}{360}$ of a complete rotation of a circle. $1° = \frac{1}{360}$ full circle round 2) **Minute (') :** One minute is defined as $\frac{1}{60}$ of a degree, so 1° is 60'. 3) **Second (") :** One $1' = \frac{1}{60}°$ $1° = 60'$ f a minute or $\frac{1}{3600}°$ so 1° is worth 3600" and 1' is worth 60". $1° = \frac{1}{60}' = \frac{1}{3600}°$ $1° = 3600''$ 4) **Radian (rad) :** One radian is defined as the measure of the angle formed by a circle whose arc is equal to the radius of the circle.  The value of one radian is: $1 \text{ rad} = \frac{180}{\pi}°$ $1° = \frac{\pi}{180}$ rad	**Learning Activities 1** In Learning activity 1, students are able to explain the concepts of angle, radian and rotation conversions. The time allocation for this activity is 2 JP. **Definition:** **The size of the angle in a complete circle is 360°**, or in other words 360° is defined as the angle size obtained from the radius of the circle within a distance of 1 times the circumference of the circle. 1° is defined as the angle measure obtained from the radius of a circle within a rotation distance of $\frac{1}{360}$ of the circle's circumference. Angles can be expressed in various units, namely: 1) **Degree (°):** One degree is defined as $\frac{1}{360}$ of a complete rotation of a circle. $1° = \frac{1}{360}$ full circle round 2) **Minute (')**: One minute is defined as $\frac{1}{60}$ of a degree, so 1° is 60'. $1' = \frac{1}{60}°$ $1° = 60'$ 3) **Second (")**:One second is defined as $\frac{1}{60}$ of a minute or $\frac{1}{3600}°$ so 1° is worth 3600" and 1' is worth 60". $1'' = \frac{1}{60}' = \frac{1}{3600}°$ $1° = 3600''$ 4) **Radian (rad):** One radian is defined as the measure of the angle formed by a circle whose arc is equal to the radius of the circle.  The value of one radian is: $1 \text{ rad} = \frac{180}{\pi}°$ $1° = \frac{\pi}{180}$ rad **As an example reference, you can see via the link:** http://bit.ly/KonversiSudut 

No	Before Revision	After Revision
4		

From Table 4 it is explained that image number 1 has been improved in the display format to make it more attractive as well as the YouTube link. In picture number 2, the image editing of the questions was corrected and some of the words in the questions were corrected. In picture number 3 there is an improvement to the word in the definition, namely "... obtained from ..." as well as the addition of a link from the material. In figure 4, the display format has been improved, especially the table, and the words in the table have been improved from "β" to "α". Then in picture number 4 the word correction was also carried out in the group problem, namely "270°".

After being revised, the revised results are then called prototype II which is ready for a limited trial with the aim of knowing that the LKPD that has been developed really fits the user's needs. Then a trial phase was carried out on the developed LKPD to see how practical and effective it was. To find out the level of practicality through observing the implementation of LKPD and questionnaires for teacher and student responses. The results of observing the implementation of LKPD from each meeting by observers are presented in the table below.

Table 5. Results of PBL-based Independent Curriculum LKPD Implementation

The Meeting	Score	Teacher Activities (%)
1	13	87%
2	13	87%
3	14	93%
4	15	100%
Average Percentage of Implementation	13,75	92%

Based on Table 5, the average percentage of LKPD implementation for teacher activities is 92% with very practical qualifications. This was obtained from the percentage of LKPD implementation for teacher activities at the 1st meeting was 87% with very practical qualifications, for teacher activities at the 2nd meeting was 87% with very practical qualifications, for teacher activities at the 3rd meeting was 93%. with very practical qualifications, as well as for teacher activities at the 4th meeting is 100% with very practical qualifications. It can be seen that there has been an increase in the implementation of LKPD for teacher activities from the 1st meeting to the 4th meeting so that it shows an improvement in teacher activities in learning.

In addition to the results of PBL-based Independent Curriculum LKPD implementation, the results of teacher response questionnaires and student response questionnaires were also obtained. The results were obtained from the teacher's response questionnaire sheet and student response questionnaires given to teachers and students after the Post Test. A summary of the results of the teacher's response questionnaire and the student's response questionnaire can be seen as follows.

Table 6. Teacher Response Questionnaire Results

No	Statement	Score
1	Products can be used to achieve learning objectives.	5
2	The scope of the material on the questions already represents each Indicator of Achievement of Learning Objectives (IKTP) in Class X Trigonometry Learning Objectives (TP).	5
3	The combination of text, images and videos in the product is attractive and harmonious.	4
4	Instructions for use are clearly listed in the product.	5
5	Products can be used easily.	5
6	Products use language that is simple and easy to understand.	4
7	The words or terms used are consistent and easy to understand.	5
8	There are video examples of introductory problems and solving instructions to help understand the material.	5
9	Variations in how to answer challenging questions to solve.	5
10	The product supports independent mastery of material and can be used as an alternative learning resource.	4
	Amount	47
	Teacher Response Percentage	94%
	Criteria	Very Practical

Table 7. Student Response Questionnaire Results

Respondents	Statement Points									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S1	5	5	5	4	5	4	4	5	5	5
S2	4	5	5	5	4	3	4	4	4	4

Respondents	Statement Points									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
S3	5	4	4	5	5	4	5	4	4	4
S4	4	5	5	5	5	3	5	5	5	4
S5	4	4	3	5	5	5	5	4	4	4
S6	5	5	5	5	4	4	4	4	5	4
S7	5	4	4	5	5	5	5	4	4	5
S8	4	4	4	4	5	4	4	5	5	4
S9	4	5	5	4	5	5	5	4	3	3
S10	5	4	4	4	4	3	4	4	4	4
S11	4	4	5	5	5	4	5	5	5	4
S12	4	5	4	4	5	5	5	4	4	4
S13	5	4	4	5	3	4	5	4	5	4
S14	4	3	5	5	5	4	4	4	4	4
S15	4	5	4	5	5	5	4	5	5	4
S16	5	4	5	4	4	4	3	5	4	3
S17	3	4	3	5	5	3	5	4	4	4
S18	5	4	5	5	5	4	4	4	5	4
S19	5	4	5	5	5	3	4	3	4	5
S20	4	5	4	4	4	4	5	4	4	4
S21	4	5	4	4	4	5	5	4	5	5
S22	4	5	5	5	5	4	5	4	5	4
S23	5	4	5	4	5	5	5	5	4	4
S24	4	5	5	5	4	4	4	4	4	4
S25	5	5	4	4	5	4	4	4	5	4
S26	4	4	5	5	5	5	5	4	4	5
S27	3	5	4	4	5	4	4	4	4	5
S28	4	4	5	5	4	4	4	5	4	5
S29	5	5	5	4	5	5	4	4	4	4
S30	4	4	5	5	5	4	4	4	4	5
S31	5	5	5	5	5	5	5	4	5	4
S32	4	5	5	4	5	5	4	5	4	5
Amount	139	143	145	147	150	134	142	136	139	135
Total number	1410									
Percentage of Student Responses	88%									
Criteria	Very Practical									

Based on Table 6, the percentage of teacher responses in using PBL-based Independent Curriculum LKPD was 94% with very practical qualifications. This shows that the teacher is easy to use LKPD in learning. From Table 7 it is obtained that the percentage of student responses was 88% with very practical qualifications. This shows that students are interested in reading and studying the developed LKPD and feel that the developed LKPD is easy to use and understand. This is in line with the results of a study

by Khairunisa et al. (2020) which stated that Problem Based Learning received positive responses from teachers and students. Based on the results of the questionnaire, the responses of teachers and students who used learning tools in the form of PBL-based Independent Curriculum LKPD showed the very practical category.

Then to find out the level of effectiveness through observing the activities of students and the results of written assessments in the form of Pre Test and Post Test. Student activities start from the initial meeting to the end through the PBL stages contained in the LKPD, namely: (1) students orient the problem in the LKPD, (2) students group together to learn through the LKPD, (3) students discuss problems in the LKPD, (4) students present the results of their discussions, and (5) students evaluate the problem solving process to draw conclusions about learning activities. The results of observations of student activities from each meeting by the observer are presented in the following table.

Table 8. Student Activity Results

The Meeting	Score	Student Activity (%)
1	12	80%
2	13	87%
3	13	87%
4	14	93%
Average Percentage of Activity	13	87%

From Table 8 it is obtained that the average percentage of student activity is 87% with very effective qualifications. This was obtained from the percentage of student activity at the 1st meeting which was 80% with effective qualifications, for student activities at the 2nd meeting was 87% with very effective qualifications, for student activities at the 3rd meeting was 87% with qualifications are very effective, and for student activities at the 4th meeting is 93% with very effective qualifications. It can be seen that there has been an increase in student activity from the 1st meeting to the 4th meeting so that it shows that students are more active in learning, even though at the 1st meeting with effective qualifications.

In addition to the results of student activities on the use of PBL-based Independent Curriculum LKPD, the results of written assessments for the Pre Test and Post Test were also obtained. The results of the Pre Test and Post Test are presented in the table below.

Table 9. Pre Test and Post Test Results

Pre Test	Post Test	HOTS Learners	Ideal Score	Score N-Gain	N-Gain Interpretation
41	81	96%	100	0,6813	Keep

From the results of Table 9 it can be seen that the use of PBL-based Independent Curriculum LKPD has an effect on student scores. Because when using LKPD students experienced significant development, namely initially getting an average Pre Test score of 41, after using the PBL-based Independent Curriculum LKPD obtained an average Post Test score of 81. Results from the Pre Test and Post Test on the assessment writing obtained an increase in HOTS students by 96%. Then the N-Gain value if added up is 0.6813 which indicates that there is a sufficient (Oktapia & Siregar, 2023) increase in HOTS students by using PBL-based Independent Curriculum LKPD. This is in line with the results of research conducted by Purwasi & Fitriyana (2020) which states that Problem Based Learning can increase students' HOTS. Based on the results of student activities and the results of written assessments using PBL-based Independent Curriculum LKPDs, they are included in the very effective category. This shows that through a series of activities and practice questions in the form of HOTS questions in LKPD, students' HOTS can be increased, which is in line with the research results of Rizal (2018). However, the tests in this research were still limited to one class where the N-Gain value had not yet reached the high category.

CONCLUSION

Based on the results and discussion above, it can be concluded that the LKPD Independent Curriculum based on Problem Based Learning on Trigonometry material that was developed fulfills valid, practical, and effective categories to improve students' HOTS. Validity is shown by the average percentage of LKPD validation results is 91%. Practicality is shown by (1) the average percentage of LKPD implementation is 92%, (2) the percentage of teacher responses is 94%, and (3) the percentage of student responses is 88%. Effectiveness is shown by (1) the average percentage of student activity is 87% and (2) the HOTS increase of students from written assessments is 96%. From the N-Gain value of 0.6813, it indicates that there is a sufficient increase in the HOTS of students by using PBL-based Independent Curriculum LKPD. Suggestions for further research, in the development of Problem Based Learning-based LKPD Independent Curriculum in the form of a digital form called e-LKPD and can also develop the Independent Curriculum e-LKPD with other learning models.

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