DEVELOPING WORKSHEETS BASED ON
SCIENTIFIC CREATIVITY IN FUNDAMENTAL
PHYSICS COURSE

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Abstract—The goals of this study are to develop worksheets that valid and effective to
improve students’ scientific creativity in fundamental physics course. Designs of this
development are include preliminary research, prototype phase, and assessment phase.
The pilot study of worksheets was carried out by 30 students of Physics Education
FKIP at Lambung Mangkurat University Banjarmasin in March to July 2016. Data
collected from validation by experts of physics learning, tests, and qualitative
descriptive analysis. Data were analyzed by descriptive quantitative and qualitative.
Design of worksheets include identity, learning indicators, necessary of creative
learning, creatively problem finding, creatively experiment designing, creatively
science problem solving, and strengthening scientific creativity. The validation results
of worksheets include design, format, content, language, presentation, support
innovation and learning quality in a highly valid criterion. It is developed according to
the needs and logically arranged by degree of renewal of scientific knowledge. A lot of
students’ scientific creativity (creativity problem finding, creatively experiment
designing, and creatively science problem solving) those have creative criteria/highly
creative criteria. And increasing students’ scientific creativity before and after the
learning process as many as 57% is in high criteria, 43% are in the middle criteria,
and no students in the less criteria. The conclusion is the worksheet that developed in
this research, valid and effective to improve students’ scientific creativity in
fundamental physics course.

Keywords: scientific creativity, worksheets, fundamental physics course

I. INTRODUCTION

Modern society requires creativity to solve problems [28][1], and adapt to new demands in a flexibility
[8][2]. Creativity involves the production of new ideas and unusual, as well as thinking about unique
solutions to solve the problem [5][3], [22][4], [27][5], [10][6], [17][7], [1][8], [2][9]. Creativity related to
physics learning, known as scientific creativity [17][7]. Scientific means that the creativity must be tested
through the evidence of observation or experiment [18][10]. Scientific are specific needs of scientific
creativity [10][6]. Scientific creativity can be defined as the ability to use scientific knowledge and skills
to produce a certain product that is original and has certain social or personal value. It is concerned with
creative science experiments, creative problem finding and solving, and creative scientific activity
[9][11], [10][6], [23][12].

Development of scientific creativity in the physics learning involves the interaction to generalization
hypothesis, experimental design, and evidence evaluation [17][7], [1][8]. Generalization hypothesis
involves students to formulating hypothesis, which derived from previous knowledge or from
experimental data, and then verify the rationality of hypotheses to be investigated. Experimental design
involves students when designing and implementing the right experiment to prove or disprove the
hypothesis. The evidence evaluation is done by verifying the agreement between theory and the results
of the investigation. Physics Learning involving as many possible questions that encourage students to use
their creative ideas, give a challenge, create a fun atmosphere during learning activity, notice the
difference as a profit not a problem, appreciate every products of imagination (students’ vision in the
future, new ideas, solutions provided, experiments were conducted, they understood better exploration,
etc.), see the mistakes as a part of learning process to create change towards success, do the innovations to
existing products by accept suggestions and criticism bravely [12][13]. Investigation based learning and a variety of fun activities, that aim to empower and motivate students to control the learning process itself [14][14].

The development of scientific creativity in the physics learning at Universitas Lambung Mangkurat Banjarmasin tends to be ignored until now. It's because the learning process is still oriented on products [25][15]. Students did not understand the usage of the physics concept for something unusual. The students also get the difficulties when using the physics concept to improve product quality and design products more creative [13][16]. Therefore, the goals of this study are to develop worksheets that valid and effective to improve students' scientific creativity in fundamental physics course. Development of scientific creativity is adapted The Scientific Structure Creativity Model [9][11]. It includes creatively problem finding, creatively experiment designing, and creatively science problem solving. Creatively problem finding is to measure the degree of sensitivity to science problems. It to raise new questions, new possibilities from a new angle, requires imagination and is necessary to make real advances in science. Creatively experiment designing is to design an experiment creatively include formulating a hypothesis, identify variables, making the operational definition of variables, designing data tables, and designing experimental procedures. Creatively science problem solving to measure ability of creative science problem solving.

II. Methodology

A. Research Design

Designs of this development are include preliminary research, prototype phase, and assessment phase. Worksheets, that were developed, get validation by experts of physics learning and then modeling at 48 students of Physics Education FKIP at Universitas Lambung Mangkurat Banjarmasin. The goal of modeling is to provide a direct experience to the lecturers' models, and also knowing the constraints worksheets during the worksheets is used in the classroom. Further lecturers models conduct the pilot study of worksheets. The pilot study used a one group pretest posttest design. It was carried out by 30 students of Physics Education FKIP at Universitas Lambung Mangkurat Banjarmasin in March to July 2016. The learning activity is began with a pretest, training scientific process skills as a provision for prior knowledge students. Implementations of learning with worksheets based on scientific creativity are finished by a posttest. Data were analyzed by descriptive qualitative. The average score of the results of the expert assessment adjusted to include the validation assessment criteria are highly valid, valid, less valid, and invalid. The pretest-posttest results were classified based on the criteria of scientific creativity is highly creative, creative, less creative and uncreative. Increasing scientific creativity is determined based on the value of r-gain with the criteria of high, middle, and low.

B. Worksheet Description

Worksheet that based on scientific creativity is developed on the electricity and magnetism subject. The development of worksheets considered the metacognitive skills theory, theory of complex cognitive process, constructivism, and scaffolding. Scaffolding can help students gain experience in solving ill-defined problem [6][17]. Worksheet 1: Current and Resistance and Worksheet 2: Direct Current Circuits, used in the early learning and is designed to use the full scaffolding (lecturer's helps have written clearly and completely in worksheet). The worksheet is used at the 1st and 2nd meeting for teach scientific creativity step by step and the autonomy of the students are still low. Worksheet 3: Magnetism is used for 3rd meeting. Scaffolding began to be reduced and began to eliminate some explanations. Students learn to use the scientific creativity automatically learn by direct experience, and internalize standards of behavior. Worksheet 4: Faraday's Law, Worksheet 5: Alternating Current Circuits, and worksheet 6: Power in an AC Circuits used at 4th, 5th, and 6th meeting. Students are given greater responsibility for developing scientific creativity in solving a given problem.

Each worksheet outline consists of seven parts. First, the identity of the worksheet includes student group identity (name, student identity number, groups, and semester), meetings, and material to be learned. Completeness identity will make lecturers can perform the evaluation easily. It also made easily follow-up on the results of scientific creativity and learning process that has been done by the students. Second, learning indicators, the expected results after the students following the learning process. Well-defined indicators will clarify these expectations in the form of performance/achievement of students were measured and observed. Indicators developed learning is to apply scientific creativity in solving
physics problems. Third, the necessary of creative learning. Students more likely to think creatively if the learning environment to able to stimulate and encourage independent thought [15][18]. Clarity of presentation tools and materials as well as the media is helping students to recognize various experimental variables that support investigative activities to be undertaken. Fourth, creatively problem finding. A science problem is an issue or problem situation related to science [4][19]. Problems playing a major role in the advancement of science. It because the problem leads to the growth of science and encourage scientific investigation [13][20]. The problem that developed was III-defined problem, that the problem of loosely formulated in order to produce some of the strategies and solutions [15][18]. This four phases intended to improve problem finding. Students are expected to be able to imagine the way to finding a relationship between variables. The variables can be written or not written even in its application in everyday life. So students can write as much as possible formulation of the problem to be investigated using tools and materials or media PhET available within five minutes. Fifth, creatively experiment designing. This stage has the main goal of improving creatively experiment designing. Students are asked to select one formulation of the problem that has been written in the previous stage. And the student asked to design an experiment creatively include formulating a hypothesis, identify variables, making the operational definition of variables, designing data tables; and designing experimental procedures correctly. Sixth, creatively science problem solving. Students are given the opportunity to carry out experiments based on the design of experiments that have been made in the previous stage. Students do documentation for every performed activity and recorded information is found in the design of observational data tables that have been made. Students also analyze the observed data and then compare it with the study of theory or the theory of computation. So it can draw conclusions accordingly. Seventh, strengthening of scientific creativity. This stage aims to strengthen the scientific creativity of students. Students are asked to relearn indicators of scientific creativity with examples of test items, then given the responsibility to make two test items scientific creativity and solutions with appropriate indicators of the division of tasks given group. In addition, each group was asked to present the group's work in front of the class. Moreover, added the bibliography as a major reference in the development of the worksheet.

III. RESULTS AND DISCUSSION

The validity of worksheet based scientific creativity indicates a worksheet quality measures to provide convenience to the lecturers in teaching the scientific creativity of students in fundamental physics course. The results of worksheet validation are presented in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>W1 Score</th>
<th>W1 Exp</th>
<th>W2 Score</th>
<th>W2 Exp</th>
<th>W3 Score</th>
<th>W3 Exp</th>
<th>W4 Score</th>
<th>W4 Exp</th>
<th>W5 Score</th>
<th>W5 Exp</th>
<th>W6 Score</th>
<th>W6 Exp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design</td>
<td>3.74</td>
<td>HV</td>
<td>3.81</td>
<td>HV</td>
<td>3.78</td>
<td>HV</td>
<td>3.80</td>
<td>HV</td>
<td>3.96</td>
<td>HV</td>
<td>3.93</td>
<td>HV</td>
</tr>
<tr>
<td>2</td>
<td>Format</td>
<td>3.93</td>
<td>HV</td>
<td>3.93</td>
<td>HV</td>
<td>3.87</td>
<td>HV</td>
<td>3.83</td>
<td>HV</td>
<td>4.00</td>
<td>HV</td>
<td>3.93</td>
<td>HV</td>
</tr>
<tr>
<td>3</td>
<td>Content</td>
<td>3.78</td>
<td>HV</td>
<td>4.03</td>
<td>HV</td>
<td>3.83</td>
<td>HV</td>
<td>3.94</td>
<td>HV</td>
<td>4.06</td>
<td>HV</td>
<td>3.89</td>
<td>HV</td>
</tr>
<tr>
<td>4</td>
<td>Language</td>
<td>4.00</td>
<td>HV</td>
<td>4.00</td>
<td>HV</td>
<td>4.00</td>
<td>HV</td>
<td>4.00</td>
<td>HV</td>
<td>4.00</td>
<td>HV</td>
<td>4.00</td>
<td>HV</td>
</tr>
<tr>
<td>5</td>
<td>Presentation</td>
<td>3.47</td>
<td>HV</td>
<td>3.47</td>
<td>HV</td>
<td>3.03</td>
<td>HV</td>
<td>3.67</td>
<td>HV</td>
<td>3.73</td>
<td>HV</td>
<td>3.80</td>
<td>HV</td>
</tr>
<tr>
<td>6</td>
<td>Support innovation</td>
<td>3.76</td>
<td>HV</td>
<td>3.76</td>
<td>HV</td>
<td>3.81</td>
<td>HV</td>
<td>3.90</td>
<td>HV</td>
<td>3.90</td>
<td>HV</td>
<td>3.90</td>
<td>HV</td>
</tr>
</tbody>
</table>

Note: W = Worksheet, Exp = Explanation, HV = Highly Valid

Table 1 shows that the results of the validation of each worksheet includes the aspects of design, format, content, language, presentation, support innovation and the quality of learning activities to get the assessment criteria are very valid and reliable. Development of worksheet has compiled with all aspects of assessment, namely: (1) design, including identity, learning indicators, necessary of creative learning, creatively problem finding, creatively experiment designing, creatively science problem solving, strengthening scientific creativity, and a bibliography, (2) format, each section of the worksheet is identified clearly, the material relevant to the purpose of each activity, the numbering system is clear and compelling, balanced text and illustrations, the physical size appropriateness for students, and the level of attractiveness of the worksheet visually, (3) material, using a reference standard book, the truth of the content (facts, principles, concepts, laws, theories, and scientific processes), recency of the content,
maintaining linkage content worksheet with implementation in education, systematic corresponding structure of science, and relevant to the curriculum of higher education, (4) language, using the Indonesian language is good and right, the term is used appropriately and easily understood, using a term steady, and using language communicative and effective, (5) the presentation, can teach process skills, critical thinking, and scientific creativity in accordance with the level of thinking and reading skills of students and lecturers in physics, encouraging students to be actively involved, as well as the presentation of interesting and fun, and (6) to support innovation and improve the quality of learning activities, worksheets according to the higher education curriculum, emphasis on the application of education the real world, supporting active learning, facilitate the development of scientific creativity and problem solving, utilizing the media usage of ICT, support learning activities tinged learning to know, learning to do, learning to be yourself, and learn to live by togetherness. Means worksheet based scientific creativity is developed according to the needs and logically arranged by decree of renewal of scientific knowledge, so it is valid to be used in fundamental physics course.

The effectiveness of worksheet shows the achievement of the students' scientific creativity before and after the learning process is presented in Figure 1.

![Figure 1. The Analysis of Scientific Creativity](image)

Figure 1 shows that of 30 students who can complete the test scientific creativity in the criteria of creative/highly creative in the indicators of creatively problem finding as many as 3 students; creatively designing experiment as much as 1 students, and creatively science problem solving as many as 6 students. It means the most of student are still difficulties in creatively problem finding, creatively experiment designing, creatively science problem solving. Implementation of learning can increase the number of students who meet the criteria are highly creative/creative, indicators of creatively problem finding as many as 18 students, creatively experiment designing as many as 26 students, and creatively science problem solving as many as 27 students. The increasing students’ scientific creativity before and after the learning process by worksheet based scientific creativity as many as 57% are in high criteria, 43% are in the middle criteria, and no students in the low criteria. The process of learning with worksheet based scientific creativity to make the most of the students can complete the test criteria of scientific creativity in creative/highly creative, although there are 12 students who have difficulty in creatively problem finding. Student been able to formulate the problem by using variables that are written in the given equation, but some students are still having trouble connecting in common with everyday problem solving, some students also still get difficulty distinguishing the formulation of the problem with research questions. The learning process is said to be effective if the learning outcomes achieved graduates are effective with emphasis on internalizing the material is good and right in the optimum time [20][21].

IV. CONCLUSION

Worksheet based on creativity is developed to give an easy ways for lecturer during teaching of scientific creativity of students in fundamental physics course. Scientific creativity is adapted The Scientific Structure Creativity Model [9][11], includes creatively problem finding, creatively experiment designing, and creatively science problem solving. Design of worksheets include identity, learning indicators, necessary of creative learning, creatively problem finding, creatively experiment designing, creatively science problem solving, and strengthening scientific creativity. Learning worksheets based scientific creativity begins with science process skills training. Scientific creativity must depend on scientific knowledge and skills [9][11], [15][18]. The validation results of worksheets include design, format, content, language, presentation, support innovation and learning quality in very valid criteria. Means worksheet based on scientific creativity is developed according to the needs and logically arranged...
by decree of renewal of scientific knowledge, so it is valid to be used in fundamental physics course. The results show that a lot of students' scientific creativity (creatively problem finding, creatively experiment designing, and creatively science problem solving) those have creative criteria/highly creative criteria, but some students are less creative in creativity product design. And increasing students' scientific creativity before and after the learning process by worksheet based on scientific creativity as many as 5% are in high criteria and 45% are in the middle criteria. This worksheet supporting the implementations Indonesian National Qualifications Framework and National Standards for Higher Education, in which the learning process in higher education should provide space for the development of creativity, initiative, personality, independence in looking for and finding knowledge, and to produce graduates competence creative accordance of demands of the 21st century [21][22], [19][23], [20][21]. Recommendations for further research are increasing creatively problem finding.

ACKNOWLEDGMENT

The research reported in this study was supported by The Ministry of Education and Culture provides scholarships for Post-Graduate Program and Doctoral Dissertation Research Grant. Universitas Lambung Mangkurat gives permission for task studying.

REFERENCES

A. Indikator Pembelajaran

Menunjukkan kreativitas linear (creatively problem finding, creatively experiment designing, creatively science problem solving) dalam menyelesaikan masalah arus listrik dan hambatan.

B. Kebutuhan Belajar Kreatif

Diskusi tentang kebutuhan belajar kreatif meliputi hal yang dibahas pada media PhET yang disebutkan di bawah ini.

KIT 1: Arus Listrik dan Hambatan

**Media PhET:** Circuit-construction-kit-dc_in

Bayangan sebuah rangkaian terdiri atas sebuah lampu DC LED yang dihidupkan dengan sebuah sumber tegangan DC oleh suatu kawat kondusor. Arus listrik yang mengalir dalam rangkaian tersebut memenuhi persamaan: $i = \frac{V}{R}$ dan $P = i^2R$

Hambatan pada kawat kondusor adalah: $R = \frac{V}{i}$ dan $R = \frac{P}{i^2}$

Masalah dikerjakan dalam bentuk kalimat tanya terbuka dan secara spesifik (mengandung 1 variabel manipulasi dan 1 variabel respon), dan dapat diuji melalui penyelidikan.

Kamu diberikan waktu 5 menit. Tulislah sebanyak-banyaknya rumus masalah yang mungkin untuk diselidiki dengan menggunakan alat dan bahan atau media PhET yang tersedia (problem finding).

D. Mendesain Experiment sesuai Kreatif

Kamu diberikan waktu sepuluh menit. Buatlah salah satu rumusan masalah yang sudah kamu tuliskan, kemudian desainlah sebuah eksperimen kreatif meliputi merumuskan hipotesis, identifikasi variabel, membuat definisi operasional variabel, merancang tabel data pengamatan, dan merancang prosedur eksperimen.

1. Rumusan Masalah yang Ingat Disedihkan

2. Rumusan Hipotesis

Hipotesis adalah suatu prediksi berdasarkan pengamatan yang dapat diuji atau jujub sementara dari rumusan masalah.

Hipotesis dirumuskan dalam bentuk suatu pernyataan, jika (variabel manipulasi) maka (variabel respon).

Buatlah rumusan hipotesis untuk menjawab rumusan masalah yang kamu pilih.

3. Identifikasi Variabel

Variabel adalah suatu bebanan yang dapat berubah atau berubah pada situasi tertentu. Identifikasi variabel meliputi variabel manipulasi (variabel yang senang disebabkan perilaku), variabel respon (variabel yang berguna bervariabel sebagai akibat perubahan variabel manipulasi), dan variabel kontrol (variabel yang dapat mempengaruhi suatu hasil penelitian tetapi dijaga agar tidak mempengaruhi penelitian).

Lakukan identifikasi variabel terhadap rumusan hipotesis yang sudah kamu buat.

Variabel manajemen (Apa yang kamu amati atau ukur): 

Variabel respon (Apa yang kamu ukut atau ukur): 

Variabel Kontrol (Apa yang kamu cek atau kondisinya sama): 

4. Definisi Operasional Variabel
Definisi operasional variabel adalah penyesuaian yang mendeskripsikan bagaimana variabel tersebut harus diukur atau bagaimana suatu bentuk kondisi harus dikerjakan.

Buat definisi operasional terhadap variabel-variabel yang sudah kamu identifikasi!

Definisi Operasional Variabel Manipulasi (Bagaimana kamu mengubahnya):

Definisi Operasional Variabel Repon (Bagaimana kamu mengukurnya):

Definisi Operasional Variabel Kontrol (Bagaimana cara kamu mengontrolnya):

5. Merancang Tabel Data Pengamatan

Tabel data adalah suatu informasi terorganisir dalam baris-baris dan kolom-kolom. Merancang tabel data dilengkapi judul tabel data pengamatan, mengatur 1 variabel manipulasi dan 1 variabel respon, dan menggambarkan setiap nomor atau skor yang digunakan.

Rumuslah tabel data pengamatan untuk menentukan hasil pengamatan yang akan kamu lakukan!

6. Merancang Prosedur Ekspерimen

Prosedur eksperimen adalah suatu deskripsi lanjut bagaimana variabel manipulasi dan variabel respon mengarungi bagaimana cara kausalitas terhadap variabel respon.

Rumuslah prosedur eksperimen untuk menguji rumusan hipotesis yang kamu buat!

E. Memecah Masalah Sains secara Kreatif

Lakukan eksperimen untuk mendapatkan informasi yang diperlukan dan catatlah hasilnya pada tabel pengamatan yang telah kamu buat sebelumnya. Kemudian buatlah berbagai referensi untuk membantu memecahkan masalah data secara akurat dan mendalam, serta merancang kemampuan dengan tepat.

1. Melakukan eksperimen

Ekspерimen dilaksanakan untuk mengumpulkan data-data yang diperlukan dalam menguji hipotesis. Data hasil eksperimen dapat berupa data kuantitatif atau data kualitatif.

Dokumentasi Registasi (pakai logistik)

2. Analisis data

Mengartikali data adalah mengidentifikasi atau mengartikan data yang diperoleh dari hasil eksperimen. Mengartikali data dilakukan dengan cara membendung atau mencari kesederhanaan dari data yang disusun, serta mengevaluasi kemampuan hasil eksperimen dengan teori-perkutungan secara teori.

Lakukan analisis berdasarkan data yang telah kamu peroleh!

Lakukan analisis sesuai teori atau perhitungan secara teori!

3. Kesimpulan

Kesimpulan adalah pemahaman yang menggambarkan apa yang telah dipelajari dari suatu eksperimen atau pengamatan. Kesimpulan disusun dengan penegakan bahwa hipotesis diterima atau ditolak, kemudian diberikan keterangan secara arah dan jelas.

Berdasarkan kesimpulan berdasarkan hasil analisis data yang telah kamu lakukan!

Hipotesis

F. Pemantapan Kreativitas Ilmiah

Pendidikan kreativitas ilmiah harus berbasis contoh butir besar cukup bawah ini!

1) Creative problem finding: Tingkat kepesertaan terhadap masalah-masalah sains.


2) Creative experiment design: Mencipta eksperimen secara kreatif.


3) Creative science problem solving: Penciptaan masalah sains secara kreatif.


Lakukan kerja sama untuk membantu butir tes kreativitas ilmiah dengan indikator senai pembagian tugus kelompok berikut ini!
<table>
<thead>
<tr>
<th>Kelompok</th>
<th>Tugas Membuat Buku Tes Kreativitas Bimah dengan Indikator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 dan 2</td>
<td>Problem finding</td>
</tr>
<tr>
<td>3 dan 4</td>
<td>Creatively product design</td>
</tr>
<tr>
<td>5 dan 6</td>
<td>Creatively science problem solving</td>
</tr>
</tbody>
</table>

Daftar Pustaka

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