COLLABORATIVE AND PROBLEM SOLVING INSTRUMENTS IN PROJECT-BASED PHYSICS LEARNING

Viyanti[1*], Undang Rosidin[2], Rizki Eka Shintya[3]

[1,2,3]Department of Physics Education, Faculty of Teacher Training and Education, Universitas Lampung, Indonesia

Corresponding author: viyanti.1980@fkip.unila.ac.id

Article Info	ABSTRACT
	This study aims to develop an assessment instrument that is able to measure collaboration and problem solving abilities in project-based physics learning that is valid, reliable and practical. This type of research is Research & Development by adapting 7 stages of development from Borg & Gall. Product expert validation was carried out to assess aspects of construction, substance and language, the results of expert validation of the assessment instrument were 87.85% with very valid criteria. As for the analysis of the results of field trials on 64 students using the Rasch model, it was obtained: (1) 21 questions about the collaboration ability instrument and 19 questions about the problem solving ability instrument were declared valid; (2) the reliability value of the collaborative and problem-solving ability assessment instrument is 0.97 and 0.89 (very good category); (3) the average value of the practicality test of the collaboration and solving ability assessment instrument is 81.21 (very high criteria).

ASESMEN KEMAMPUAN KOLABORASI DAN PEMECAHAN MASALAH PADA PEMBELAJARAN FISIKA BERBASIS PROYEK

	ABSTRAK
	Penelitian ini bertujuan untuk mengembangkan instrumen penilaian yang mampu mengukur kemampuan kolaborasi dan pemecahan masalah pada pembelajaran fisika berbasis proyek yang valid, reliabel dan praktis. Jenis penelitian ini adalah Research & Development dengan mengadaptasi 7 tahap pengembangan dari Borg & Gall. Validasi ahli produk dilakukan untuk menilai aspek konstruksi, substansi dan bahasa, hasil validasi ahli instrumen penilaian sebesar 87,85% dengan kriteria sangat valid. Adapun analisis hasil uji coba lapangan terhadap 64 siswa menggunakan model Rasch diperoleh: (1) 21 butir soal instrumen kemampuan kolaborasi dan 19 butir soal instrumen kemampuan pemecahan masalah dinyatakan valid; (2) nilai reliabilitas instrumen penilaian kemampuan kolaborasi dan pemecahan masalah berturut-turut sebesar 0,97 dan 0,89 (kategori bagus sekali); (3) rata-rat nilai uji kepraktisan instrumen penilaian kemampuan kolaborasi dan pemecahan sebesar 81,21 (kriteria sangat tinggi).

1. INTRODUCTION

Assessment based on Permendikbud No. 23 of 2016 concerning Educational Assessment Standards is a process of collecting and processing information to measure the achievement of student learning outcomes. The basic objectives of the assessment are the process of gathering information, processing information, and achieving learning outcomes. The process of gathering information is carried out using various assessment techniques, various assessment instruments, and comprehensive supporting sources. The information processing process is carried out using analytical techniques and procedures in accordance with the assessment criteria.

The achievement of student learning outcomes must be assessed as a continuous process in learning [1]. Assessment activities require assessment instruments that not only focus on assessing student learning outcomes, but also during the learning process. Data collection instruments in the assessment can use standard instruments or developed instruments [2]. According to [3], the assessment instrument consists of test and non-test assessment instruments. The test assessment instrument includes a written test sheet (multiple choice questions or descriptions). Meanwhile, non-test assessment instruments include observation sheets or observation sheets, attitude scales, anecdotal notes, checklists, and others. Revealed that the assessment of student abilities can use various techniques, including project assessment, product assessment, practice assessment, portfolio assessment and other techniques in the form of a written test [4]. The skill assessment technique used should be selected and adapted to the characteristics of KD in KI-4. The project assessment technique is one of the assessment techniques used to support the learning achievement of the 2013 Curriculum [5]. The assessment technique is allegedly able to train 21st century competency improvement.

21st century educational competencies lead students to have the following abilities: critical thinking and problem solving, communication, creativity and innovation, and collaboration [6]. Indicators of student success in the 21st century are new demands for teachers to change the direction and process of assessment in order expand and create new knowledge. This statement shows the importance of collaboration and problem-solving abilities for high school students to compete in the globalization era of the 21st century.

The ability to collaborate is very important for students, as a condition for working together in individual differences in each group as an initial provision to face the increasing competence of the 21st century [7]. Students must be able to work together collaboratively order to be able to find various solutions to a complex problem in project-based tasks that have been given through different perspectives. The ability to collaborate and solve problems must be applied to everyday life to have a good working experience in a team.

Problem solving is one component of the ability that students must have in the 21st century. This is in accordance with the opinion [8] which states that the 21st century abilities that must be possessed by students include creative and innovation, critical thinking and problem solving, communication and collaboration. This indicates that students must be able to find and have various solutions to a complex problem through different perspectives. To get a good problem-solving process, it is very important to have a good cooperative role in the team, as well as creative and effective collaboration between teachers and students by involving technology. Thus, being able to identify, define and understand various sources of information and the parts contained in the subject matter. As well as being able to consider the strategies needed to overcome these problems [9]. Stated that in the successful achievement of learning objectives, problem solving abilities are needed [10]. Problem solving ability is often used in physics learning because problem solving is done mathematically. Problem solving requires effective and creative

collaboration to involve technology, as well as understanding the parts of the problem, knowing the sources of information and strategies used to solve problems.

Students' collaboration and problem-solving abilities must be measured and assessed using appropriate assessment instruments. Therefore, teachers should develop and apply appropriate assessment instruments during the learning process. However, based on a preliminary study of teachers using a questionnaire on teachers of SMAN 1 Kotagajah, it was found that teachers had not made a special assessment to measure collaboration and problem-solving abilities during physics learning. This happens because of the limited examples of assessment instruments in the realm of abilities, so the teacher has not implemented the assessment optimally. The assessment of students' collaboration and problem-solving abilities is only supported by an assessment of the teacher's opinion. Thus, determining the final score for the achievement of student learning outcomes in each learning process is less objective.

The instrument for assessing collaboration and problem-solving abilities can be used when teachers carry out learning that involves active and creative students in each stage of their learning. Through active learning, students can practice collaboration, problem solving, critical thinking, and creative abilities. As a result, students can have the ability to collaborate and solve problems to support the success of the teaching and learning process in classroom learning.

Active learning can be facilitated by learning models that support the improvement of 21st century competencies, [11] revealing that the Project Based Learning (PjBL) model is a learning model that supports teachers in facing 21st century competencies. The 21st century competencies in question are the ability to collaborate and solve problems for convey ideas or ideas, participate in groups, and solve problems in the learning process that can be trained in learning using the PjBL Model. In line with the statement [12]; [13] that learning activities supported by the PjBL Model can present real projects that trigger high learning motivation, challenging questions and problems to form mastery of competencies that are carried out in collaboration in an effort to solve problems. Supported by the statement [14] that the PjBL model has the aim of increasing students' motivation to learn, working together, and increasing collaboration abilities in achieving high levels of academic abilities needed in 21st Century educational competencies constructivism.

Assessment instruments that lead to exploring abilities in understanding, applying, investigating, and presenting information on projects completed within a certain period/time can clearly be facilitated by real and authentic assessments.[15] revealed that authentic assessment as a form of assessment that reflects the learning process, learning outcomes, motivation, and attitudes towards relevant learning activities. It is also supported by the statement [16] that learning assessment can be done collaboratively. Furthermore, [17] states that assessment should provide opportunities for students to be able to evaluate and reflect on their own understanding and abilities.

Based on the literature review of recent years conducted by researchers, there has been no development of an instrument for evaluating collaboration and problem-solving abilities based on project-based learning. Therefore, the skill assessment instrument that has been developed is the development of a self-assessment instrument to assess students' cognitive aspects as a complement to formative assessment in physics learning [18]. The other assessment instruments that have been developed are those oriented towards the process of student performance during problem-based learning developed for summative assessment. Furthermore, [19] developed instrument items in the form of self-assessment for assessing collaboration and communication skills based on Project-Based Learning using assessment as learning as the assessment approach in this research. This is supported

by the results of a preliminary research on students of SMAN 1 Kotagajah, that teachers have not implemented an assessment of collaboration and problem-solving abilities. Based on the statement above, as one of the improvement efforts to deal with solutions to problems that exist in SMA N 1 Kotagajah, the researchers have developed an assessment instrument to measure collaboration and problem-solving abilities in project-based physics learning.

2. METHOD
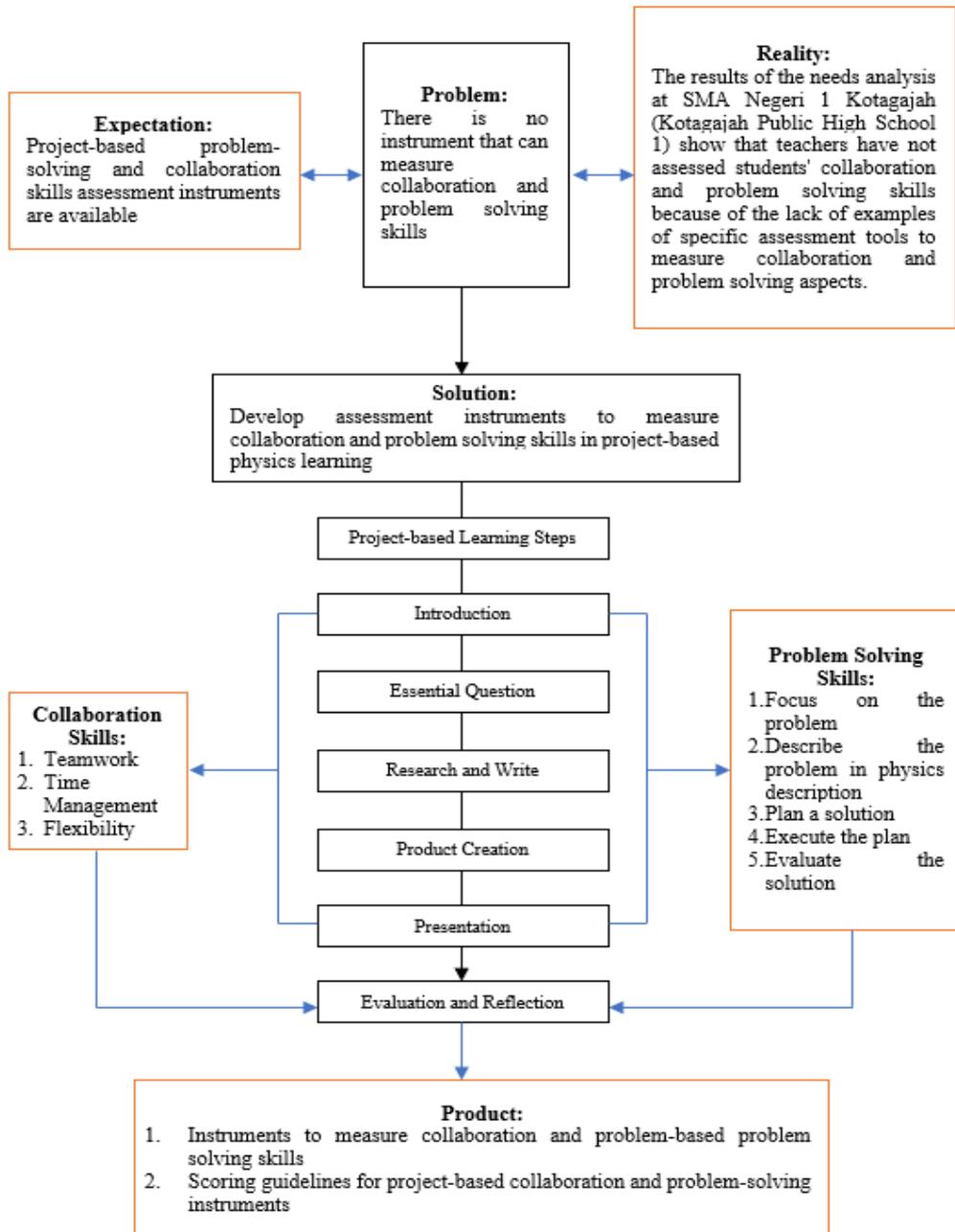
Figure 1. Represents the Research Steps from the Initial Stage to the Initial Field Trial

The Research and Development (R&D) research method adapts the development procedure [20] by being limited to the 7th step. The subject of this research is an instrument for assessing the ability of collaboration and project-based problem solving. Meanwhile, the test subjects in this study consisted of three groups, namely needs analysis subjects

consisting of students and physics teachers, theoretical validity test subjects namely expert lecturers and practitioners, practicality test subjects namely expert practitioners and empirical validity test subjects namely students. Data collection techniques using a questionnaire. The distribution of questionnaires was carried out in the field study, the product validation stage in the form of substance, language, and construct tests, as well as the product practicality test stage.

The research steps in developing research products use the steps presented in Figure 1. Figure 1 represents the research steps from the initial stage to the initial field trial. In general, it is described as follows: based on needs analysis, it shows that teachers have not assessed collaboration and problem solving abilities using special instruments due to several reasons, including: (1) the lack of examples of collaboration and problem solving ability assessment instruments; (2) the ability assessment instrument in SMA has not specifically measured the aspects of collaboration and problem solving abilities as a whole; (3) the assessment instrument used is only using observation techniques so that the teacher is less than optimal in observing students' abilities when collaborating and solving problems from the physics problems that have been given.

The stages of the project-based learning model adapted to the PjBL stages [21] are: Introduction, Essential Questions, Research and Write, Product Creation, Presentation, and Evaluation and Reflection. (Evaluation and Reflection). Each step in project-based learning is linked to each indicator of collaboration ability and problem solving ability. Furthermore, the indicators of collaboration ability that the researcher uses in this development research are: the contribution of each member during group work, working productively in groups, managing group task activities, respecting friends, having a caring attitude towards group friends, being able to adapt when working in groups. As for the indicator of problem solving ability, the researcher adapted from [22] Heller & Heller (2010), with the following steps: focus the problem (understand the problem), describe the problem in physics description (describe the problem into physics concepts), plan a solution (design solutions to problems), execute the plan (test the solution design), evaluate the solution (evaluate solutions).

The questionnaire data analysis technique on the feasibility and practicality analysis of the assessment instrument consisted of testing the validity of the substance, language, and construct. The expert validation test data uses a score based on a Likert scale with 4 levels, namely 4, 3, 2 and 1 which is then analyzed through calculations as:

$$P = \frac{total\ score\ obtained}{highest\ score\ count} x100\% \qquad (1)$$

The results of obtaining the average value of the validity of the assessment instrument are then categorized according to the criteria for the feasibility results in Table 1.

Table 1. Eligibility Percentage Results Criteria [23]

Percentage	Criteria
25 % - 43,75 %	Invalid
43,76 % - 62,50 %	Quite valid
62,51 % - 81,25 %	Valid
81,26 % - 100 %	Very valid

The empirical validity test in this development research uses the Rasch model assisted by Ministep software, the parameters used are as shown in Table 2.

Table 2. Parameters of Logit Value [24]

Outfit mean square value (MNSQ)	0,5 < MNSQ < 1,5.	Accepted
Outfit Z-standars value (ZSTD)	-2,0 < MNSQ < +2,0	Accepted
Outfit Point Measure Correlation Value (Pt Mean Corr)	0,4 < Pt Measure Corr < 0,85.	Accepted

The reliability test using the Rasch model with the help of Ministep 4.5.1 software obtained two results of reliability analysis, namely item reliability and person reliability as shown in Table 3.

Table 3. Cronbach's Alpha Criteria using the Rasch Model [25]

Score	Criteria
> 0,8	Very good
0,7 – 0,8	Good
0,6 – 0,7	Enough
0,5 – 0,6	Bad
< 0,5	Very Bad

The item reliability measures the quality of the items in the instrument and person reliability concludes with the consistency of answers from the respondents, the item criteria are presented in Table 4.

Table 4. Criteria for Item Reliability and Person Reliability [25]

Score	Criteria
> 0,94	Special
0,91 – 0,94	Very good
0,81 – 0,90	Good
0,67 – 0,80	Enough
< 0,67	Weak

Other data that can be used as a reference for the assessment parameters of the Rasch modeling analysis are the INFIT MNSQ and OUTFIT MNSQ values for the person table, if the value obtained is closer to 1.00, it means the better. Meanwhile, the INFIT ZSTD and OUTFIT ZSTD values are getting closer to perfect if they are close to the ideal value of 0.0, this means that the quality of the person is getting better.

Analysis of practicality criteria refers to the interval of practicality criteria in terms of teacher response questionnaires presented in Table 5.

Table 5. Practical Criteria for Learning Devices [26]

Score	Criteria
81-100	Very high
60-80	High
40-60	Enough
20-40	Low
0-20	Very low

3. RESULTS AND DISCUSSION

The product developed in this research and development is an assessment instrument to measure collaboration and problem solving abilities in project-based physics learning. The results of product development with the stages of the development model [27] carried out by researchers can be described as follows.

Research and Data Collection Phase Preliminary research was conducted at SMAN 1 Kotagajah, through distributing questionnaires to two teachers and 44 students of class XI. In the results of the preliminary study that has been carried out, data related to

conditions in the field are obtained that support the research on developing instruments to measure collaboration and problem solving abilities in project-based physics learning.

It was found that the instrument for assessing collaboration and problem-solving ability in project-based physics learning was not yet available at SMAN 1 Kotagajah. The assessment instruments available in schools are only examples of general instruments found in the teacher's book provided by the Ministry of Education and Culture 2013.

The planning stage is carried out by formulating research objectives and product development steps adapted from Borg & Gall and limited to only 7 development steps. The steps of operational field testing, final product revision and dissemination on the Borg & Gall development model were not carried out due to time and cost as research limitations. The product design in the initial content of the instrument consists of student worksheets, cover, foreword, table of contents, and rationale. Meanwhile, the instrument content section consists of a grid, instrument items, rubrics and instrument final scoring guidelines. In the final content section, the instrument consists of an assessment sheet, final score recapitulation, recommendations and bibliography.

The initial product development stage is carried out in the form of an instrument for assessing collaboration and problem-solving abilities in project-based physics learning, with the product development stages, namely: preparation of assessment instrument specifications containing ability indicators, writing instruments adapted to project-based learning steps, grids, formats and the form of the instrument (Figure 2).

Figure 2. The Cover and Table of Contents of Assessment

The rubric scale used in the observation aspect is based on the choice of scores that indicate the level of student ability based on predetermined aspects. The choice of assessment score is based on a rating scale of 4, 3, 2, 1. Researchers choose a rating scale

to assess collaboration and problem solving abilities because it adapts to the form of the instrument developed. This is in line with the opinion of [28] which states that the rating scale is able to provide a description regarding a set of statements of ability to be measured along with the fulfillment criteria, where the final results of assessment observations are able to show the quality of the abilities possessed by students. Meanwhile, the rubric of the assessment instrument contains scores along with aspects of the criteria that must be possessed by students.

The scoring guideline consists of each aspect and criteria with all aspects of the question being positive. A score of 4 indicates that students "always" do, a score of 3 indicates that students "often" does, a score of 2 indicates that students "sometimes" does, and a score of 1 indicates that students "never" perform activities according to the question indicators on the assessment instrument.

The interpretation of the assessment of collaboration and problem solving abilities is carried out with standard criteria of a 0-100% scale which are presented in Table 5.

Table 5. Assessment Criteria Based on [29]

Percentage (%)	Criteria
81-100	Very Good (A)
61-80	Good (B)
41-60	Enough (C)
21-40	Bad (D)
<21	Very Bad (E)

In the Initial Field Trial phase, expert validation tests were carried out on the assessment instruments, Student Worksheets (LKS) and Learning Implementation Plans (RPP) on aspects of construction, substance, and language. Each aspect was assessed by two Physics Education expert lecturers and one physics teacher. At this stage, a practical test of the instrument for assessing collaboration and problem-solving abilities was also carried out on aspects of ease of use, attractiveness of presentation, and usefulness by three practitioners with a minimum teacher education level of S2 and an educational background in Physics and the school where the practitioner teaches has implemented the 2013 Curriculum in their learning.

The results of the expert validity test on three aspects of substance, language and construct obtained a value of 87.85% with very valid criteria [30]. So that the developed instrument is suitable for use for field trials with improvements according to suggestions from experts. Project-based learning in its application must be applied in a structured and systematic manner so that learning activities are more directed, effective dan efisien.

So, we need a Learning Implementation Plan (RPP) that has been prepared, adjusted and validated by experts. Based on Table 14, the results of the expert validation test on the lesson plan, the average percentage score of the RPP feasibility assessment was 81.85% with very valid criteria [31].

In addition, to support the learning process and make it easier for teachers and students to work on project assignments, Student Worksheets (LKS) are prepared as a learning tool to increase student involvement or activity in the teaching and learning process. Based on the results of the expert validation test on the LKS, the average percentage score for the LKS feasibility assessment was 82.17% with valid criteria.

Based on the test data of the practicality of the instrument for assessing collaboration and problem solving abilities in the aspect of ease of use, an average score of 80.55 was obtained, the attractiveness of the presentation was 83.33 and the usefulness of the instrument was 79.76. Thus, the average score of the instrument's practicality assessment

was 81.21 and was included in the very high criteria. So that the instrument for assessing the ability of collaboration and practical problem solving is used with improvements according to suggestions from the three practitioners.

In the Revision Stage of the Test Results, the researcher revised the instruments, lesson plans and worksheets in accordance with the suggestions for improvement of the revisions obtained to be used to find out discrepancies, errors or deficiencies in each product, then revised or corrected them according to comments and suggestions from experts.

The Field Trial phase was carried out after the instrument for assessing collaboration and problem-solving abilities had been revised and declared valid by the three validators, then the instrument was tested limited to empirical validity and instrument reliability to 64 students of SMAN 1 Kotagajah who were studying the physics of optical instruments. Researchers assessed students' collaboration and problem solving abilities using observation techniques during the learning process. Learning is done face-to-face limited and each class has been divided into 6 groups according to the schedule of students' departure to school. The data obtained during field trials were then analyzed using Rasch modeling assisted by Ministep 4.5.1 software in a way, the data obtained were tabulated in Ms. Excel to then be converted and analyzed with the help of Ministep software.

Based on the item fit analysis of the collaboration ability assessment instrument, 21 of the 25 questions on the collaboration ability assessment instrument have met the criteria for valid parameters according to [32] . Meanwhile, 4 questions were declared invalid, namely numbers 1, 6, 19 and 21. Questions numbered 1, 6 and 19 were declared invalid because the ZSTD value exceeded the parameter criteria. While question number 21 is declared invalid because the MNSQ and ZSTD values exceed the parameter criteria. So, based on the data from the analysis of the table above, there are 21 valid questions and can be used. Meanwhile, 4 items are invalid, so they cannot be used or discarded.

Based on the item fit analysis of the problem-solving ability assessment instrument, 19 of the 20 items of the problem-solving ability assessment instrument have met the valid parameter criteria according to [33]. Meanwhile, 1 question that is not valid is number 5 because the ZSTD value exceeds the parameter criteria. So, based on the data from the analysis of the table above, there are 19 valid questions and can be used. While 1 item is invalid, so it cannot be used or discarded.

Based on Table 2. Parameters of logit value and the analysis of person reliability of the collaboration ability assessment instrument, it is known that the mean INFIT MNSQ and OUTFIT MNSQ respectively are 1.00 and 0.98, meaning that the value is getting better because the value is close to the ideal, namely 1.00. The average value of INFIT ZSTD and OUTFIT ZSTD, respectively, is -0.13 and -0.15, meaning that the quality of the person is getting better because the value is close to the ideal, which is 0.0. The value of person reliability is 0.90 which indicates that the consistency of the answers from the respondents is good.

According to parameters of logit value Table 2 and based on the analysis of person reliability of the problem-solving ability assessment instrument, it is known that the mean INFIT MNSQ and OUTFIT MNSQ, respectively, are 0.99 and 0.99, meaning that the value is getting better because the value is close to the ideal, namely 1.00. The average value of INFIT ZSTD and OUTFIT ZSTD respectively is -0.9 and -0.9, meaning that the quality of the person is getting better because the value is close to the ideal, which is 0.0. The value of person reliability of 0.87 indicates that the consistency of the answers from each respondent is good.

Based on the item reliability analysis of the collaborative assessment instrument, it is known that the mean INFIT MNSQ and OUTFIT MNSQ, respectively, are 1.00 and 0.98, according to parameters of logit value in Table 2. meaning that the value is getting better because the value is close to the ideal, which is 1.00. The average value of INFIT ZSTD and OUTFIT ZSTD, respectively, is -0.20 and -0.28, which means the quality of the items is getting better because the value is close to the ideal, which is 0.0. The value of item reliability is 0.86 which indicates that the quality of the items is good, meaning that the items on the collaborative assessment instrument are able to measure what they want to measure.

Based on the item reliability analysis of the problem-solving ability assessment instrument, it is known that the mean INFIT MNSQ and OUTFIT MNSQ, respectively, are 1.00 and 0.99, which means the value is getting better because the value is close to the ideal, namely 1.00. The average value of INFIT ZSTD and OUTFIT ZSTD, respectively, is -0.00 and -0.07, meaning that the quality of the items is getting better because the value is close to the ideal, which is 0.0. The value of item reliability is 0.79 which indicates that the quality of the items is quite good, meaning that each item on the problem-solving ability assessment instrument is able to measure what it wants to measure.

Operational product revision phase is carried out to improve the product so that the instrument has new parameters. Based on the results of the analysis on the collaboration ability assessment instrument, 4 invalid items were obtained, namely numbers 1, 6, 9 and 21 because the MNSQ and ZSTD values exceeded the parameter criteria. Meanwhile, for the problem-solving ability assessment instrument, one item is invalid, namely number 5 because the ZSTD value exceeds the parameter criteria. Thus, the question was decided to be discarded because it did not meet the standard question parameters. In addition, without 4 questions in the collaboration ability assessment instrument and one question in the problem solving instrument, the indicators for measuring collaboration and problem solving abilities are still fulfilled.

Based on the result according of parameters logit value and item reliability analysis of the assessment instrument. The final product of the assessment instrument to measure collaboration and problem-solving abilities consists of the initial content in the form of worksheets, cover, foreword, table of contents, and rationale. The contents of the content section consist of a grid, instrument form, rubric and instrument final scoring guidelines. The final content section consists of an assessment sheet, final score recapitulation, recommendations, and bibliography. The final result of this product is an instrument for assessing collaboration and problem-solving abilities, which consists of 21 questions for the assessment instrument for collaboration and 19 questions for the instrument for assessing problem-solving abilities.

The description of student activities for each question item on the collaboration ability assessment instrument developed refers to indicators from the aspect of collaboration abilities and is adjusted to each stage of project-based learning, namely: 1) collaboration consisting of 2 indicators, namely the contribution of each active member during group work and work productively in groups; 2) time management with indicators for managing group task activities; 3) flexibility which consists of 3 indicators, namely respecting friends, having a caring attitude towards friends, and being able to adapt when working in groups. The development of each item and description of activities on the problem-solving ability assessment instrument also refers to problem-solving indicators, namely: 1) understanding the problem; 2) describe the problem; 3) designing solutions to problems; 4) test the solution design; 5) evaluate the solution. Therefore, The results of the validation and practicality tests of the products developed are in the valid, reliable and

practical categories. So it is feasible to use to measure collaboration and problem solving abilities in project-based physics learning. This is supported by opinions [34] and [35] which reveal that the developed assessment instrument is said to be feasible if the developed assessment instrument is valid, reliable and practical.

4. CONCLUSION

Based on the presentation of the research results and discussion, it can be concluded that the instrument for assessing collaboration and problem-solving abilities in project-based physics learning is valid, reliable, and practical. The category for reliable is very good and the practicality criteria are included in the very high criteria. Thus, the collaborative and problem solving ability assessment instrument can be used as an alternative to measure collaboration and problem-solving abilities in project-based physics learning

REFERENCES

[1] Hariyatmi, H., & Luthfia, A. R. "Profil Soal Ulangan Biologi SMA di Kecamatan Kartasura dari Perspektif HOTs". Prosiding SNPBS (Seminar Nasional Pendidikan Biologi Dan Saintek) Ke-5. 2020

[2] Rosidin, U. *Evaluasi dan Asesmen Pembelajaran*. Media Akademi. 2017

[3] Hutabarat, O. R. *Model-model Penilaian Berbasis Kompetensi PAK*. Bina Media Informasi. 2004

[4] Setiawati, W., Oktavia, A., Yoki, A., Reisky, B., & A. P. *Buku Penilaian. Berorientasi Higher Order Thinking Skills*. In Kementerian Pendidikan dan Kebudayaan.2019

[5] Ansori, A. "Project Based Assessment on Biological Teaching and Learning Process at Madrasah Aliyah". Jurnal Diklat Keagamaan, 2017.

[6] Arnyana, I. B. . "*Pembelajaran untuk Meningkatkan Kompetensi 4C (Communication, Collaboration, Critical Thinking dan Creative Thinking) untuk Menyongsong Era Abad 21*". Prosiding : Konferensi Nasional Matematika Dan IPA Banyuwangi : Universitas PGRI Banyuwangi, 1(1). 2019

[7] Muiz, A., Wlujeng, I., Jumadi, & S. "Implementasi Model SUSAN LOUCKS-HORSLEY Terhadap Communication and Collaboration Peserta Didik SMP". Unnes Science Education Journal. 5(1), 1079–1084. 2016

[8] Yani dan Ruhimat. *Teori dan Implementasi Pembelajaran Saintifik Kurikulum 2013*. PT Refika Aditama (2018)

[9] Zubaidah, S. "Keterampilan Abad Ke-21: Keterampilan yang Diajarkan Melalui Pembelajaran. Disampaikan pada Seminar Nasional Pendidikan". Disampaikan pada Seminar Nasional Pendidikan. STKIP Persada Khatulistiwa Sintang.2016

[10] Docktor, J.L., et al. "Assessing student written problem solutions: A problem-solving rubric with application to introductory physics". Physical Review Physics Education Research, 12. 2016

[11] Yustinaningrum, B. "Model Pembelajaran Matematika Abad 21 (Kajian Model Project Based Learning)". Jurnal Sinektik, 1(2). 2019

[12] Barell, J. Problem based learning: The Foundation for 21st century skills.In J. Ballanca & R. Brandt (Eds.), 21st century skills: Rethinking how students learn. Solution Tree Press.2010

[13] Baron, K. (2011). Six steps for planning a successful project. Retrieved on Nov, 15 2020, from www.edutopia.org/maine-project-learning-six-stepsplanning. 2011

[14] Cole, J. E, & Washburn-Moses, L. H. "Going beyond "the math wars". A special

educator's guide to understanding and assisting with inquiry-based teaching in mathematics". Teaching Exceptional Children, 42(4), 14–21.2010

[15] O'Malley, J.M., & Pierce, L. V. Authentic Assessment for English Language Learner: Practical Approaches for teacher. New York: Addison-Wesley. 1996

[16] Marzano, R. J., Pickering, D.J. and McTighe J. Assessing student outcomes: performance assessment using the Dimensions of Learning model Alexandria. Va: Association for Supervision and Curriculum Development. 1993

[17] Waters, Robert and Michael McCracken. Assessment And Evaluation In Problem-Based Learning. [online] http://www.fie-conference.org/ diakses 24-10-2014. 2012

[18] Wijayanti, E., & Mundilarto. Pengembangan Instrumen Asesmen Diri dan Teman Sejawat Kompetensi Bidang Studi Pada Mahasiswa.Jurnal Penelitian dan Evaluasi Pendidikan. 19 (2), 129-144. 2015

[19] Noviana, Ayu., et al. Development and Validation of Collaboration and Communication Skills Assessment Instruments Based on Project-Based Learning. Journal of Gifted Education and Creativity, August, 6(2), 133-146. 2019.

[20] Borg, W. R., & Gall, M. *Educational research: An introduction (5th ed.)*. Longman. 1989

[21] Cameron, S., & C. C. *Project-Based Learning Task for Common Core State Standards, Grade 6-8*. Mark Twain Media, Inc.2014

[22] Heller, K & P. Heller. *Cooperative Problem Solving in Physics A User's Manual. [Online].* Tersedia: http://www.aapt.org/Conferences/newfaculty/upload/Coop-Problem-Solving-Guide.pdf. 2010

[23] Octavia, N. R. "Pengembangan Kuis Interaktif Tipe Multiple Choice Menggunakan Wondershare Quiz Creator Materi Impuls dan Momentum bagi Siswa SMA". Lampung University. 2017

[24] Boone, W.J., Staver, J.R., & Yale, M. . *Rasch Analysis in the Human Science*. Springer.2014

[25] Sumintono, B., & Widhiarso, W. *Aplikasi Pemodelan Rasch Pada Assessment Pendidikan*. Tim Komunikata.2015

[26] Riduwan. *Cara Mudah Menggunakan dan Memaknai Path Analysis (Analisis Jalur)*. Alfabeta. 2012

[27] Borg, W. R., & Gall, M. *Educational research: An introduction (5th ed.)*. Longman. 1989

[28] Zainul, A. *Alternative Assessment Applied Approach Mengajar di Perguruan Tinggi. Pusat Antar Universitas Untuk Peningkatan dan Pengembangan Aktivitas Instruksional*. Ditjen Dikti Depdiknas.2001

[29] Arikunto, S., & Jabar. *Evaluasi Program Pendidikan (Edisi revi)*. Bumi Aksara. 2007.

[30] Octavia, N. R. "Pengembangan Kuis Interaktif Tipe Multiple Choice Menggunakan Wondershare Quiz Creator Materi Impuls dan Momentum bagi Siswa SMA". Lampung University. 2017

[31] Octavia, N. R. "Pengembangan Kuis Interaktif Tipe Multiple Choice Menggunakan Wondershare Quiz Creator Materi Impuls dan Momentum bagi Siswa SMA". Lampung University. 2017

[32] Boone, W.J., Staver, J.R., & Yale, M. . *Rasch Analysis in the Human Science*. Springer.2014

[33] Boone, W.J., Staver, J.R., & Yale, M. . *Rasch Analysis in the Human Science*. Springer.2014

[34] Wusqo, I.U., Taufiq, M., & Handayani, R. "Pengembangan Asesmen Alternatif

Praktikum Kimia Dasar Melalui Chemistry Fair Project (CFP) Berbasis Konservasi Dengan Memanfaatkan Daily Chemical". Jurnal Penelitian Pendidikan, 33(2). 2016

[35] Hasana, I., Saptasari, M., & Wulandari, N. "Pengembangan Instrumen Penilaian Kemampuan Literasi Sains Siswa Kelas XI Materi Sistem Ekskresi Dan Koordinasi di SMAN 9 Malang". Jurnal Pendidikan Biologi, 8(2), 52–56. 2017