Development of physics learning tools based on inquiry to increase creative thinking skills

M Asy'ari[1], S Prayogi[1], B Mirawati[1], Syarifuddin[2], Hunaepi[1], Syahrir[1], and Suhirman[3]

[1]Universitas Pendidikan Mandalika, Mataram 82125, Indonesia
[2]Universitas Halu Oleo, Kendari, Indonesia
[3]Universitas Islam Negeri Mataram, Indonesia

E-mail: saifulprayogi@ikipmataram.ac.id

Abstract. This study aimed to produce physics learning tools based on inquiry that are valid, practical, and effective to improve students' creative thinking skills on heat material. This study is a developmental research using the 4D (define, design, develop, disseminate) model. Learning tools in the form of syllabus, lesson plan, student activity sheets, student textbooks, and test instruments were validated by 2 experts before being implemented on 22 students. The research data were collected using instruments of validation, observation, questionnaires, and tests which were then analyzed descriptively and statistically. The results showed that the learning tools produced was valid in terms of content and construct, was practical based on the implementation of learning and student responses, and was effective in improving students' creative thinking skills. Research findings based on indicators of creative thinking skills such as fluency, flexibility, originality, and elaboration are also described in this paper.

1. Introduction

Higher order thinking skills have a lot of definition and thinking activities [1] which not only requires skills to remember, but also requires higher thinking skills [2]. Creative thinking skills have aspects such as fluency, flexibility, originality, and elaboration [3] Creative thinking skills have aspects such as fluency, flexibility, originality, and elaboration [4]. Creative thinking is a unique form of expression for a person [5] which leads to novelty, the ability to create something, apply new forms, generalize various skills, or create something new from something that already exists [6].

Some studies showed that students' creative thinking skills were still low [3] and showed a downward trend over time among American students of all ages [7]. Implementation of learning in schools that is not as expected [8] and the minimal use of innovative learning models [9] is alleged to be the cause of these problems. In line with that description, another studies showed that 57.8% of students' creative thinking skills fall into the poor category [10] and can't show a detailed flow of problem solving [11] because science learning in Indonesia is more focused on remembering science concepts [12]. Inquiry learning model is often applied to improve students' creative thinking skills [13,14].

Inquiry learning model can help students to practice in a team, develop competence in research, knowledge, motivation, writing skills, cooperative learning and social skills [15]. The inquiry learning model can facilitate students in learning activities by giving initial questions and leading to a

discussion [16]. It is further explained that the inquiry learning model emphasizes observation, questioning, evaluating information sources to determine what is known [17,18], planning investigations, conducting experiments [19,20], utilizing tools for data collection, analysis and interpreting data, formulating answers, elaborating, predicting, and communicating the results obtained [21] from learning activities.

Inquiry learning has three main characteristics such as (1) emphasizing the maximum student activity to seek and find, which means placing students as learning subjects, (2) all activities carried out by students are directed to seek and find their own answers to something being questioned, so that is expected to foster self-belief, and (3) develop the ability to think systematically, logically and critically, or develop intellectual abilities as part of the mental process. [22] and six steps i.e. (1) gain attention and explain the inquiry process, (2) present the inquiry problem or discrepant event, (3) have students formulate hypotheses to explain the problem or event, (4) encourage students to collect data to test the hypothesis, (5) formulate explanations and/or conclusions, and (6) reflect on the problem situation and the thinking processes used to inquire into it [21].

Based on the results of preliminary observations, it was found that several obstacles caused the weakness of students' creative thinking skills, including (1) readiness of learning devices, (2) weak emphasis on process aspects, and (3) lack of use of innovative learning models that demand student activity in learning, so that the development of student-centered interactive model-based learning tools is important. Several studies related to the development of inquiry learning tools in various science teaching materials showed positive results in an effort to improve students' scientific literacy [22, 23] and critical thinking skills [24, 16,25] but these studies did not look at aspects of creative thinking skills. Research related to the development of inquiry learning tools to teach creative thinking skills was delivered by Ningsih et al [26] who found that structured inquiry with brainstorming strategy learning tools proved valid, practical and effective in improving students' creative thinking skills. The research was conducted on elementary school students and did not explicitly explain the teaching material that was integrated into the developed tools.

This study aimed to develop physics learning tools on heat material based on inquiry learning model in the form of a syllabus, lesson plan, student activity sheets, student textbooks, and test instruments to improve high school students' creative thinking skills with fluency, flexibility, originality, and elaboration indicators. This research is important to do considering higher order thinking skills are the goal of education globally [27] and the importance of emphasizing process aspects in school science learning [19,28,29,30].

2. Method

This study is a developmental research that using Four D Models with the stages of define, design, develop and disseminate [31]. The study data obtained are data on the validity, practicality and effectiveness of physics learning tools based on inquiry that collected using validity instruments, observation sheets and response questionnaires (practicality), and creative thinking skills test instruments (effectiveness).

Learning tools in the form of syllabus, lesson plan, student activity sheets, student textbooks, and test instruments were first validated by 2 competent validators to assess the content and construct aspects of the learning tools developed. The assessment of the validity of the learning tools uses four rating scales, namely 1 = invalid, 2 = less valid, and 3 = valid, and 4 = very valid [32] which then converted into qualitative data on a scale of 4 based on the criteria in Table 1.

Table 1. Validity of learning tools

Score Interval	Category	Description
$3.7 \leq S \leq 4$	Very valid	Can be used without revision
$2.8 \leq S \leq 3.6$	Valid	Can be used with minor revisions
$1.9 \leq S \leq 2.7$	Less valid	Can be used with multiple revisions
$1 \leq S \leq 1.8$	Invalid	Not yet usable and still requires consultation

The practicality of the learning tools is determined by observing the implementation of the lesson plan by 2 observers at each meeting. Observation data on the implementation of learning obtained are in the form of scores ranging from 1 to 4, with categories 1 = not good, 2 = good enough, 3 = good, and 4 = very good, which are then interpreted in the form of scores in Table 2.

Table 2. Scoring Criteria

Score interval	Percentage (%)	Category
1 – 1.5	0 - 50	Not good
1.6 – 2.5	50 - <65	Good enough
2.6 – 3.5	65 - < 85	Good
3.6 – 4	85 - 100	Very good

Student responses after learning are also a component of the practicality assessment of the learning tools developed. Students give responses after learning by choosing statements objectively consisting of 2 categories (yes and no). The percentage of student responses was then converted based on the criteria (1) 0% - 20% = very weak, (2) 21% - 40% = weak, (3) 41% - 60% = sufficient, (4) 61% - 80% = strong, and (5) 81% - 100% = very strong [33]. The reliability of the learning tools assessment is determined using the equation: *percentage of agreement= 100 [1-(A-B)/(A+B)]* [34].

This study was conducted on 22 students in one of the senior high schools in central Lombok who were observed in the pre-test stage (O_1) which was then followed by particular treatment (X) and *post-test* (O_2) [35]. Students' creative thinking skills are measured using a test instrument that refers to the Guilford and Hoepfner [36] creative thinking test. Students are declared creative if the creative thinking test score is $\geq$ 61.2% [37]. The analysis of the improvement of students' creative thinking skills was carried out by using paired sample tests on pre-test and post-test data with the help of SPSS 17 for windows software and equations: score = (obtained score/maximum score) x 100% which are further categorized based on the criteria in Table 3.

Table 3. Criteria for creative thinking skills

Interval	Category
81.00% - 100%	Very creative
65.00 % - 80.99%	Creative
41.00% - 64.99%	Less creative
0.00% - 40.99 %	Not creative

3. Result and Discussion

3.1. Learning tools validity

Physics learning tools based on inquiry model in the form of a syllabus, lesson plan, student activity sheets, student textbooks, and test instruments are validated before being implemented. The results of the validation of the learning tools developed are presented briefly in Table 4.

Table 4. Validity of learning tools

No	Item	Validity	Category	Reliability	Category
1	Syllabus	3.51	Valid	0.94	Reliable
2	Lesson plan	3.44		0.96	
3	Student worksheet	3.60		0.98	
4	Textbook	3.36		0.95	
5	Test instrument	3.50		0.98	

Table 4 shows that the learning tools developed are declared valid and reliable to be implemented to students to learn creative thinking skills. The learning model that is integrated in the developed tools is an inquiry learning model that emphasizes scientific activity [18] so that it helps students have the ability to see problems from various points of view and be able to generate many ideas [38].

3.2. Learning tools practicality

The learning tools developed were also stated to be practical to improve students' creative thinking skills based on the results of the analysis of the implementation of learning for three meetings. The results showed that the overall implementation of learning activities was categorized as very good (score: 3.62) and reliable (reliability: 0.99). The results of the analysis of student responses to inquiry learning and learning tools showed a positive response (94%) further strengthening the practicality of learning tools developed in improving students' creative thinking skills. Inquiry learning models that emphasize the presentation of scientific problems, formulate and test hypotheses, conclude, and reflect on the knowledge they have [18] can encourage students to be creative in solving problems at hand [39].

3.3. Learning tools effectiveness

The creative thinking test instrument developed is open-ended, which is a type of question that has many possible correct answers. The open-ended test instrument can help increase creativity by generating various ideas, and students can solve problems independently in the future [40][41]. The measured creative thinking skills are fluency, flexibility, originality & elaboration. The results showed that the percentage of students' creative thinking skills was categorized as less creative (46.1%) before learning and in the creative category (72%) after learning using inquiry-based physics learning tools developed. The results of the analysis of the normality test and paired sample test of students' critical thinking skills are in Table 5 and Table 6.

Table 5. Data normality of students' creative thinking skills

Item	N	Creative thinking skills			
		Asymp. Sig. (2-tailed)			
		Fluency	Flexibility	Originality	Elaboration
Pre-test post-test	22	.391	.491	.161	.054

Table 6. The results of the paired sample test of students' creative thinking skills

Pair	Indicators	Test	N	Mean	SD	p
Pair 1	Fluency	Pre-test	22	1.9545	.65300	.001
		Post-test		3.2273	.68534	
Pair 2	Flexibility	Pre-test		2.5227	.39271	
		Post-test		3.5455	.34188	
Pair 3	Originality	Pre-test		1.9091	.61016	
		Post-test		3.1818	.58849	
Pair 4	Elaboration	Pre-test		2.1818	.36337	
		Post-test		3.4773	.49946	

Table 5 shows that the significance of all indicators of students' creative thinking skills is> 0.05, so it can be stated that the pre-test and post-test data of students' creative thinking skills are normally distributed. Table 6 shows that the increase in students' creative thinking skills after learning was statistically also stated to have a positive and significant impact ($p < 0.05$).

The physics learning tool based on inquiry model developed emphasizes student activities in breaking down problems into simple parts so as to allow students to formulate as many hypotheses as possible. This statement is in accordance with the nature of creative thinking skills, which is the ability to unravel problems to enable students to develop various solutions [42].

4. Conclusion

Based on the results of the study, it can be concluded that physics learning tools based on inquiry are valid, practical and effective to improve high school students' creative thinking skills on heat material. The results showed that students needed to be given more contextualization of teaching material with daily life to make it easier for students to relate their initial knowledge to the new knowledge being taught. Further research using different teaching materials and research sites is also important in the future.

Acknowledgement

The authors would like to thank those who have contributed to this study, especially research partners and participants. Hopefully this study can provide benefits for education in general.

References

[1] Mahanal S 2019 Asesmen Keterampilan Berpikir Tingkat Tinggi *J. Penelit. dan Pengkaj. Ilmu Pendidik. e-Saintika* **3** (2) 51-73
[2] King F J, Goodson L, and Rohani F 1998 *Assessment & Evaluation: Higher Order Thinking Skills Obtido de: Www.Cala.Fsu.Edu*, 1â€“176 Retrieved from http://www.cala.fsu.edu/files/higher_order_thinking_skills.pdf
[3] Zubaidah S, Fuad N M, Mahanal S, and Suarsini E 2017 Improving creative thinking skills of students through Differentiated Science Inquiry integrated with mind map *J. Turkish Sci. Educ* **14** (4) 77-91
[4] Singh R K A, Singh C K S, Mostafa N A, and Singh T S M 2018 A Review of Research on the Use of Higher Order Thinking Skills to Teach Writing *Int. J. English Linguist* **8** (2) 86-93.
[5] Abraham A 2016 Gender and creativity: an overview of psychological and neuroscientific literature *Brain Imaging and Behavior* **9** (2)
[6] Greenstein L M 2012 *Accessing 21 century skills: To guide to evaluating mastery and authentic learning* (USA: Corwin Press)
[7] Kim K H 2011 The Creativity Crisis: The Decrease in Creative Thinking Scores on the Torrance Tests of Creative Thinking *Creat. Res. J* **23** (4) 285-295
[8] Dennis K F 2008 *Menguak Rahasia Berfikir Kritis dan Kreatif* (Jakarta: Pustakarya)
[9] Yusnaeni Y, Corebima A D, Susilo H, and Zubaidah S. 2017 Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy *Int. J. Instr*
[10] Junaidi J, Roza Y, and Maimunah M 2020 Kemampuan Berpikir Siswa dalam Menyelesaikan Soal HOTs pada Materi Pola dan Barisan Bilangan *J. Penelit. dan Pengkaj. Ilmu Pendidik. e-Saintika*
[11] Qamariah N, Gummah S, and Prasetyo D S B 2016 Penerapan Model Pembelajaran Scramble untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa *Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*
[12] Prayitno B A, Corebima D, Susilo H, Zubaidah S, and Ramli M 2017 Closing the science process skills gap between students with high and low level academic achievement *J. Balt. Sci. Educ.*
[13] Michalopoulou A 2014 Inquiry-Based Learning through the Creative Thinking and Expression in Early Years Education *Creat. Educ.*
[14] Nurhadi, Lukman, Abas R, Erni, Yuliana, and Hamrina 2016 Implementation of Inquiry Based Learning to Improve Understanding the Concept of Electric Dynamic and Creative Thinking Skills (An empirical study in Class IX Junior High School Students State 4 Kendari) *Int. J. Sci. Res.*
[15] Kuhlthau C, Maniotes L, and Caspari A 2012 Guided inquiry design: A framwork for inquiry in your school *J. New Members Round Table*

[16] Prayogi S, Yuanita L, and Wasis 2018 Critical-Inquiry-Based-Learning: Model of Learning to Promote Critical Thinking Ability of Pre-service Teachers in *Journal of Physics: Conference Series*
[17] Asy'ari M, Ikhsan M, and Muhali 2019 The effectiveness of inquiry learning model in improving prospective teachers' metacognition knowledge and metacognition awareness *Int. J. Instr* 12(2) 455–470.
[18] Arends R I 2012 *Learning to Teach*, 9th Edition (New York: McGraw-Hill)
[19] Muhali, Yuanita L, and Ibrahim M 2019 The validity and effectiveness of the reflective-metacognitive learning model in improving students' metacognitive ability in Indonesia *Malaysian J. Learn. Instr*
[20] Hussain A and Shakoor A 2011 Physics Teaching Methods: Scientific Inquiry Vs Traditional Lecture *Int. J. Humanit. Soc. Sci.*
[21] Eggen P and Kauchak D 2012 *Strategies and Models for Teachers: Teaching Content and Thinking Skills*.
[22] Sanjaya W 2012 *Perencanaan dan Desain Sistem Pembelajaran Edisi Pertama* (Prenada Media Group)
[23] Choirunnisak, Ibrahim M, and Yuliani 2018 The development of guided inquiry-based learning devices on photosynthesis and respiration matter to train science literacy skills in *IOP Conference Series: Materials Science and Engineering*
[24] Prayogi S, Yuanita L, and Wasis 2018 Critical inquiry based learning: A model of learning to promote critical thinking among prospective teachers of physic *J. Turkish Sci. Educ*.
[25] Prayogi S and Muhali 2015 pengembangan model pembelajaran aktif berbasis inkuiri (abi) untuk mengembangkan keterampilan berpikir kritis mahasiswa *Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*
[26] Ningsih R Q and Widodo W 2019 Development of Learning Devices Intructured Inquiry Model With Brainstorming Strategy To Improve Creative Thinking Ability Of Basic School Students *Int. J. Sci. Res. Publ*.
[27] Partnership for 21st Century Learning 2015 P21 Framework Definitions.
[28] Fitriani H, Asy'Ari M, Zubaidah S, and Mahanal S 2018 Critical Thinking Disposition of Prospective Science Teachers at IKIP Mataram, Indonesia in *Journal of Physics: Conference Series*
[29] Wahyudi, Verawati N N S P, Ayub S, and Prayogi S 2019 Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers in *Journal of Physics: Conference Series*
[30] Asy'ari M, Fitriani H, Zubaidah S, and Mahanal S 2019 The science process skills of prospective biology teachers in plant cell material based on gender *Int. J. Emerg. Technol. Learn*
[31] Thiagarajan S 1974 Instructional development for training teachers of exceptional children: A sourcebook *J. Sch. Psychol*
[32] Asy'ari M, Hidayat S, and Muhali 2019 Validitas dan efektivitas prototipe buku ajar fisika dasar reflektif-integratif berbasis problem solving untuk meningkatkan pengetahuan metakognisi *J. Inov. Pendidik. IPA*
[33] Riduwan 2007 *Skala Pengukuran Variabel-variabel Penelitian*
[34] Borich G D 2016 *Observation Skills for Effective Teaching*
[35] Sugiyono 2014 *Metode Penelitian Pendidikan pendekatan Kuantitatif, Kualitatif dan R&D* (Jakarta: Rosdakayya)
[36] Guilford J P and Hoepfner R 1971 *The analysis of intelligence*
[37] Khanafiyah S and Rusilowati A 2010 Penerapan Pendekatan Modified Free Inquiry Sebagai Upaya Meningkatkan Kreativitas Mahasiswa Calon Guru Dalam Mengembangkan Jenis Eksperimen Dan Pemahaman Terhadap Materi Fisika *Berk. Fis* 13(2)7–14

[38] Wenning C J 2011 The Levels of Inquiry Model of Science Teaching *J. Phys. Tchr. Educ. Online*
[39] Mierdel J and Bogner F X 2019 Is creativity, hands-on modeling and cognitive learning gender-dependent? *Think. Ski. Creat.*
[40] Eragamreddy N 2013 Teaching Creative Thinking Skills *Int. J. English Lang. Transl. Stud* 1(2) 124–145
[41] Sternberg R J 2012 The Assessment of Creativity: An Investment-Based Approach *Creativity Research Journal*
[42] Gibby B 2012 Creativity and intelligence in *Theory and Practice of Curriculum Studies*

Gmail

ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

Registration from Mr Prayogi (saifulprayogi@ikipmataram.ac.id)

Registration ICTAP & SFN 2020 <ictap_sfn2020@unram.ac.id>
to ictap_sfn2020, me

Thank You for Registered to ICTAP and SFN 2020

Registration Summary:
E-mail

saifulprayogi@ikipmataram.ac.id

Mr/Mrs/Ms

Mr

First Name

Saiful

Last Name

Prayogi

Date of Birth

1986-12-05

Phone

081805208485

Gmail ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

Letter of Acceptance

External Inbox ×

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
to me

Dear authors,
It's my pleasure to inform you that, after the peer review, your paper :

Title : Development of physics learning tools based on inquiry to increase creative thinking s
Authors : Saiful Prayogi and Muhammad Asy'ari

has been **ACCEPTED as an oral presenter** on ICTAP and SFN 2020. To fit into the event, pleas
Be sure you have been paid the conference registration fee (include publication fee) for **IDR 1.750**

Bank Name: BANK MANDIRI
Account Name: NI NYM SRI PUTU VERAWATI
Account Number: 1610005918078

Please submit/share your proof payment transfer to WhatsApp no 081224774718 (Aris Doyan

We also want to inform you that the conference was held by teleconference in the 20th-22nd November 202
hesitate to contact me if you have any questions.

Mataram, October 18th, 2020
Sincerely,
Aris Doyan, Ph.D
Chairman of ICTAP and SFN 2020

Letter of Acceptance (LoA)

No: 06/committee/ICTAP /2020

Dear authors,

It's my pleasure to inform you that, after the peer review, your paper :

Title : Development of physics learning tools based on inquiry to increase creative thinking skills

Authors : Saiful Prayogi and Muhammad Asy'ari

has been **ACCEPTED as an oral presenter** on ICTAP and SFN 2020. To fit into the event, please re-submit your Full Paper in http://ictap.unram.ac.id/full-paper-submission/ before 20th October 2020. Be sure you have been paid the conference registration fee (include publication fee) for **IDR 1.750.000,-** before 20th October 2020 through the Account Committee:

Bank Name: BANK MANDIRI
Account Name: NI NYM SRI PUTU VERAWATI
Account Number: 1610005918078

Please submit/share your proof payment transfer to WhatsApp no 081224774718 (Aris Doyan) or 081805255663 (Ni Nyoman Sri Putu Verawati) for the payment confirmation.

We also want to inform you that the conference was held by teleconference in the 20th-22nd November 2020, because of the COVID-19 situation. For more information, please visit ictap.unram.ac.id. Also, please do not hesitate to contact me if you have any questions.

Mataram, October 18th, 2020

Sincerely,

Aris Doyan, Ph.D

Chairman of ICTAP and SFN 2020

10th International Conference on Theoretical and Applied Physics
10th ICTAP SFNXXXIII 2020
Simposium Fisika Nasional

Full Paper of article is titled

External Inbox ×

Full Paper Submission ICTAP & SFN 2020 <ictap_sfn2020@unram.ac.id>
to ictap_sfn2020

Thank You for your Full Paper Submission

Submission Summary:

E-mail

saifulprayogi@ikipmataram.ac.id

Mr/Mrs/Ms

Mr

First Name

Saiful

Last Name

Prayogi

Organization/Department/University

Universitas Pendidikan Mandalika

Department Address

Jl. Pemuda No. 59A Mataram

Sub Topic

Physics Education

Gmail ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

ICTAP 2020: Similarity Check Result

Inbox ×

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
to me

Dear. Author(s) ICTAP 2020

Your article is in the review process while we are sending the similarity screening results.

Therefore, while waiting for the expert's review results, please look at the similarity's results as attached.

Please wait for the review's result. The revision process can do after that. We will immediately send the review

Kind Regards,
Editor ICTAP 2020

PDF **113 Development o.**

Thanks a lot. Thank you for your mail. Noted with thanks.

Reply Forward

Gmail

ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

1st review article ICTAP 2020

Inbox ×

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
to me

Dear Author(s) ICTAP 2020

This is the first-round review of your article. After this step, we perhaps will review again until your article is rea

As a summary, please ensure the following:
• Used the template (**Document B**) for a word file or latex template.
• Paper size is European A4.
• Margins are 4cm (top), 2.5cm (left and right) and 2.7cm (bottom).
• The paper includes the author's name and affiliation (full address including country).
• There are no page numbers, or headers and footers, within the paper.
• The PDF is free of formatting errors (e.g., corrupt equations, missing or low-resolution figures) since convers
• Text is single-spaced, not double spaced.
• The PDF file is editable and not password protected.
• All pages are portrait (landscape pages should be rotated).
• Reference lists are checked for accuracy. References can only be linked via Crossref if they are correct and
• Figures are placed within the text, not collected at the end of the document.
• A thorough proofread is conducted to check the standard of English and ensure the wording is clear and con

Before revising according to reviewer suggestions, please pay attention to the article's format following points.
• Used the template (**Document B**) for word file OR latex template.
• Be sure to read **Document C** for the simple instruction on fixing your article as a template.
• Be sure read Document D for the reference instruction
• If there is any misunderstanding for editing in a word document, please read the **Document E** and **Documer**

Note: If a discrepancy is found later, we will return the article to revise it.

Please revise your article as the reviewer's suggestions in your recent article file that commented and review

Please send your revised article file DOCX (or zip for latex format) to the ictap_sfn2020@unram.ac.id with the

Development of physics learning tools based on inquiry to increase creative thinking skills

M Asy'ari[1], S Prayogi[1], B Mirawati[1], Syarifuddin[2], Hunaepi[1], Syahrir[1], Suhirman[3]
[1]Universitas Pendidikan Mandalika, Mataram 82125, Indonesia
[2]Universitas Halu Oleo, Kendari, Indonesia
[3]Universitas Islam Negeri Mataram, Indonesia

Email: saifulprayogi@ikipmataram.ac.id

Abstract. This study aimed to produce physics learning tools based on inquiry that are valid, practical, and effective to improve students' creative thinking skills on heat material. This study is a pre-experimental research with one group pre-test post-test design that begins with the development of learning tools using the 4D (define, design, develop, disseminate) model. Learning tools in the form of syllabus, lesson plan, student activity sheets, student textbooks, and test instruments were validated by 2 experts before being implemented on 22 students. The research data were collected using instruments of validation, observation, questionnaires, and tests which were then analyzed descriptively and statistically. The results showed that the learning tools produced was valid in terms of content and construct, was practical based on the implementation of learning and student responses, and was effective in improving students' creative thinking skills. Research findings based on indicators of creative thinking skills such as fluency, flexibility, originality, and elaboration are also described in this paper.

Commented [A1]: Belum ada kata kunci

1. Introduction

Higher order thinking skills have a lot of definition and thinking activities[1]which not only requires skills to remember, but also requires higher thinking skills[2].Creative thinking skills have aspects such as fluency, flexibility, originality, and elaboration[3]Creative thinking skills have aspects such as fluency, flexibility, originality, and elaboration[4]. Creative thinking is a unique form of expression for a person[5]which leads to novelty, the ability to create something, apply new forms, generalize various skills, or create something new from something that already exists[6].

Some studies showed that students' creative thinking skills were still low [3]and showed a downward trend over time among American students of all ages[7].Implementation of learning in schools that is not as expected[8]and the minimal use of innovative learning models[9]is alleged to be the cause of these problems. In line with that description, another studies showed that 57.8% of students' creative thinking skills fall into the poor category[10] and can't show a detailed flow of problem solving[11]because science learning in Indonesia is more focused on remembering science concepts[12].Inquirylearning modelis often applied to improve students' creative thinking skills[13][14][3].

Inquiry learning model can help students to practice in a team, develop competence in research, knowledge, motivation, writing skills, cooperative learning and social skills[15]. The inquiry learning model can facilitate students in learning activities by giving initial questions and leading to a discussion[16].It is further explained that the inquiry learning model emphasizes observation,

questioning, evaluating information sources to determine what is known[17][18], planning investigations, conducting experiments[19][20], utilizing tools for data collection, analysis and interpreting data, formulating answers, elaborating, predicting, and communicating the results obtained [21]from learning activities.

Inquiry learning has three main characteristics such as (1) emphasizing the maximum student activity to seek and find, which means placing students as learning subjects, (2) all activities carried out by students are directed to seek and find their own answers to something being questioned, so that is expected to foster self-belief, and (3) develop the ability to think systematically, logically and critically, or develop intellectual abilities as part of the mental process.[22]and six steps i.e. (1) gain attention and explain the inquiry process, (2) present the inquiry problem or discrepant event, (3) have students formulate hypotheses to explain the problem or event, (4) encourage students to collect data to test the hypothesis, (5) formulate explanations and/or conclusions, and (6) reflect on the problem situation and the thinking processes used to inquire into it[21].

Based on the results of preliminary observations, it was found that several obstacles caused the weakness of students' creative thinking skills, including (1) readiness of learning devices, (2) weak emphasis on process aspects, and (3) lack of use of innovative learning models that demand student activity in learning, so that the development of student-centered interactive model-based learning tools is important. Several studies related to the development of inquiry learning tools in various science teaching materials showed positive results in an effort to improve students' scientific literacy[23]and critical thinking skills [24][16][25]but these studies did not look at aspects of creative thinking skills. Research related to the development of inquiry learning tools to teach creative thinking skills was delivered byNingsih et al [26]who found that structured inquiry with brainstorming strategy learning tools proved valid, practical and effective in improving students' creative thinking skills. The research was conducted on elementary school students and did not explicitly explain the teaching material that was integrated into the developed tools.

This study aimed to develop physics learning tools onheat materialbased on inquiry learning modelin the form of a syllabus, lesson plan, student activity sheets, student textbooks, and test instruments to improve high school students' creative thinking skills with fluency, flexibility, originality, and elaboration indicators.This research is important to do considering higher order thinking skills are the goal of education globally[27]and the importance of emphasizing process aspects in school science learning[19][28][29][30].

2. Method

This study is apre-experimental with one-group pre-test post-test design. This study was conducted on 22 students in one of the senior high schools in central Lombok who were observed in the pre-teststage (O_1) which was then followed by particular treatment (X) and*post-test* (O_2) [31].The study begins with the development of learning tools using Four D Models with the stages of define, design, develop and disseminate[32].

The study data obtained are data on the validity, practicality and effectiveness of physics learning tools based on inquiry that collected using validity instruments, observation sheets and response questionnaires (practicality), and creative thinking skills test instruments (effectiveness).

Learning tools in the form of syllabus, lesson plan, student activity sheets, student textbooks, and test instruments were first validated by 2 competent validators to assess the content and construct aspects of the learning tools developed. The assessment of the validity of the learning tools uses four rating scales, namely 1 = invalid, 2 = less valid, and 3 = valid, and 4 = very valid[33]which then converted into qualitative data on a scale of 4 based on the criteria in Table 1.

Table 1. Validity of learning tools

Score Interval	Category	Description
$3.6 \leq S \leq 4$	Very valid	Can be used without revision
$2.6 \leq S \leq 3.5$	Valid	Can be used with minor revisions
$1.6 \leq S \leq 2.5$	Less valid	Can be used with multiple revisions
$1 \leq S \leq 1.5$	Invalid	Not yet usable and still requires consultation

Commented [A2]: Tampilkan formula matematis untuk analisis deskriptif dan statistic yang digunakan

Commented [A3]: Perbaiki skor interval, bagaimana dengan nilai seperti 3.55, akan masuk ke kategori yang mana

The practicality of the learning tools is determined by observing the implementation of the lesson plan by 2 observers at each meeting. Observation data on the implementation of learning obtained are in the form of scores ranging from 1 to 4, with categories 1 = not good, 2 = good enough, 3 = good, and 4 = very good, which are then interpreted in the form of scores in Table 2.

Table 2. Scoring Criteria

Interval score	Category
1 – 1.5 or 0% - 50%	Not good
1.6 – 2.5 or 50% - <65%	Good enough
2.6 – 3.5 or 65% - < 85%	Good
3.6 – 4 or 85% - 100 %	Very good

Student responses after learning are also a component of the practicality assessment of the learning tools developed. Students give responses after learning by choosing statements objectively consisting of 2 categories (yes and no). The percentage of student responses was then converted based on the criteria (1) 0% - 20% = very weak, (2) 21% - 40% = weak, (3) 41% - 60% = sufficient, (4) 61% - 80% = strong, and (5) 81% - 100% = very strong[34]. The reliability of the learning tools assessment is determined using the equation:*percentage of agreement= 100 [1-(A-B)/(A+B)]*[35].

Students' creative thinking skills are measured using a test instrument that refers to the Guilford and Hoepfner[36]creative thinking test. Students are declared creative if the creative thinking test score is ≥ 61.2% [37]. The analysis of the improvement of students' creative thinking skills was carried out by using paired sample tests on pre-test and post-test data with the help of SPSS 17 for windows software and equations: score = (obtained score/maximum score) x 100% which are further categorized based on the criteria in Table 3.

Table 3. Criteria for creative thinking skills

Interval	Category
81.00% - 100%	Very creative
65.00 % - 80.99%	Creative
41.00% - 64.99%	Less creative
0.00% - 40.99 %	Not creative

3. Result and Discussion

3.1. Learning device validity

Physics learning tools based on inquiry model in the form of a syllabus, lesson plan, student activity sheets, student textbooks, and test instruments are validated before being implemented. The results of the validation of the learning tools developed are presented briefly in Table 4.

Table 4. Validity of learning tools

No	Item	Validity	Category	Reliability	Category
1	Syllabus	3.51	Valid	0.94	Reliable
2	Lesson plan	3.44		0.96	
3	Student worksheet	3.60		0.98	
4	Textbook	3.36		0.95	
5	Test instrument	3.50		0.98	

Table 4 shows that the learning tools developed are declared valid and reliable to be implemented to students to learn creative thinking skills. The learning model that is integrated in the developed tools is an inquiry learning model that emphasizes scientific activity[18]so that it helps students have the ability to see problems from various points of view and be able to generate many ideas[38].

3.2. Learning device practicality

The learning tools developed were also stated to be practical to improve students' creative thinking skills based on the results of the analysis of the implementation of learning for three meetings. The results showed that the overall implementation of learning activities was categorized as very good (score: 3.62) and reliable (reliability: 0.99). The results of the analysis of student responses to inquiry

Commented [A4]: Perbaiki interval skor, sama dengan yang di atas dan interval presentase. Buat kolom tersendiri untuk interval presentase

Commented [A5]: Tampilkan formula validitas yang digunakan

Commented [A6]: Tampilkan formula reliabilitas yang digunakan

learning and learning tools showed a positive response (94%) further strengthening the practicality of learning tools developed in improving students' creative thinking skills. Inquiry learning models that emphasize the presentation of scientific problems, formulate and test hypotheses, conclude, and reflect on the knowledge they have[18]can encourage students to be creative in solving problems at hand[39].

3.3. Learning device effectiveness

The creative thinking test instrument developed is open-ended, which is a type of question that has many possible correct answers. The open-ended test instrument can help increase creativity by generating various ideas, and students can solve problems independently in the future [40][41].The measured creative thinking skills are fluency, flexibility, originality & elaboration. The results showed that the percentage of students' creative thinking skills was categorized as less creative (46.1%) before learning and in the creative category (72%) after learning using inquiry-based physics learning tools developed. The results of the analysis of the normality test and paired sample test of students' critical thinking skills are in Table 5 and Table 6.

Table 5. Data normality of students' creative thinking skills

Item	N	Creative thinking skills			
		Asymp. Sig. (2-tailed)			
		Fluency	Flexibility	Originality	Elaboration
Pre-test post-test	22	.391	.491	.161	.054

Table 6. The results of the paired sample test of students' creative thinking skills

Pair	Indicators	Test	N	Mean	SD	p
Pair 1	Fluency	Pre-test	22	1.9545	.65300	.000
		Post-test		3.2273	.68534	
Pair 2	Flexibility	Pre-test		2.5227	.39271	
		Post-test		3.5455	.34188	
Pair 3	Originality	Pre-test		1.9091	.61016	
		Post-test		3.1818	.58849	
Pair 4	Elaboration	Pre-test		2.1818	.36337	
		Post-test		3.4773	.49946	

Commented [A7]: Bisakah ditampakkan sampai ada angka

Table 5 shows that the significance of all indicators of students' creative thinking skills is> 0.05, so it can be stated that the pre-test and post-test data of students' creative thinking skills are normally distributed. Table 6 shows that the increase in students' creative thinking skills after learning was statistically also stated to have a positive and significant impact ($p < 0.05$).

The physics learning tool based on inquiry model developed emphasizes student activities in breaking down problems into simple parts so as to allow students to formulate as many hypotheses as possible. This statement is in accordance with the nature of creative thinking skills, which is the ability to unravel problems to enable students to develop various solutions[42].

4. Conclusion

Based on the results of the study, it can be concluded that physics learning tools based on inquiry are valid, practical and effective to improve high school students' creative thinking skills on heat material. The results showed that students needed to be given more contextualization of teaching material with daily life to make it easier for students to relate their initial knowledge to the new knowledge being taught. Further research using different teaching materials and research sites is also important in the future.

References

[1] S. Mahanal, "AsesmenKeterampilanBerpikir Tingkat Tinggi," *J. Penelit. danPengkaj. IlmuPendidik. e-Saintika*, 2019.

[2] F. J. King, L. Goodson, and F. Rohani, *Assessment & Evaluation: Higher Order Thinking Skills*. 1998.

[3] S. Zubaidah, N. M. Fuad, S. Mahanal, and E. Suarsini, "Improving creative thinking skills of

students through Differentiated Science Inquiry integrated with mind map," *J. Turkish Sci. Educ.*, 2017.
[4] R. K. A. Singh, C. K. S. Singh, T. M. T. M., N. A. Mostafa, and T. S. M. Singh, "A Review of Research on the Use of Higher Order Thinking Skills to Teach Writing," *Int. J. English Linguist.*, 2017.
[5] A. Abraham, "Gender and creativity: an overview of psychological and neuroscientific literature," *Brain Imaging and Behavior*. 2016.
[6] L. M. Greenstein, *Accessing 21 century skills: To guide to evaluating mastery and authentic learning.* USA: Corwin Press, 2012.
[7] K. H. Kim, "The Creativity Crisis: The Decrease in Creative Thinking Scores on the Torrance Tests of Creative Thinking," *Creat. Res. J.*, 2011.
[8] K. Filsaime Dennis, "MenguakRahasiaBerpikirKritisdanKreatif," *MenguakRahasiaBerfikirKritisdanKreatif*. 2008.
[9] Y. Yusnaeni, A. D. Corebima, H. Susilo, and S. Zubaidah, "Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy," *Int. J. Instr.*, 2017.
[10] J. Junaidi, Y. Roza, and M. Maimunah, "KemampuanBerpikirSiswadalamMenyelesaikanSoal HOTs padaMateriPoladanBarisanBilangan," *J. Penelit. danPengkaj. IlmuPendidik. e-Saintika*, 2020.
[11] N. Qamariah, S. Gummah, and D. S. B. Prasetyo, "Penerapan Model Pembelajaran Scramble untukMeningkatkanKemampuanBerpikirKreatifSiswa," *Prism. Sains J. Pengkaj. IlmudanPembelajaran Mat. dan IPA IKIP Mataram*, 2016.
[12] B. A. Prayitno, D. Corebima, H. Susilo, S. Zubaidah, and M. Ramli, "Closing the science process skills gap between students with high and low level academic achievement," *J. Balt. Sci. Educ.*, 2017.
[13] A. Michalopoulou, "Inquiry-Based Learning through the Creative Thinking and Expression in Early Years Education," *Creat. Educ.*, 2014.
[14] Nurhadi, Lukman, R. Abas, Erni, Yuliana, and Hamrina, "Implementation of Inquiry Based Learning to Improve Understanding the Concept of Electric Dynamic and Creative Thinking Skills (An empirical study in Class IX Junior High School Students State 4 Kendari)," *Int. J. Sci. Res.*, 2016.
[15] C. Kuhlthau, L. Maniotes, and A. Caspari, "Guided inquiry design: A framworkfo inquiry in your school," *J. New Members Round Table*, 2012.
[16] S. Prayogi, L. Yuanita, and Wasis, "Critical-Inquiry-Based-Learning: Model of Learning to Promote Critical Thinking Ability of Pre-service Teachers," in *Journal of Physics: Conference Series*, 2018.
[17] M. Asy'ari, M. Ikhsan, and Muhali, "The effectiveness of inquiry learning model in improving prospective teachers' metacognition knowledge and metacognition awareness," *Int. J. Instr.*, vol. 12, no. 2, pp. 455–470, 2019.
[18] R. I. Arends, *Learning to Teach*, 9th Editio. New York: McGraw-Hill, 2012.
[19] Muhali, L. Yuanita, and M. Ibrahim, "The validity and effectiveness of the reflective-metacognitive learning model in improving students' metacognitive ability in Indonesia," *Malaysian J. Learn. Instr.*, 2019.
[20] A. Hussain and A. Shakoor, "Physics Teaching Methods: Scientific Inquiry Vs Traditional Lecture," *Int. J. Humanit. Soc. Sci.*, 2011.
[21] P. Eggen and D. Kauchak, *Strategies and Models for Teachers: Teaching Content and Thinking Skills*. 2012.
[22] W. Sanjaya, "PerencanaandanDesainSistemPembelajaranEdisiPertama," *Prenada Media Group*. 2012.
[23] Choirunnisak, M. Ibrahim, and Yuliani, "The development of guided inquiry-based learning devices on photosynthesis and respiration matter to train science literacy skills," in *IOP Conference Series: Materials Science and Engineering*, 2018.
[24] S. Prayogi, L. Yuanita, and L. Wasis, "Critical inquiry based learning: A model of learning to

promote critical thinking among prospective teachers of physic," *J. Turkish Sci. Educ.*, 2018.
[25] S. Prayogi and M. Muhali, "pengembangan model pembelajaranaktifberbasisinkuiri (abi) untukmengembangkanketerampilanberpikirkritismahasiswa," *Prism. Sains J. Pengkaj. IlmudanPembelajaran Mat. dan IPA IKIP Mataram*, 2015.
[26] R. Q. Ningsih, T. -, and W. Widodo, "Development of Learning Devices Intructured Inquiry Model With Brainstorming Strategy To Improve Creative Thinking Ability Of Basic School Students," *Int. J. Sci. Res. Publ.*, 2019.
[27] Partnership for 21st Century Learning, "P21 Framework Definitions," 2015.
[28] H. Fitriani, M. Asy'Ari, S. Zubaidah, and S. Mahanal, "Critical Thinking Disposition of Prospective Science Teachers at IKIP Mataram, Indonesia," in *Journal of Physics: Conference Series*, 2018.
[29] Wahyudi, N. N. S. P. Verawati, S. Ayub, and S. Prayogi, "Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers," in *Journal of Physics: Conference Series*, 2019.
[30] M. Asy'ari, H. Fitriani, S. Zubaidah, and S. Mahanal, "The science process skills of prospective biology teachers in plant cell material based on gender," *Int. J. Emerg. Technol. Learn.*, 2019.
[31] Sugiyono, "MetodePenelitianPendidikanpendekatanKuantitatif, Kualitatifdan R&D.," in *METODE PENELITIAN ILMIAH*, 2014.
[32] S. Thiagarajan, "Instructional development for training teachers of exceptional children: A sourcebook," *J. Sch. Psychol.*, 1974.
[33] M. Asy'ari, S. Hidayat, and M. Muhali, "Validitasdanefektivitasprototipebuku ajar fisikadasarreflektif-integratifberbasis problem solving untukmeningkatkanpengetahuanmetakognisi," *J. Inov. Pendidik. IPA*, 2019.
[34] Riduwan, *SkalaPengukuranVariabel-variabelPenelitian*. 2007.
[35] G. D. Borich, *Observation Skills for Effective Teaching*. 2016.
[36] J. P. (Joy P. Guilford and R. Hoepfner, *The analysis of intelligence*. 1971.
[37] S. Khanafiyah and A. Rusilowati, "PenerapanPendekatan Modified Free Inquiry SebagaiUpayaMeningkatkanKreativitasMahasiswaCalon Guru DalamMengembangkanJenisEksperimen Dan PemahamanTerhadapMateriFisika," *Berk. Fis.*, vol. 13, no. 2, pp. E7–E14, 2010.
[38] C. J. Wenning, "The Levels of Inquiry Model of Science Teaching," *J. Phys. Tchr. Educ. Online*, 2011.
[39] J. Mierdel and F. X. Bogner, "Is creativity, hands-on modeling and cognitive learning gender-dependent?," *Think. Ski. Creat.*, 2019.
[40] N. Eragamreddy, "Teaching Creative Thinking Skills," *Int. J. English Lang. Transl. Stud.*, vol. 1, no. 2, pp. 124–145, 2013.
[41] R. J. Sternberg, "The Assessment of Creativity: An Investment-Based Approach," *Creativity Research Journal*. 2012.
[42] B. Gibby, "Creativity and intelligence," in *Theory and Practice of Curriculum Studies*, 2012.

REVIEW SUMMARY

Round : 1st Review
ID Article : 113
Article Title : Development of physics learning tools based on inquiry to increase creative thinking skills

Criteria	Comment
Technical Criteria	
• Scientific merit: notably scientific rigour, accuracy and correctness.	
• Clarity of expression; communication of ideas; readability and discussion of concepts.	
• Sufficient discussion of the context of the work, and suitable referencing.	
Quality Criteria	
• Originality: Is the work relevant and novel?	
• Motivation: Does the problem considered have a sound motivation? All papers should clearly demonstrate the scientific interest of the results.	
• Repetition: Have significant parts of the manuscript already been published?	
• Length: Is the content of the work of sufficient scientific interest to justify its length?	
Presentation Criteria	
• Title: Is it adequate and appropriate for the content of the article?	
• Abstract: Does it contain the essential information of the article? Is it complete? Is it suitable for inclusion by itself in an abstracting service?	Belum ada kata kunci yang dituliskan
• Diagrams, figures, tables and captions: Are they essential and clear?	• Perbaiki skor interval (table 1), bagaimana dengan nilai seperti 3.55, akan masuk ke kategori yang mana. • Perbaiki interval skor (table 2), sama dengan yang di atas dan interval presentase. Buat kolom tersendiri untuk interval presentase. • Tampilkan formula validitas dan reliabilitas yang digunakan pada table 4. • Nilai variable p pada taberl 6 apakah bisa

	ditampilkan hingga terdapat angka selain nol
• Text and mathematics: Are they brief but still clear? If you recommend shortening, please suggest what should be omitted.	• Tampilkan formula matematis untuk analisis deskriptif dan statistic yang digunakan. • Masih ada kata yang menggunakan bahasa indonesia, kemudian penulisan bilangan decimal menggunakan tanda titik, contohnya 0.001
• Conclusion: Does the paper contain a carefully written conclusion, summarizing what has been learned and why it is interesting and useful?	

Recommendation:

* Publish after optional minor revision

Best Regards,

**) Delete which is not match*

Development of physics learning tools based on inquiry to increase creative thinking skills

M Asy'ari[1], S Prayogi[1], B Mirawati[1], Syarifuddin[2], Hunaepi[1], Syahrir[1], Suhirman[3]
[1]Universitas Pendidikan Mandalika, Mataram 82125, Indonesia
[2]Universitas Halu Oleo, Kendari, Indonesia
[3]Universitas Islam Negeri Mataram, Indonesia

Email: saifulprayogi@ikipmataram.ac.id

Abstract. This study aimed to produce physics learning tools based on inquiry that are valid, practical, and effective to improve students' creative thinking skills on heat material. This study is a pre-experimental research with one group pre-test post-test design that begins with the development of learning tools using the 4D (define, design, develop, disseminate) model. Learning tools in the form of syllabus, lesson plan, student activity sheets, student textbooks, and test instruments were validated by 2 experts before being implemented on 22 students. The research data were collected using instruments of validation, observation, questionnaires, and tests which were then analyzed descriptively and statistically. The results showed that the learning tools produced was valid in terms of content and construct, was practical based on the implementation of learning and student responses, and was effective in improving students' creative thinking skills. Research findings based on indicators of creative thinking skills such as fluency, flexibility, originality, and elaboration are also described in this paper.

1. Introduction

Higher order thinking skills have a lot of definition and thinking activities [1] which not only requires skills to remember, but also requires higher thinking skills [2]. Creative thinking skills have aspects such as fluency, flexibility, originality, and elaboration [3] Creative thinking skills have aspects such as fluency, flexibility, originality, and elaboration [4]. Creative thinking is a unique form of expression for a person [5] which leads to novelty, the ability to create something, apply new forms, generalize various skills, or create something new from something that already exists [6].

Some studies showed that students' creative thinking skills were still low [3] and showed a downward trend over time among American students of all ages [7]. Implementation of learning in schools that is not as expected [8] and the minimal use of innovative learning models [9] is alleged to be the cause of these problems. In line with that description, another studies showed that 57.8% of students' creative thinking skills fall into the poor category [10] and can't show a detailed flow of problem solving [11] because science learning in Indonesia is more focused on remembering science concepts [12]. Inquiry learning model is often applied to improve students' creative thinking skills [13][14][3].

Inquiry learning model can help students to practice in a team, develop competence in research, knowledge, motivation, writing skills, cooperative learning and social skills [15]. The inquiry learning model can facilitate students in learning activities by giving initial questions and leading to a discussion [16]. It is further explained that the inquiry learning model emphasizes observation, questioning,

evaluating information sources to determine what is known [17][18], planning investigations, conducting experiments [19][20], utilizing tools for data collection, analysis and interpreting data, formulating answers, elaborating, predicting, and communicating the results obtained [21] from learning activities.

Inquiry learning has three main characteristics such as (1) emphasizing the maximum student activity to seek and find, which means placing students as learning subjects, (2) all activities carried out by students are directed to seek and find their own answers to something being questioned, so that is expected to foster self-belief, and (3) develop the ability to think systematically, logically and critically, or develop intellectual abilities as part of the mental process. [22] and six steps i.e. (1) gain attention and explain the inquiry process, (2) present the inquiry problem or discrepant event, (3) have students formulate hypotheses to explain the problem or event, (4) encourage students to collect data to test the hypothesis, (5) formulate explanations and/or conclusions, and (6) reflect on the problem situation and the thinking processes used to inquire into it [21].

Based on the results of preliminary observations, it was found that several obstacles caused the weakness of students' creative thinking skills, including (1) readiness of learning devices, (2) weak emphasis on process aspects, and (3) lack of use of innovative learning models that demand student activity in learning, so that the development of student-centered interactive model-based learning tools is important. Several studies related to the development of inquiry learning tools in various science teaching materials showed positive results in an effort to improve students' scientific literacy [23] and critical thinking skills [24][16][25] but these studies did not look at aspects of creative thinking skills. Research related to the development of inquiry learning tools to teach creative thinking skills was delivered by Ningsih et al [26] who found that structured inquiry with brainstorming strategy learning tools proved valid, practical and effective in improving students' creative thinking skills. The research was conducted on elementary school students and did not explicitly explain the teaching material that was integrated into the developed tools.

This study aimed to develop physics learning tools on heat material based on inquiry learning model in the form of a syllabus, lesson plan, student activity sheets, student textbooks, and test instruments to improve high school students' creative thinking skills with fluency, flexibility, originality, and elaboration indicators. This research is important to do considering higher order thinking skills are the goal of education globally [27] and the importance of emphasizing process aspects in school science learning [19][28][29][30].

2. Method

This study is a pre-experimental with one-group pre-test post-test design. This study was conducted on 22 students in one of the senior high schools in central Lombok who were observed in the pre-test stage (O_1) which was then followed by particular treatment (X) and *post-test* (O_2) [31]. The study begins with the development of learning tools using Four D Models with the stages of define, design, develop and disseminate [32].

The study data obtained are data on the validity, practicality and effectiveness of physics learning tools based on inquiry that collected using validity instruments, observation sheets and response questionnaires (practicality), and creative thinking skills test instruments (effectiveness).

Learning tools in the form of syllabus, lesson plan, student activity sheets, student textbooks, and test instruments were first validated by 2 competent validators to assess the content and construct aspects of the learning tools developed. The assessment of the validity of the learning tools uses four rating scales, namely 1 = invalid, 2 = less valid, and 3 = valid, and 4 = very valid [33] which then converted into qualitative data on a scale of 4 based on the criteria in Table 1.

Table 1. Validity of learning tools

Score Interval	Category	Description
$3.6 \leq S \leq 4$	Very valid	Can be used without revision
$2.6 \leq S \leq 3.5$	Valid	Can be used with minor revisions
$1.6 \leq S \leq 2.5$	Less valid	Can be used with multiple revisions
$1 \leq S \leq 1.5$	Invalid	Not yet usable and still requires consultation

Commented [A1]: As there is a mismatch between the title and content of the article. The content of the article is more towards the implementation of the product developed. However, if author want to retain the title, then in the method section it is necessary to add how the development procedure is carried out and discussion needs to be added regarding the characteristics of the resulting product

The practicality of the learning tools is determined by observing the implementation of the lesson plan by 2 observers at each meeting. Observation data on the implementation of learning obtained are in the form of scores ranging from 1 to 4, with categories 1 = not good, 2 = good enough, 3 = good, and 4 = very good, which are then interpreted in the form of scores in Table 2.

Table 2. Scoring Criteria

Interval score	Category
1 – 1.5 or 0% - 50%	Not good
1.6 – 2.5 or 50% - <65%	Good enough
2.6 – 3.5 or 65% - < 85%	Good
3.6 – 4 or 85% - 100 %	Very good

Student responses after learning are also a component of the practicality assessment of the learning tools developed. Students give responses after learning by choosing statements objectively consisting of 2 categories (yes and no). The percentage of student responses was then converted based on the criteria (1) 0% - 20% = very weak, (2) 21% - 40% = weak, (3) 41% - 60% = sufficient, (4) 61% - 80% = strong, and (5) 81% - 100% = very strong [34]. The reliability of the learning tools assessment is determined using the equation: *percentage of agreement= 100 [1-(A-B)/(A+B)]* [35].

Students' creative thinking skills are measured using a test instrument that refers to the Guilford and Hoepfner [36] creative thinking test. Students are declared creative if the creative thinking test score is ≥ 61.2% [37]. The analysis of the improvement of students' creative thinking skills was carried out by using paired sample tests on pre-test and post-test data with the help of SPSS 17 for windows software and equations: score = (obtained score/maximum score) x 100% which are further categorized based on the criteria in Table 3.

Table 3. Criteria for creative thinking skills

Interval	Category
81.00% - 100%	Very creative
65.00 % - 80.99%	Creative
41.00% - 64.99%	Less creative
0.00% - 40.99 %	Not creative

3. Result and Discussion

3.1. Learning device validity

Physics learning tools based on inquiry model in the form of a syllabus, lesson plan, student activity sheets, student textbooks, and test instruments are validated before being implemented. The results of the validation of the learning tools developed are presented briefly in Table 4.

Table 4. Validity of learning tools

No	Item	Validity	Category	Reliability	Category
1	Syllabus	3.51	Valid	0.94	Reliable
2	Lesson plan	3.44		0.96	
3	Student worksheet	3.60		0.98	
4	Textbook	3.36		0.95	
5	Test instrument	3.50		0.98	

Table 4 shows that the learning tools developed are declared valid and reliable to be implemented to students to learn creative thinking skills. The learning model that is integrated in the developed tools is an inquiry learning model that emphasizes scientific activity [18] so that it helps students have the ability to see problems from various points of view and be able to generate many ideas [38].

3.2. Learning device practicality

The learning tools developed were also stated to be practical to improve students' creative thinking skills based on the results of the analysis of the implementation of learning for three meetings. The results showed that the overall implementation of learning activities was categorized as very good (score: 3.62) and reliable (reliability: 0.99). The results of the analysis of student responses to inquiry learning and

learning tools showed a positive response (94%) further strengthening the practicality of learning tools developed in improving students' creative thinking skills. Inquiry learning models that emphasize the presentation of scientific problems, formulate and test hypotheses, conclude, and reflect on the knowledge they have [18] can encourage students to be creative in solving problems at hand [39].

3.3. Learning device effectiveness

The creative thinking test instrument developed is open-ended, which is a type of question that has many possible correct answers. The open-ended test instrument can help increase creativity by generating various ideas, and students can solve problems independently in the future [40][41]. The measured creative thinking skills are fluency, flexibility, originality & elaboration. The results showed that the percentage of students' creative thinking skills was categorized as less creative (46.1%) before learning and in the creative category (72%) after learning using inquiry-based physics learning tools developed. The results of the analysis of the normality test and paired sample test of students' critical thinking skills are in Table 5 and Table 6.

Table 5. Data normality of students' creative thinking skills

Item	N	Creative thinking skills			
		Asymp. Sig. (2-tailed)			
		Fluency	Flexibility	Originality	Elaboration
Pre-test post-test	22	.391	.491	.161	.054

Table 6. The results of the paired sample test of students' creative thinking skills

Pair	Indicators	Test	N	Mean	SD	p
Pair 1	Fluency	Pre-test	22	1.9545	.65300	.000
		Post-test		3.2273	.68534	
Pair 2	Flexibility	Pre-test		2.5227	.39271	
		Post-test		3.5455	.34188	
Pair 3	Originality	Pre-test		1.9091	.61016	
		Post-test		3.1818	.58849	
Pair 4	Elaboration	Pre-test		2.1818	.36337	
		Post-test		3.4773	.49946	

Table 5 shows that the significance of all indicators of students' creative thinking skills is> 0.05, so it can be stated that the pre-test and post-test data of students' creative thinking skills are normally distributed. Table 6 shows that the increase in students' creative thinking skills after learning was statistically also stated to have a positive and significant impact ($p < 0.05$).

The physics learning tool based on inquiry model developed emphasizes student activities in breaking down problems into simple parts so as to allow students to formulate as many hypotheses as possible. This statement is in accordance with the nature of creative thinking skills, which is the ability to unravel problems to enable students to develop various solutions [42].

4. Conclusion

Based on the results of the study, it can be concluded that physics learning tools based on inquiry are valid, practical and effective to improve high school students' creative thinking skills on heat material. The results showed that students needed to be given more contextualization of teaching material with daily life to make it easier for students to relate their initial knowledge to the new knowledge being taught. Further research using different teaching materials and research sites is also important in the future.

References

[1] S. Mahanal, "Asesmen Keterampilan Berpikir Tingkat Tinggi," *J. Penelit. dan Pengkaj. Ilmu Pendidik. e-Saintika*, 2019.

[2] F. J. King, L. Goodson, and F. Rohani, *Assessment & Evaluation: Higher Order Thinking Skills*. 1998.

[3] S. Zubaidah, N. M. Fuad, S. Mahanal, and E. Suarsini, "Improving creative thinking skills of

students through Differentiated Science Inquiry integrated with mind map," *J. Turkish Sci. Educ.*, 2017.
[4] R. K. A. Singh, C. K. S. Singh, T. M. T. M., N. A. Mostafa, and T. S. M. Singh, "A Review of Research on the Use of Higher Order Thinking Skills to Teach Writing," *Int. J. English Linguist.*, 2017.
[5] A. Abraham, "Gender and creativity: an overview of psychological and neuroscientific literature," *Brain Imaging and Behavior*. 2016.
[6] L. M. Greenstein, *Accessing 21 century skills: To guide to evaluating mastery and authentic learning.* USA: Corwin Press, 2012.
[7] K. H. Kim, "The Creativity Crisis: The Decrease in Creative Thinking Scores on the Torrance Tests of Creative Thinking," *Creat. Res. J.*, 2011.
[8] K. Filsaime Dennis, "Menguak Rahasia Berpikir Kritis dan Kreatif," *Menguak Rahasia Berfikir Kritis dan Kreatif*. 2008.
[9] Y. Yusnaeni, A. D. Corebima, H. Susilo, and S. Zubaidah, "Creative thinking of low academic student undergoing search solve create and share learning integrated with metacognitive strategy," *Int. J. Instr.*, 2017.
[10] J. Junaidi, Y. Roza, and M. Maimunah, "Kemampuan Berpikir Siswa dalam Menyelesaikan Soal HOTs pada Materi Pola dan Barisan Bilangan," *J. Penelit. dan Pengkaj. Ilmu Pendidik. e-Saintika*, 2020.
[11] N. Qamariah, S. Gummah, and D. S. B. Prasetyo, "Penerapan Model Pembelajaran Scramble untuk Meningkatkan Kemampuan Berpikir Kreatif Siswa," *Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, 2016.
[12] B. A. Prayitno, D. Corebima, H. Susilo, S. Zubaidah, and M. Ramli, "Closing the science process skills gap between students with high and low level academic achievement," *J. Balt. Sci. Educ.*, 2017.
[13] A. Michalopoulou, "Inquiry-Based Learning through the Creative Thinking and Expression in Early Years Education," *Creat. Educ.*, 2014.
[14] Nurhadi, Lukman, R. Abas, Erni, Yuliana, and Hamrina, "Implementation of Inquiry Based Learning to Improve Understanding the Concept of Electric Dynamic and Creative Thinking Skills (An empirical study in Class IX Junior High School Students State 4 Kendari)," *Int. J. Sci. Res.*, 2016.
[15] C. Kuhlthau, L. Maniotes, and A. Caspari, "Guided inquiry design: A framwork fo inquiry in your school," *J. New Members Round Table*, 2012.
[16] S. Prayogi, L. Yuanita, and Wasis, "Critical-Inquiry-Based-Learning: Model of Learning to Promote Critical Thinking Ability of Pre-service Teachers," in *Journal of Physics: Conference Series*, 2018.
[17] M. Asy'ari, M. Ikhsan, and Muhali, "The effectiveness of inquiry learning model in improving prospective teachers' metacognition knowledge and metacognition awareness," *Int. J. Instr.*, vol. 12, no. 2, pp. 455–470, 2019.
[18] R. I. Arends, *Learning to Teach*, 9th Editio. New York: McGraw-Hill, 2012.
[19] Muhali, L. Yuanita, and M. Ibrahim, "The validity and effectiveness of the reflective-metacognitive learning model in improving students' metacognitive ability in Indonesia," *Malaysian J. Learn. Instr.*, 2019.
[20] A. Hussain and A. Shakoor, "Physics Teaching Methods: Scientific Inquiry Vs Traditional Lecture," *Int. J. Humanit. Soc. Sci.*, 2011.
[21] P. Eggen and D. Kauchak, *Strategies and Models for Teachers: Teaching Content and Thinking Skills*. 2012.
[22] W. Sanjaya, "Perencanaan dan Desain Sistem Pembelajaran Edisi Pertama," *Prenada Media Group*. 2012.
[23] Choirunnisak, M. Ibrahim, and Yuliani, "The development of guided inquiry-based learning devices on photosynthesis and respiration matter to train science literacy skills," in *IOP Conference Series: Materials Science and Engineering*, 2018.
[24] S. Prayogi, L. Yuanita, and L. Wasis, "Critical inquiry based learning: A model of learning to

promote critical thinking among prospective teachers of physic," *J. Turkish Sci. Educ.*, 2018.
[25] S. Prayogi and M. Muhali, "pengembangan model pembelajaran aktif berbasis inkuiri (abi) untuk mengembangkan keterampilan berpikir kritis mahasiswa," *Prism. Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. dan IPA IKIP Mataram*, 2015.
[26] R. Q. Ningsih, T. -, and W. Widodo, "Development of Learning Devices Intructured Inquiry Model With Brainstorming Strategy To Improve Creative Thinking Ability Of Basic School Students," *Int. J. Sci. Res. Publ.*, 2019.
[27] Partnership for 21st Century Learning, "P21 Framework Definitions," 2015.
[28] H. Fitriani, M. Asy'Ari, S. Zubaidah, and S. Mahanal, "Critical Thinking Disposition of Prospective Science Teachers at IKIP Mataram, Indonesia," in *Journal of Physics: Conference Series*, 2018.
[29] Wahyudi, N. N. S. P. Verawati, S. Ayub, and S. Prayogi, "Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers," in *Journal of Physics: Conference Series*, 2019.
[30] M. Asy'ari, H. Fitriani, S. Zubaidah, and S. Mahanal, "The science process skills of prospective biology teachers in plant cell material based on gender," *Int. J. Emerg. Technol. Learn.*, 2019.
[31] Sugiyono, "Metode Penelitian Pendidikan pendekatan Kuantitatif, Kualitatif dan R&D.," in *METODE PENELITIAN ILMIAH*, 2014.
[32] S. Thiagarajan, "Instructional development for training teachers of exceptional children: A sourcebook," *J. Sch. Psychol.*, 1974.
[33] M. Asy'ari, S. Hidayat, and M. Muhali, "Validitas dan efektivitas prototipe buku ajar fisika dasar reflektif-integratif berbasis problem solving untuk meningkatkan pengetahuan metakognisi," *J. Inov. Pendidik. IPA*, 2019.
[34] Riduwan, *Skala Pengukuran Variabel-variabel Penelitian*. 2007.
[35] G. D. Borich, *Observation Skills for Effective Teaching*. 2016.
[36] J. P. (Joy P. Guilford and R. Hoepfner, *The analysis of intelligence*. 1971.
[37] S. Khanafiyah and A. Rusilowati, "Penerapan Pendekatan Modified Free Inquiry Sebagai Upaya Meningkatkan Kreativitas Mahasiswa Calon Guru Dalam Mengembangkan Jenis Eksperimen Dan Pemahaman Terhadap Materi Fisika," *Berk. Fis.*, vol. 13, no. 2, pp. E7–E14, 2010.
[38] C. J. Wenning, "The Levels of Inquiry Model of Science Teaching," *J. Phys. Tchr. Educ. Online*, 2011.
[39] J. Mierdel and F. X. Bogner, "Is creativity, hands-on modeling and cognitive learning gender-dependent?," *Think. Ski. Creat.*, 2019.
[40] N. Eragamreddy, "Teaching Creative Thinking Skills," *Int. J. English Lang. Transl. Stud.*, vol. 1, no. 2, pp. 124–145, 2013.
[41] R. J. Sternberg, "The Assessment of Creativity: An Investment-Based Approach," *Creativity Research Journal*. 2012.
[42] B. Gibby, "Creativity and intelligence," in *Theory and Practice of Curriculum Studies*, 2012.

REVIEW SUMMARY

Round : 1st Review
ID Article : 113
Article Title : Development of physics learning tools based on inquiry to increase creative thinking skills

Criteria	Comment
Technical Criteria	
• Scientific merit: notably scientific rigour, accuracy and correctness.	Good
• Clarity of expression; communication of ideas; readability and discussion of concepts.	Good
• Sufficient discussion of the context of the work, and suitable referencing.	Good
Quality Criteria	
• Originality: Is the work relevant and novel?	Yes
• Motivation: Does the problem considered have a sound motivation? All papers should clearly demonstrate the scientific interest of the results.	Yes
• Repetition: Have significant parts of the manuscript already been published?	[please type here]
• Length: Is the content of the work of sufficient scientific interest to justify its length?	[please type here]
Presentation Criteria	
• Title: Is it adequate and appropriate for the content of the article?	As there is a mismatch between the title and content of the article. The content of the article is more towards the implementation of the product developed. However, if you want to retain the title, then in the method section it is necessary to add how the development procedure is carried out and discussion needs to be added regarding the characteristics of the resulting product
• Abstract: Does it contain the essential information of the article? Is it complete? Is it suitable for inclusion by itself in an abstracting service?	Yes
• Diagrams, figures, tables and captions: Are they essential and clear?	Yes

• Text and mathematics: Are they brief but still clear? If you recommend shortening, please suggest what should be omitted.	Yes
• Conclusion: Does the paper contain a carefully written conclusion, summarizing what has been learned and why it is interesting and useful?	Yes

Recommendation:

Publish after optional minor revision

Best Regards,

**) Delete which is not match*

Gmail ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

Dokumen dari Yogi AW

Inbox ×

Saiful Prayogi <saifulprayogi@ikipmataram.ac.id>
to ictap

Revision 1st_113_Muhammad Asy'ari.docx

Revision 1st_113_...

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
to me

Thank you Mr.

Best regards

Editor

Pada tanggal Jum, 8 Jan 2021 pukul 14.31 Saiful Prayogi <saifulprayogi@ikipmataram.ac.id> menulis:
> Revision 1st_113_Muhammad Asy'ari.docx

Well received with thanks. Received, thank you. Thanks a lot.

Reply Forward

Gmail ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

Final draft

Inbox ×

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
to me

Dear Author (s) ICTAP 2020

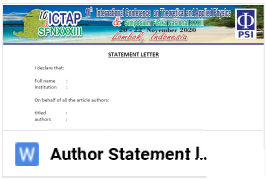
Here we send the final draft of your article. Please pay attention to the following steps:
1) Check your article with the following conditions:
• Are all author names correct?
• Are all article parts correct?

2) Send the article's final version's approval **by filling out and signing** the author statement letter form accor

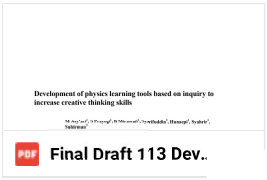
We hope that the statement letter has been signed and sent back to email ictap_sfn2020@unram.ac.id **no lat**

Kind Regards,
Aris Doyan, Ph.D
ICTAP 2020 Chairman

2 Attachments



Author Statement l..



Final Draft 113 Dev..

Yes, I approve. Yes, everything is correct. No, it's not.

Gmail ictap_sfn2020@unram.ac.id

Compose

Inbox 453
Starred
Snoozed
Sent
Drafts 9
More

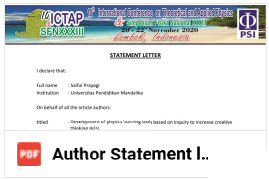
Meet
New meeting
My meetings

Hangouts
Saiful

No recent chats
Start a new one

Author STATEMENT LETTER M Asy'ari et al. Inbox ×

Saiful Prayogi <saifulprayogi@ikipmataram.ac.id>
to ictap



Author Statement l..

ictap Conference2020 <ictap_sfn2020@unram.ac.id>
to me

Indonesian English Translate message

Terima Kasih atas konfirmasinya.
Artikel akan langsung kami proses untuk submit ke JPCS.

Salam Hormat,

Tim Editor

Pada tanggal Min, 17 Jan 2021 pukul 09.42 Saiful Prayogi <saifulprayogi@ikipmataram.ac.id> menulis:

STATEMENT LETTER

I declare that:

Full name : Saiful Prayogi
Institution : Universitas Pendidikan Mandalika

On behalf of all the article authors:

titled : Development of physics learning tools based on inquiry to increase creative thinking skills
authors : M Asy'ari, S Prayogi, B Mirawati, Syarifuddin, Hunaepi, Suhirman, & Syahrir

agree with the article's final draft version submitted to the Journal of Physics: Conference Series according to the guidelines (https://publishingsupport.iopscience.iop.org/author-guidelines-for-conference-proceedings/). We also recognize that publishing decisions are at the discretion of the publisher and if the publisher declines my article, then I agree that all payments are non-refundable. We also have read and understood IOP Publishing's ethical policy (https://publishingsupport.iopscience.iop.org/ethical-policy-journals/). We have also read and accepted all of the Proceedings Publication Licence and responsible for the article content (https://publishingsupport.iopscience.iop.org/questions/iop-proceedings-licence/).

Under this statement, we recognize that amendment after submission and post-publication change is not possible. For exceptional circumstances, if any part of the papers published should require replacement and/or amendments after submission, if agreed by the Publisher, any such changes or amendments will be conducted with appropriate reference to the conventions, guidelines, and scientific practices publishing. Also, we are willing to meet the additional costs charged.

Regards,

(Saiful Prayogi)