DEVELOPMENT OF BIOLOGY INSTRUCTIONAL DESIGN USING PROBLEM BASED LEARNING (PBL) ASSISTED BY PODCAST AND GOOGLE CLASSROOM TO IMPROVE CRITICAL THINKING AND PROBLEM SOLVING SKILL OF SENIOR HIGH SCHOOL STUDENTS

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Abstract: Technology development allows every individuals to learn from various learning sources and media especially during the COVID-19 pandemic that makes students have to study online from home. However, the implementation of online learning considered less able to improve students' 21st century skills especially critical thinking and problem solving skill. One of the learning models that can develop students' 21st century skills is PBL. The objectives of this research and development are (1) to produce instructional design which are syllabus, lesson plan, student's worksheet, assessment sheets, and podcast using PBL model and (2) to improve students' critical thinking and problem solving skill through the implementation of instructional design that have been prepared. The method of this research is Research and Development (R&D) with ADDIE model. The subject are students of XI MIPA 1 SMAN 1 Turen, Malang, East Java. Validation test result from the validators stated that the product has average score of 95.6% with very valid category. Practicality test result based on learning syntax implementation and students' response questionnaire consecutively has average score of 93% and 82% with very practical category. Effectiveness test gained from pretest, posttest, and calculation of N-gain has score of 0,3 for problem solving skills and 0,4 for critical thinking skills with moderate category. It can be concluded that (1) the instructional design have very valid and practical category to be implemented on biology learning process, and (2) students' critical thinking and problem solving skill improved after the implementation of the instructional design.

Keywords: critical thinking, PBL, podcast, problem solving

INTRODUCTION

The development of 21st century skills or better known as 4C (communication, collaboration, creative thinking, and critical thinking and problem solving) requires a learning process to prepare learners who are ready to face the life demands. Živkovic (2016) stated that the main focus of education are to teach students to think, use rational reason, and become a problem solver so that students should develop their 21st century skills such as problem solving skills and critical thinking skills.

Critical thinking is an activity related to the process of understanding, finding some data and solutions, and also sharing it in a group (Suci et al., 2019). Students' critical thinking skills should be developed as an effort to prepare themselves to face the challenges or problems that will be encountered now or in the future. Through critical thinking skills, students are expected to be able to use their thinking skill in making effective solutions, solving problems, making conclusions, and making decisions (Zubaidah et al., 2015).

Critical thinking skills assessment is an important aspect to pay attention to when measuring critical thinking skills. According to Ennis (2011), assessments that should be developed for critical thinking skills are open-ended tests, not multiple-choice tests. Open-ended tests are more comprehensive than multiple-choice tests that make students to be able to develop their thinking

skills. Teachers can develop the assessments according to students' conditions based on indicators of the definition they refer. One indicator that can be used as a basis for critical thinking assessment skills is the one that stated by Ennis (2011) which consists of some aspects which are providing simple explanations, building basic skills, concluding, providing further explanation, providing assumptions and integration, and the ability to help.

Problem solving is an activity that make individual to choose a way out of a problem that in accordance with current and expected conditions (Khoiriyah & Husamah, 2018). Problem-solving skill needed in make some reasoning based on observational and data results. The process consist of (1) test the hypotheses, (2) solve complex problems, (3) represent mathematical equations by connecting results before and after testing the hypotheses, and also (4) have a great teamwork (Sitika et al. in Walagole & Hudha, 2019).

Students' problem-solving skills can be measured through a problem-solving indicator. The indicator that can be used is the one that stated by Mourtos et al. in Novitasari et al. (2015). The problem-solving indicator consists of defining the problem, examining the problem, planning a solution, executing the plan, and evaluating.

Critical thinking and problem-solving skills are important to be developed so that students can find a way out of the problems they faced (Polya in Cahyani & Setyawati, 2016), especially during the COVID-19 pandemic where learning is done online from home. However, online learning form home encounter many difficulties, one of that difficulties is learning activities that considered less valuable and less able to improve students' 21st century skills (Herdiana, 2020). Observation conducted at SMAN 1 Turen, Malang Regency, East Java in September 2020 showed that about 65% of XI grade students having difficulty when they faced with concrete problems and were less able to formulate or analyze the problem. The result of the observation obtained from students' worksheet of Movement System and during learning activities.

Another problem is that online learning considered monotonous so that students become fed up faster (Mastura & Santaria, 2020). The results of observation at SMAN 1 Turen and the interview with Biology teachers about the implementation of online learning showed that Biology learning activities were only carried out through the WhatsApp application to submit tasks. Such learning activities make students fed up from the tasks given.

Based on the problems related to students' critical thinking and problem solving skills, it requires learning process implementation that stimulate students to improve their critical thinking and problem-solving skills, one of them is by implementing the Problem Based Learning (PBL) model. PBL is one of the innovative learning models that able to develop students' thinking skills in solving a problem (Hung et al., 2008). The main focus of PBL is developing critical thinking and problem-solving skills and also developing students' ability to build their knowledge actively. PBL also intended to improve students' learning independence and social skills through collaborating students to identify relevant information, strategies, and learning resources to solve problems (Hosnan, 2014).

Research conducted by Fakhriyah (2014) proves that the implementation of PBL can develop students' critical thinking skills. Research from Nafiah & Suyanto (2014) also mentioned that PBL can improve students' critical thinking skills during learning process especially in Coordination System material. Redhana (2013) also proved that PBL can improve students' problem-solving and critical thinking skills when combined with *socratic* questions. Arends in Khoiriyah & Husamah (2018) stated that PBL have learning stages which are (1) orienting students to problems, (2) organizing students to learn, (3) conducting investigations, (4) presenting work results, and (5) evaluating and reflecting.

To adjust to the conditions of online learning, it requires learning application that can facilitate the learning process through Learning Management System (LMS), one of which is Google Classroom. Google Classroom is a product from Google specifically developed to help students and teachers during the online learning. Google Classroom helps students to learn the learning materials independently and can increase students' motivation and enthusiasm to understand the material taught by teachers (Akpan et al. in Alfina (2020). Research from Alfina (2020) shows that using Google Classroom during online learning is proven to help students to understand lecture materials independently and systematically, improve learning outcomes, and increase students' learning enthusiasm especially during the COVID-19 pandemic.

As an innovation so that students do not fed up quickly, it can be used variety of familiar media used by students nowadays such as podcast. Podcast is a digital audio file (or audio-video file) uploaded to the internet to be shared with listeners. Podcasts in the learning process can be used as innovative learning media to prepare the learning process and help students increasing their learning motivation. Podcast also can help students in understanding the concepts, theories, and applications of learning materials that have not been delivered in the classroom and can be an alternative media for the implementation of online learning (Hutabarat, 2020).

Frydenberg in Hutabarat (2020) stated that there are 3 benefits of using podcast in learning, (1) increasing learning flexibility, (2) improving the accessibility of learning, especially the use of mobile access, and (3) enriching the students' learning experience through the application of blended learning. Merolli et al. in Hutabarat (2020) explain that there are 4 stages to create a podcast, (1) recording, (2) testing podcasts that have been created, (3) uploading podcasts to platforms, blogs, or the web owned, and (4) sharing podcasts to listeners.

The objectives of this research and development are (1) to produce instructional design which are syllabus, lesson plan, student's worksheet, assessment sheets, and podcast using PBL model assisted by podcast and Google Classroom and (2) to improve students' critical thinking and problem solving skill through the implementation of instructional design that have been prepared.

METHOD

This study is a Research and Development (R&D) with ADDIE model. ADDIE model consist of 5 stages which are Analyze, Design, Develop, Implement, and Evaluate (Branch in Thohir, 2018). The product of this research are syllabus, lesson plan, student worksheet, assessment sheet, and podcast. The study was conducted from September 2020 to July 2021 with the subject are 21 students of XI MIPA 1 at SMAN 1 Turen academic year 2020/2021.

The analysis stage that conducted in September 2020 begins with problem validation to find out the gap between expectations and reality. The analysis stage was conducted by observing online learning process in class XI MIPA 1 and interviewing biology teachers in class XI MIPA 1. From this stage, the problems that can be concluded are monotonous learning process and students' critical thinking and problem-solving skills that are still low.

The design stage that conducted from October 2020 to April 2021 begins with designing instructional design based on analysis result by identifying important task in accordance with basic competence of Coordination System materials so that learning objectives can be achieved. The Coordination System sub-materials in this study consist of Sensory System, Hormonal System, and Psychotropic substances. The instructional design was designed for 4x meetings with 2x25 minutes each. In this stage also carried out the preparation of product testing instruments. The validity of the products validated by material expert, instructional design expert, and teacher through validity sheets. The practicality of the products obtained from learning syntax implementation and students' response questionnaire. The effectiveness of the products gained from pretest, posttest, and calculation of N-gain score from students.

The development stage that conducted from May to June 2021 aimed to produce the instructional design, validate, and test the products. Data obtained from this stage are qualitative and quantitative data. Qualitative data obtained from comments and suggestions from validators, while quantitative data obtained from validation questionnaires by validators with a rating scale of 1-5. The validated product then tested on 22 students in class XII MIPA 1 with a small group trial design.

The implementation stage that conducted in June 2021 aimed to implement the products to XI MIPA 1 students in learning process. This stage begins with preparing the teacher then preparing students. Pretest was held before learning at the first meeting begins. Learning process was done through Google Classroom, including student worksheet and podcast links sharing. Posttest was held after the learning process at the last meeting had been completed.

The evaluation stage aimed to determine the effectiveness of the products in order to improve students' critical thinking and problem-solving skills. This stage begins by determining the evaluation criteria for the validity, practicality, and effectiveness tests. Evaluation criteria can be seen on Table 1, 2, and 3.

Table 1. Validity test score interpretation

Validity percentage (%)	Validity criteria	Description
85,00-100,00	Very valid	Can be used without revision
70,00-84,00	Valid	Can be used with small revision
55,00-89,00	Valid enough	Can be used with revision
40,00-54,00	Less valid	Suggested not to be used
00,00-39,00	Not valid	Can't be used

Source: Akbar in Thohir (2018)

Table 2. Practicality test score interpretation

Practicality percentage (%)	Criteria
81,00-100,00	Very practical
61,00-80,00	Practical
41,00-60,00	Practical enough
21,00-40,00	Less practical
00,00-20,00	Not practical

Source: Akbar in Thohir (2018)

Table 3. Effectiveness test score interpretation

Effectiveness score (n-gain)	Criteria
N gain ≥ 0,7	High
0,3 < N gain < 0,7	Moderate
N gain ≤ 0,3	Low

Source: Akbar in Thohir (2018)

Validity and practicality test data analyzed quantitatively using following formula:

$$x = \frac{\Sigma xi}{\Sigma x\ max} x\ 100\%$$

in which : x= validity/practicality percentage
Σ xi= score obtained from validators
Σ x max= maximal score

Analysis result determined the validity or practicality of the products based in Table 1 and 2.

Effectiveness of the products obtained from the results of pretest-posttest in the form of gain score. Gain score indicates the level of learning effectiveness that refers to the pretest-posttest value. The gain score can be calculated by the following formula, with the effectiveness criteria can be seen in Table 3.

$$N\ gain = \frac{posttest\ score - pretest\ score}{maximal\ score - pretest\ score} x\ 100\%$$

RESULT AND DISCUSSION

Result

Validity test result of syllabus, lesson plan, student worksheet, assessment sheet, and podcast can be seen in **Fig. 1**.

Products that have been validated and revised according to validator's suggestion then will be tested before being implemented to XI MIPA 1 student. The trial was conducted with a small group design to 22 students of XII MIPA 1 who had studied Coordination System materials through filling out readability questionnaires. The questionnaire aimed to assess the ease of use of student worksheet, podcasts, and the problem presented.

Products that have tested then implemented to 21 students XI MIPA 1. At the implementation stage, practicality test data and effectiveness tests are obtained. The practicality test result which are learning syntax implementation and students' response questionnaire can be seen consecutively in **Fig. 2** and **Fig. 3**. Pretest and posttest result can be seen in **Fig. 4**.

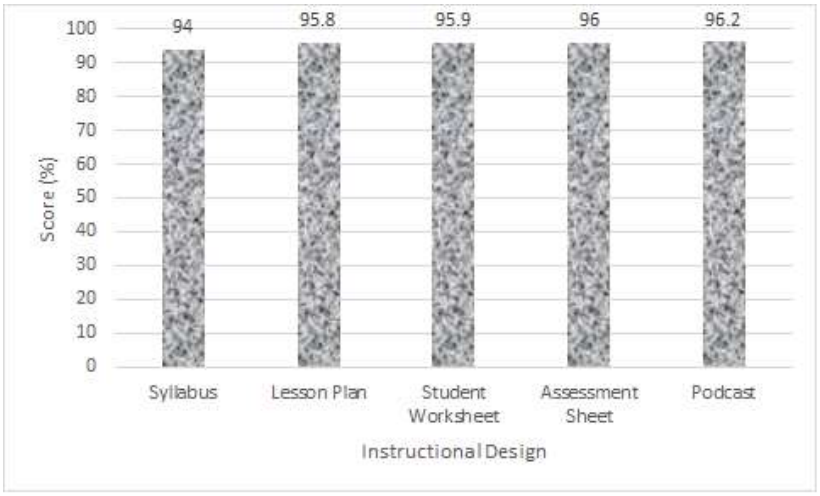


Fig 1. Validity result of syllabus, lesson plan, student worksheet, assessment sheet, and podcast

From the **Fig. 1**, it can be concluded that all products that have been developed gained very valid category according to Table 1. The products that have been validated then will be revised according to validator's suggestion. Validators' suggestion to the syllabus is about identifying competency indicators and competency scoring. Validators' suggestion to the lesson plan is about competency indicators, learning material, and time formatting. Validators' suggestion to the assessment sheet is about score formatting at student worksheet. Validators' suggestion to the assessment sheet is about the title and text formatting. Validators' suggestion to the podcast is about the volume.

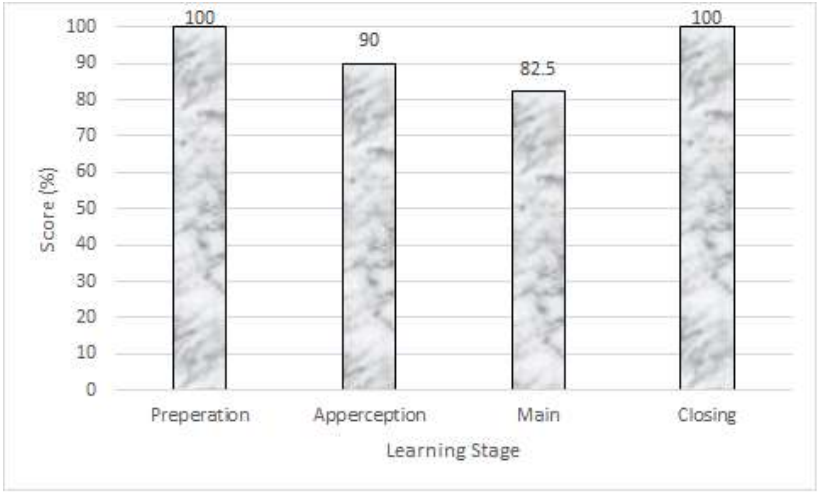


Fig 2. Practicality result from learning syntax implementation questionnaire by teacher

From the **Fig. 2**, it can be concluded that all learning stages gained very practical category according to Table 2 and were implemented well based on the syllabus and lesson plan.

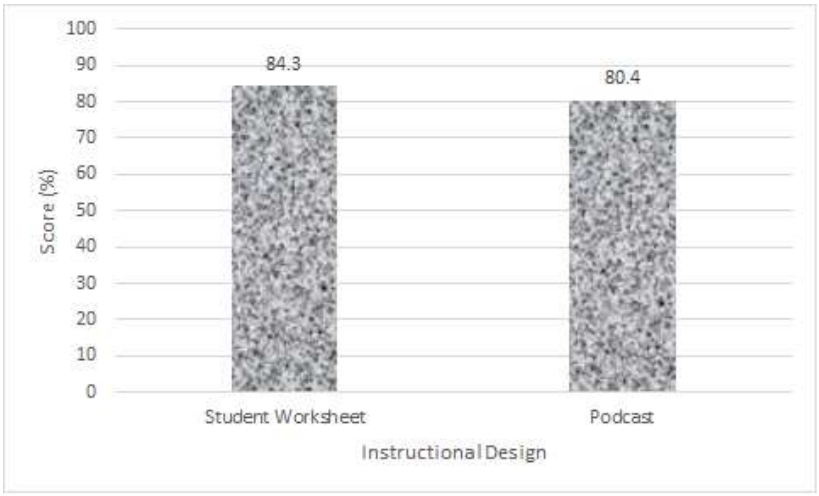
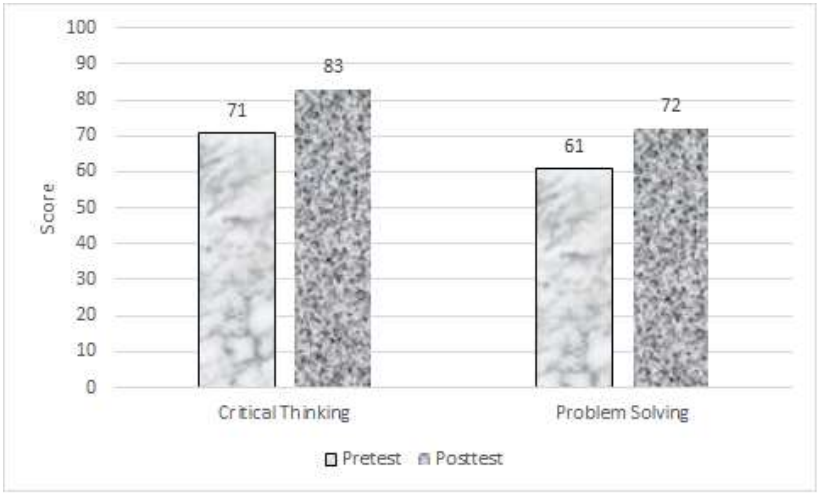


Fig 3. Practicality result from students' response questionnaire

From the **Fig. 3**, it can be concluded that student worksheet and podcast gained very practical category according to Table 2 and considered easy to use by students.



From the **Fig. 4**, it can be calculated the n-gain score of critical thinking and problem solving skill as below.

a) Critical thinking skill

$$N - gain = \frac{posttest\ score - pretest\ score}{maximal\ score - pretest\ score}$$

$$\mathrm{N-gain} = \frac{83 - 71}{100 - 71}$$

$$\mathrm{N-gain} = \frac{12}{29}$$

$$\mathrm{N-gain} = 0.4$$

According to Table 3, 0.4 score considered as moderate category.

b) Problem solving skill

$$\text{N} - \text{gain} = \frac{posttest\ score - pretest\ score}{maximal\ score - pretest\ score}$$

$$\text{N} - \text{gain} = \frac{72 - 61}{100 - 61}$$

$$\text{N} - \text{gain} = \frac{11}{39}$$

$$\text{N} - \text{gain} = 0.3$$

According to Table 3, 0.3 score considered as moderate category.

DISCUSSION

According to validators' suggestions for the products, it is known that identifying the competency indicators is an important step before the products were developed. (Hartini, 2013) stated that competency indicators indicate students' achievement based on the basic competency through their behavioral changes including attitude, knowledge, and skill. The competency indicators at syllabus that have been revised then will be developed to the lesson plans.

The lesson plans were designed for 4x meetings with 2x25 minutes each. There are 7 topics of problems that needed to be solved by students which are related to eyes, nose, ear, skin, tongue, hormonal system, and psychotropic substances. The lesson plans were designed according to PBL learning syntax.

The assessment sheets consist of pretest and posttest scoring, critical thinking and problem solving rubric, and also student worksheet answer key and scoring. Pretest and posttest scoring for critical thinking skill was developed based on indicators according to Zubaidah et al. (2015) while the scoring for problem solving skill was developed based on indicators according to Mourtos et al. in Novitasari et al. (2015).

The student worksheets were developed according to PBL learning syntax. PBL learning syntax make students to face the ill-structured or ill-defined problems so they should gather more information from various sources to complete their knowledge in order to give solutions. This methods can improve students' critical thinking and problem solving skill (Rutherford & Ahlgren in Redhana, 2013). The student worksheet were uploaded to Google Docs so that students' activity can be recorded.

Podcasts in this study were developed to help students to understand the problem given, according to Goldman in Hutabarat (2020) that explained podcast aimed to help students to prepare themselves before the learning process begin. Podcast consist of some conversations between 2 people that discuss about problems related to sensory system, hormonal system, and psychotropic substances with the durations about 3-5 minutes. Podcasts were uploaded to SoundCloud and Google Drive so that students can accessed the podcast easily. Podcasts were uploaded at problem orientation stage begin so that students can identify and investigate the problem before they conclude some conclusions.

Based on practicality test, both learning syntax implementation and students' response questionnaire gained very practical category. The learning syntax implementation questionnaire aimed to assess the learning process, while the students' response questionnaire aimed to assess practicality and easiness to use of the product which are student worksheet and podcast. The learning process were done through Google Classroom because the school didn't have any e-leaning system yet and Google Classroom considered easy to use, linked by Google Drive, flexible, and free (Durahman, 2018).

Based on pretest, posttest, and N-gain score result, it is known that the implementation of the PBL during learning can improve students' critical thinking and problem-solving skills. Rosa & Pujiati (2017) stated that students who are taught with the PBL model have higher critical and creative thinking skills compared to students who are taught with conventional models. It is because PBL model have systematic, structured, and student-centered learning syntax so that student can actively process the information, apply their knowledge, and conduct an identification before they conclude

some solutions. Orientation to problems stage at the beginning of PBL learning is an important stage so that student can explore their curiosity, motivate to find solutions, and develop thinking processes (Arends in Khoiriyah & Husamah, 2018).

PBL makes teachers more consistent in training students to think logically and analytically to be able to solve a problem related to the material taught. Teachers create more challenging learning situations and motivate students to find answers or solutions to problems independently (Karyatin in Khoiriyah & Husamah, 2018). PBL enables students to study the material presented deeper, integrate theory and practice, and apply a wide range of knowledge and skills to develop solutions to the problems presented (Amalia et al., 2017).

Product Advantages and Disadvantages

Based on the development result, it can be stated that the advantages of the products are, (1) instructional design using authentic problems that familiar to students so students have better understanding and challenged to formulate solutions to solve the problems, (2) instructional design developed based on PBL learning models is in accordance with the demands of the future life, and (3) student worksheet and podcasts are applied online so it can facilitate online learning during the COVID-19 pandemic.. The disadvantage of the products are (1) instructional design designed only for Coordination System so that the users are specific at that level, and (2) student worksheet and podcasts are uploaded on online platforms so that it requires adequate resources (mobile phones, laptops, and internet connections).

Utilization, Sharing, and Further Development Suggestions

Based on the study of the products developed, it can be suggested related to utilization which are (1) teachers can use other examples of problems that students may know about coordination system materials, and (2) teachers can use other online learning platforms such as Edmodo or school e-learning facilities. Suggestions that can be given to share the products include, (1) uploading instructional design especially podcasts on wider platforms such as YouTube, (2) publishing the results of research and development studies in scientific discussion forums, national or international seminars, educational exhibitions, and journal publishing, and (3) socializing the implementation of instructional design in other schools. Suggestions for further development can be done by conducting advanced research such as quasi experiment research or Classroom Action Research (CAR) to find out if there is a real difference on the implementation of online PBL learning assisted by podcasts and Google Classroom to improve students' critical thinking and problem-solving skills compared to conventional learning.

CONCLUSION

From this study, it can be concluded that, (1) instructional design which are syllabus, lesson plan, assessment sheet, student worksheet, and podcast that have been developed gained very valid and vary practical to be implemented on biology learning, and (2) students' critical thinking and problem solving skill improved after the implementation of the instructional design using PBL model assisted by podcast and Google Classroom.

Suggestion that can be given by researcher is that instructional design in this study can be used or implemented in biology online learning process.

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