IOP Journal of Physics Conference Series

ISSN
1742-6596 (Online)
1742-6588 (Print)

IOP Publishing

IOP Conference Series
Materials Science and Engineering

Indexed by:

Scopus

THOMSON REUTERS

Compendex

Conference Organizer

Organizer
Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019
Universitas Negeri Surabaya, Surabaya, Indonesia
September 28th, 2019

The conference is organized by **Universitas Negeri Surabaya**

Website: http://www.unesa.ac.id/

Conference Committee

Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019

Universitas Negeri Surabaya, Surabaya, Indonesia

September 28th, 2019

Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019

Organizer

Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019

Universitas Negeri Surabaya, Surabaya, Indonesia

September 28th, 2019

Welcome speech by Rector of Universitas Negeri Surabaya

Assalamu'alaikum wr wb.

The honorable Keynote speakers: Prof. Hernando Ombao, Ph.D, Assoc. Prof. Boon Chuan Low, Prof. Tomonori Ichinose, and Dr. Yusuf Fuad, M.App.Sc.

Dearest guests, presenters, and participants of the Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019.

Praise be to Allah SWT for His blessing moment, hence we can attend this valuable moment to share some ideas in this conference.
It is my pleasure, as the Rector and on behalf of Universitas Negeri Surabaya to welcome all of you, from abroad and within Indonesia, to participate in the Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019.

Ladies and Gentlemen,
The Sustainable Development Goals (SDGs), also known as the Global Goals, were adopted by all United Nations Member, including Indonesia, as a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity by 2030. The Global Goals address the global challenges we face, including those related to poverty, inequality, climate, environmental degradation, prosperity, and peace and justice, which can be described in 17 Sustainable Development Goals (SDGs). We can play important role and do significant action to support the achievement of these goals as we are educator and researchers as well.

Ladies and Gentlemen,
Inspired by the spirit of Sustainable Development Goals, the MISEIC 2019 brings the theme "Trends, Advancement, and Innovation in Mathematics, Informatics, Science and Education Toward Sustainable Development Goals". We do hope that this conference will be the home for the researchers, the lecturers, and the practitioners in Mathematics, Informatics, Science and Education to communicate their original scientific ideas based on their updated research. Their contribution will be valuable input for the development of these fields.

Ladies and Gentlemen,
We are grateful to all institutions, sponsors, all organizing and scientific committee members, and all participants for making this conference possible and successful. We wish you all have a pleasant stay here in Surabaya, the Heroic City.
May you have a very successful conference.
Thank you.

Prof. Dr. Nur Hasan, M.Kes

Welcome speech by Chairman of the Mathemathics, Informatics, Science, and Education International Conference (MISEIC) 2019

Assalamu'alaikum wr wb.
The honorable Rector of Universitas Negeri Surabaya,
The honorable Keynote speakers: Prof. Hernando Ombao, Ph.D, Assoc. Prof. Boon Chuan Low, Prof. Tomonori Ichinose, and Dr. Yusuf Fuad, M.App.Sc.

Dearest guests, presenters, and participants of the Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019.

Welcome to Surabaya, welcome to Universitas Negeri Surabaya, welcome to the venue. We are proud to host the Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019.

Ladies and Gentlemen,
MISEIC 2019 is the 3rd Mathematics, Informatics, Science and Education International Conference (MISEIC) organized by Faculty of Mathematics and Natural Sciences Universitas Negeri Surabaya. This international conference aims to bridge the scientists, education experts and practitioners, and students in the scientific forum through sharing ideas and issues about theoretical and practical knowledge in mathematics, informatics, science and STEM education. The theme for this year conference is "Trends, Advancement, and Innovation in Mathematics, Informatics, Science and Education Toward Sustainable Development Goals" as one of our contribution to success the achievement of The Sustainable Development Goals (SDGs).

Ladies and Gentlemen,
This conference is a great event for the scientists, education experts and practitioners to share their ideas and research finding. MISEIC 2019 is attended by presenters who come from overseas and Indonesia. After the plenary session, the presenters will present their articles in the parallel session based on their research field. Hopefully, this session will be a chance for scientific sharing as well as building future networking.

Ladies and Gentlemen,
Last but not least, we have to acknowledge that this conference will not be possible without tremendous supports and help from those who really give their all-out efforts and hardworking. I am very grateful to all members of the organizing committee and scientific committee for their great work to support this conference

We wish you all have a memorable moment in Surabaya and have a fruitful and very successful conference.

Thank You,
A'yunin Sofro, Ph.D.

Abstract of STEACH Keynote Speakers

BCH Domain as a Versatile Scaffold Module in Cell Signaling and Mechanobiology

Assoc. Prof. Boon Chuan Low
Mechanobiology Institute Singapore, Department of Biological Sciences and University Scholars Programme, National University of Singapore

Protein-protein interactions define specificity in cell signaling that requires precise timing and placement of interacting partners. Deregulation of such intricate networks often lead to pathologies. My laboratory pioneers the characterization of the BNIP-2 and Cdc42GAP Homology (BCH) domain as a versatile scaffold protein domain that regulates small GTPases, kinases and metabolic signaling at specific locales. Specifically, BCH domains control Ras, Rho and Rac GTPases signaling by engaging them with their immediate activators, the guanine nucleotide exchanger factors (GEFs) or their inactivators, the GTPase-activating Proteins (GAPs). This leads to dynamic actin cytoskeletal rearrangement and also activation of endosomal Ras/MAPK signaling for cell morphogenesis, motility, growth and differentiation. One BCH-containing protein BNIP-H/Caytaxin also facilitates shuttling of ATP citrate lyase (ACL) on the kinesin motor from cell body to neurite termini where it produces acetylcholine at the synapses. In this talk, I will discuss the plasticity of BCH domains in the context of its molecular evolution, unique structure, versatile functions and their links to cancer and neurological disorder such as ataxia. The significance of BCH domain as a concerted scaffold device that bridges mechanical cues to cell dynamics, will be explored in the context of the emerging field of mechanobiology.

Current Challenges in the Analysis of High Dimensional Brain Signals

Prof. Hernando Ombao, Ph.D
King Abdullah University of Science and Technology, Saudi Arabia

Advances in imaging technology has given unprecedented access for neuroscientists to examine various facets of how the brain “works”. Brain activity is complex. A full understanding of brain activity requires careful study of its multi-scale spatial-temporal organization (from neurons to regions of interest; and from transient events to long-term temporal dynamics). It is also multi-faceted and cannot be fully characterized by a single data modality. To fully appreciate brain processes, one must integrate various data that probe into both the anatomical structure and specific functionality such as electrical, metabolic and hemodynamic.

There are many challenges to analyzing brain data. First, brain data is massive - these are recordings across many location and over long recording times. Second, it has a complex structure with non-stationary properties that evolve over space and time. Third, brain data is often dominated by noise. Thus, this environment has provided big opportunities for data scientists to develop new tools and models for addressing the current research in the neuroscience community. This paper will highlight these challenges confronting in this interface between neuroscience and the data science (computational science, statistical learning and modeling).

The Effectiveness of the Methods and Approaches of ESD for 2030 Sustainable Development Goals

Prof. Tomonori Ichinose
Director of Research Center for International Understanding in Education/Miyagi University of Education, Japan

ESD is a key element of quality education. Its cross-cutting competencies in cognitive, socio-emotional and behavioural dimensions of learning bear relevance to all areas of education. (UNESCO Executive Board 20 February 2019). This study, the result of four years of research in 279 primary and secondary schools in Japan, reveals that in integrated study periods, and with the engagement of local human resources, an increase of activities across different classrooms and grades are a clear result of enhanced ESD and students' collaboration, cooperativeness, cooperative attitude, and ability to communicate are interconnected. From a pluralistic perspective of ESD, teaching students to confront tensions and conflicts and tackling issues with no single answer seems to be difficult. Since the ESD curriculum has been constructed through whole-school educational activities in Japan by linking it with other subjects and areas, utilizing integrated study periods, it is important to examine approaches to understanding the effectiveness of a whole-school approach of ESD.

Key words
SDGs, Holism, Pluralism, Japanese UNESCO-Associated Schools, Whole-school approach

Uniqueness and Stability of Stationary Periodic Behavior of PWM DC-DC Converters Using Multifrequency Modelling

Dr. Yusuf Fuad, M.App.Sc.
Department of Mathematics, Faculty of Math. and Nat. Sci.
Universitas Negeri Surabaya, Indonesia.

It is well known that the power conversion is commonly achieved using switching elements. The study of switched power converters is an area of active research. As the voltage and current ratings and switching characteristics of power semiconductors devices keep improving, the range of application continues to expand in areas such as communications and data handling systems, portable battery-operated equipment and uninterrupted power source. This study highlights the theory of PWM DC-DC converters for the standard Buck, Boost, Buck-Boost and Ćuk converters. Some aspects concerning PWM DC-DC converters will be discussed based on a multifrequency averaging, which involves Fourier series, as a generalization of the state space averaging techniques. It provides an efficient way to find the stationary state responses which are nonsinusoidal. The stationary periodic behavior plays an important field of study of PWM DC-DC converters. Moreover, it has been shown that a stabilizing controller for the state space averaging of PWM DC-DC standard converters does automatically imply a stabilizing controller for the converters itself. Utilizing the multifrequency modelling, the stationary periodic signals converter can be determined by solving a set of linear equations. Then, the existence and uniqueness of the stationary periodic signals, as well as the stability aspect of the converters, can be analyzed for open and closed loop situations. Simulations are indeed demonstrated, using Boost and Ćuk converters, in open and closed loop situations.

Keywords Multifrequency modelling, pulse-width modulated (PWM), periodic behavior, stability.

MISEIC 2019 Rundown

Time	Activity
07.00-08.00	Registration
08.00-08.45	Opening Ceremony of MISEIC Welcome Dance Singing Indonesia National Anthem & Mars Unesa Chairman Speech Rector Speech & Opening Praying Token of Appreciation
08.45-09.00	Photo Session
PLENARY SESSION 1	
09.00-09.30	**Boon Chuan Low** (*Mechanobiology Institute Singapore, Department of Biological Sciences and University Scholars Programme, National University of Singapore*) with the title "BCH Domain as a Versatile Scaffold Module in Cell Signaling and Mechanobiology"
09.30-10.00	**Hernando Ombao** (*Biostatistics Group, King Abdullah University of Science and Technology, Saudi Arabia*) with the title "Current Challenges in the Analysis of High Dimensional Brain Signals"
10.00-10.30	Discussion
PLENARY SESSION 2	
10.30-11.00	**Tomonori Ichinose** (*Research Center for International Understanding in Education/Miyagi University of Education, Japan*) with the title "The Effectiveness of the Methods and Approaches of ESD for 2030 Sustainable Development Goals"
11.00-11.30	**Yusuf Fuad** (*Applied Mathematics Research Group, Department of Mathematics, Universitas Negeri Surabaya*) with the title "Uniqueness and Stability of Stationary Periodic Behavior of PWM DC-DC Converters Using Multifrequency

	Modelling”
11.30-12.00	Discussion
12.00-13.00	Lunch Break
13.00-15.00	Parallel Session I
15.00-15.15	Coffee Break
15.15-16.00	Parallel Session II

PAPER • OPEN ACCESS

Mathematics, Informatics, Science, and Education International Conference (MISEIC) 2019

Published under licence by IOP Publishing Ltd

Journal of Physics: Conference Series, Volume 1417, Mathematics, Informatics, Science and Education International Conference (MISEIC) 2019 28 September 2019, Wyndham Hotel, Surabaya, Indonesia

Citation 2019 *J. Phys.: Conf. Ser.* **1417** 011001

https://doi.org/10.1088/1742-6596/1417/1/011001

Abstract

List of Welcome speech by Rector of Universitas Negeri Surabaya, Welcome speech by Chairman of the Mathemathics, Informatics, Science, and Education International Conference (MISEIC) 2019, Abstract of STEACH Keynote Speakers, Current Challenges in the Analysis of High Dimensional Brain Signals, The Effectiveness of the Methods and Approaches of ESD for 2030 Sustainable Development Goals, Key words, Uniqueness and Stability of Stationary Periodic Behavior of PWM DC-DC Converters Using Multifrequency Modelling, MISEIC 2019 Rundown, Images are availble in this pdf.

Table of contents

Volume 1417

2019

Previous issue Next issue

Mathematics, Informatics, Science and Education International Conference (MISEIC) 2019
28 September 2019, Wyndham Hotel, Surabaya, Indonesia

Accepted papers received: 28 November 2019
Published online: 20 December 2019

Open all abstracts

Preface

Papers

Physics

Pure and Applied Mathematics

OPEN ACCESS 012063

Student Teachers' Construction of Mathematical Theorem of Set and Cardinality

Evangelista Lus Windyana Palupi, Abdul Haris Rosyidi and Hani Rizkia Putri

+ Open abstract View article PDF

OPEN ACCESS 012064

The Instructional Design of Blended Learning on Differential Calculus Using Successive Approximation Model

A Wintarti, Abadi and D K Fardah

+ Open abstract View article PDF

OPEN ACCESS 012065

The Performance of Prospective Teachers in Interpreting Graphs on context-based tasks

D Hidayat, TYE Siswono, S Hartono, NR Prihartiwi and AW Kohar

+ Open abstract View article PDF

OPEN ACCESS 012066

Number sequence as a context for creating a mathematical problem

N R Prihartiwi, T Y E Siswono, A W Kohar, S Hartono and D Hidayat

+ Open abstract View article PDF

OPEN ACCESS 012067

The Model of Visual Thinking of Prospective Math Teacher in Understanding the Formal Definition of Convergent Sequences Based on Gender Differences

Darmadi

+ Open abstract View article PDF

OPEN ACCESS 012068

Mathematical Problem Proving and Problem Posing

T Y E Siswono, S Hartono and A W Kohar

+ Open abstract View article PDF

Science Education

OPEN ACCESS 012069

Recitation program to improve students' conceptual understanding of Thermodynamics

A S D Adila, Sutopo and Wartono

+ Open abstract View article PDF

OPEN ACCESS 012070

Critical Thinking, Creative Thinking, and Learning Achievement: How They are Related

A Fatmawati, S Zubaidah, S Mahanal and Sutopo

+ Open abstract View article PDF

OPEN ACCESS 012071

Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers

Wahyudi, N N S P Verawati, S Ayub and S Prayogi

+ Open abstract View article PDF

OPEN ACCESS 012072

The Effectiveness of the Methods and Approaches of ESD for 2030 Sustainable Development Goals; From Analysis of the Questionnaire Survey to the School Teachers

T Icihnose

+ Open abstract View article PDF

OPEN ACCESS 012073

Understanding the Nature of Science Through a Content Analysis of Dynamic Fluid: Voices of Pre-Service Physics Teachers

N Suprapto, H Mubarok and A S Adam

+ Open abstract View article PDF

OPEN ACCESS 012074

University Students' Misconception in Electromagnetism

D S Bestiantono, E H Sa'diyah, R Rachmatya, H Mubarok, A S Adam and N Suprapto

+ Open abstract View article PDF

OPEN ACCESS 012075

An Effort in Teaching Invertebrates and Training Digital Literacy to the Students

I D T Putri and R Ambarwati

+ Open abstract View article PDF

OPEN ACCESS 012076

The Effect of Environmental Pollution Module on Environmental Worldview in Senior High School

M Syamsussabri, Suhadi and Sueb

+ Open abstract View article PDF

OPEN ACCESS 012077

Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers

Effectiveness of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Prospective Physics Teachers

Wahyudi[1], N N S P Verawati[1*], S Ayub[1], and S Prayogi[2]
[1] Universitas Mataram, Jl. Majapahit No.62 Mataram 83115, Indonesia.
[2] Institut Keguruan dan Ilmu Pendidikan (IKIP) Mataram, Jl. Pemuda No. 59A, Mataram 83126, Indonesia.

e-mail: *veyra@unram.ac.id

Abstract. Critical thinking has become one of the main competencies of learning at the level of higher education in Indonesia, and teaching interventions that lead to the achieving of these competencies are important to do. One of the learning models developed to promote critical thinking ability is the Inquiry Creative Process (ICP), a learning model. This research aims to describe the effectiveness of the ICP learning model to promote the critical thinking ability of prospective physics teachers. The implementation of the ICP learning model involved prospective physics teachers at four higher education institutions in the province of West Nusa Tenggara - Indonesia, that are the Mataram University (UNRAM), Teacher Training and Education Institut of Mataram (IKIP Mataram), Mataram State Islamic University (UIN Mataram), and the University of Muhammadiyah Mataram (UM Mataram). This study is experimental research, where is for each group performed pretest, implementation of the ICP learning model, and then posttest. The critical thinking ability of prospective physics teachers was measured using a critical thinking ability test instrument. The data of critical thinking ability were analyzed descriptively and statistically, where the homogeneity, normality, t-test, and ANOVA test were conducted. The results showed that the implementation of the Inquiry Creative Process learning model was effective to promote the critical thinking ability of prospective physics teachers. Descriptions of further research results are described in this article.

1. Introduction

Students after graduation must have the ability to think critically, and this has become the general hope of educators, parents, and the general society. Critical thinking is considered important for young people who want to continue further education, compete to get a job, or simply become responsible citizens. For critical thinking to be properly cultivated in schools, we must ensure that teachers have the critical understanding and critical thinking [1], and critical thinking teaching interventions are very appropriate for prospective teachers when they are still educating at the higher education level [2].

Teaching critical thinking to learners especially prospective teachers has attracted attention in recent decades given the role of future teachers as agents of change for the education system in terms of developing learner critical thinking [3]. In higher education institutions that produce prospective teachers, lecturers must teach high-level thinking skills and education before becoming a teacher is the right time for intervention activities that can promote critical thinking [4]. However, teaching to think

remains confusing for many teachers [5]. This is due to the lack of clarity of the various methods available to teach critical thinking skills [5, 6]. At the higher education level, Bissell and Lemons [7] show that the average learner does not think critically. Thompson [8] argues that teaching critical thinking requires a holistic approach and must involve a set of appropriate learning models. Therefore, it is necessary to develop a set of specific learning models to improve learner critical thinking skills.

One of the learning models that aimed at how learners to think is the inquiry instruction model [9] and has been developed for specific purposes, for example in this study to improve the critical thinking ability of prospective physics teachers. The inquiry model is integrated with the process of scientific creativity into it, according to Philley [10] critical thinking is a multidimensional cognitive construction, as a result of the creative process. The integration of this study constructed in the learning model is called the Inquiry Creative Process (ICP) learning model. The ICP learning model is a model developed by integrating the attribution of creative processes (scientific creativity) in each syntax of inquiry models. Scientific creativity is creativity in learning science which is attributed to the emphasis on the ability to find the problems (problem finding), creating hypotheses, creatively experiment designing, science creatively problem solving, and creatively product design [11,12,13,14]. The assignment of creativity can expand the reach of creative activities, so the learner can apply, produce, find, compare, connect, imagine, and design creative ideas [15].

Attributions in scientific creativity are then integrated into scientific inquiry activities. The inquiry-based lesson according to Arends [9] consists according to activities; problem identification, formulating hypotheses, planning experiments to test hypotheses, formulating explanations, and reflecting. Inquiry processes need to be integrated and attributed to scientific creativity for the purpose to improve learner critical thinking, as explained by Adams [16] that the creative process or scientific creativity has the potential to exercise critical thinking ability. This integration is also to sharpen the potential to facilitate thinking through inquiry activities.

The ICP model promotes the critical thinking ability of prospective physics teachers. Ennis [17] and Hassard [18] define critical thinking as reasonable and reflective thinking that is focused on deciding what to believe or do. Critical thinking is often called independent thinking, reflective thinking, or evaluative thinking [19]. Critical thinking ability has been seen as a cognitive process, some previous researchers [2, 20, 21, 22] consistently use aspects of analysis, inference, evaluation, and decision making as the main indicators of critical thinking ability. This study aims to implement the ICP learning model and then evaluate its effectiveness in promoting the critical thinking ability of prospective physics teachers.

2. **Methods**

This study is a type of experimental research that aims to describe the effectiveness of the ICP learning model to promote the critical thinking ability of prospective physics teachers. The implementation of the ICP learning model involved prospective physics teachers (PPT) at four higher education institutions in the province of West Nusa Tenggara-Indonesia, which are the 20 PPT in UNRAM, 9 PPT in IKIP Mataram, 16 PPT in UIN Mataram, and 16 PPT in UM Mataram. The number of PPT involved was 61 people. For each group performed pretest, implementation of the ICP learning model, and then posttest. CT ability of PPT measured using a critical thinking ability test instrument, adapted from the Ennis-Weir Critical Thinking Essay Test with the indicators measured are the ability to analyze, inference, evaluate, and decision making [20]. The data of CT ability were analyzed descriptively and statistically, where the homogeneity, normality, t-test, and ANOVA were conducted. The effectiveness criteria of the ICP learning model if there is an improvement in critical thinking ability after the implementation of the model, and score of CT ability at least “critically” criteria in the posttest. Moreover, the effectiveness criteria according to the hypothesis tested in this study are: a) there is an increase in CT ability of PPT between the pretest score and the posttest score after implementation the ICP learning model in all group, and b) there is not significantly difference in increasing CT ability between classes after the implementation of the ICP learning model.

3. Results and Discussion

The result of the CT ability test of prospective physics teachers who are processed descriptively is shown in Table 1. The result of CT ability involving in 4 higher educational institutions (UNRAM, IKIP, UM, and UIN) shows average CT ability score on pretest of -2.13, with criteria of "not critically" (not critically, if: $X \leq -1.60$), and the posttest score of 16.34 with criteria of "critically" (critically, if: $11.20 < X \leq 17.60$), with n−gain of 0.71 with "high" criteria. From these results, it can be declared that the ICP learning model is effective in promoting the critical thinking ability of prospective physics teachers.

Table 1. The data of CT ability of prospective physics teachers in 4 group tested

Group	*Mean score & criteria*					*N-gain*	*Criteria*
	N	*Pretest*	*Criteria*	*Posttest*	*Criteria*		
UNRAM	20	-2.40	not critically	16.60	critically	0.72	high
UM	9	-1.89	not critically	16.22	critically	0.70	high
UIN	16	-1.38	not critically	15.81	critically	0.67	medium
IKIP	16	-2.88	not critically	16.75	critically	0.76	high
Average		*-2.13*	*not critically*	*16.34*	*critically*	*0.71*	*high*

Statistical analysis was performed to evaluate the effectiveness of the ICP learning model with predetermined hypothesis testing criteria. Homogeneity tests, normality tests, t-tests, and ANOVA tests were conducted. The variance homogeneity test using Levene's test, and the normality test using the Kolmogorov-Smirnov normality test in each of the four groups showed that the data variance was homogeneous and normally distributed with a significance value of all test groups greater than 0.05. The results of the homogeneity test of variance dan normality test provided in Table 2 and Table 3.

Table 2. The results of the homogeneity test of variance (Levene's test)

Data	Group	Levene test statistic	dF	Sig.
Pretest-Posttest	UNRAM	0.209	38	0.650
	UM	0.381	16	0.546
	UIN	0.658	30	0.424
	IKIP	0.668	30	0.287

Table 3. The results of the normality test (Kolmogorov-Smirnov normality test)

Data	Group	Kolmogorov- Smirnov test	N	Sig.
Pretest-Posttest	UNRAM	0.098	20	0.200
	UM	0.170	9	0.200
	UIN	0.155	16	0.200
	IKIP	0.111	16	0.200

The results of testing the critical thinking ability of each group using the t-test show that the significance value of the test (0.000) for all groups smaller than the alpha test (0.05), thus the hypothesis H_1 is accepted, its meaning that there is an increase in critical thinking ability of prospective physics teachers between the pretest score and the posttest score after implementation the ICP learning model in all of these groups. The result of the t-test is provided in Table 4.

Table 4. The result of the t-test (independent samples test)

	Group	*t-test for Equality of Means*		
		t	*df*	*Sig.*
Pretest-Posttest (Equal var. assum.)	UNRAM	-31.996	19	0.000
	UM	-27.651	8	0.000
	UIN	-22.965	15	0.000
	IKIP	-33.358	15	0.000

Analysis of differences in the improvement of critical thinking ability of all classes was tested using ANOVA (F-test). The ANOVA test results show that the significance value (0.473) is greater than the alpha test (0.05), thus that H_0 is accepted (there is no significant difference in the increasing critical thinking ability between all groups after the implementation of the ICP learning model). This means that the ICP learning model has the same effect on improving the critical thinking ability of prospective physics teachers in all groups tested. The ANOVA test results are provided in Table 5.

Tabel 5. The ANOVA test result

	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	9.764	7	1.395	0.955	0.473
Within Groups	77.384	53	1.460		
Total	87.148	60			

The results of the statistical analysis show that the ICP learning model has been consistently in promoting the critical thinking ability of prospective physics teachers. The implementation of the ICP learning model to the prospective teachers of physics is in line with the demand that a physics learning has to master CT ability into it to correlate and interrelate between two or more theories and concepts in learning physics. The use of the ICP learning model increased the PPT ability in developing their CT. The result of this current study is parallel with the previous relevant study which found that the intervention of scientific creativity to develop CT ability is significantly effective [23].

The ICP learning model has strongly built critical thinking ability because it is by following the emphasis of the principles of constructivism learning. The constructivist perspective views teaching as not transferring knowledge from a teacher to learner, but an activity that allows the learner to develop their knowledge. Constructivist principles are based on ideas where learning develops knowledge actively, rather than accepting it passively in packages, from teachers (lecturers) or outside sources. The processes of creativity in inquiry activities have underpinned constructivist principles in learning. In addition to emphasizing the aspect of critical thinking, several advantages of the ICP learning model when implemented, which can encourage the curiosity of learners, create collaborative learning, encourage a sense of responsibility, support a positive classroom, and develop skills in learning itself.

The aspects of critical thinking that are promoted through the implementation of the ICP learning model in this study include the ability to analyze, inference, evaluate, and decision making. In the aspect of analysis, prospective physics teachers can identify the actual relationship between statements, questions, concepts, descriptions, or other. In the aspect of inference, prospective physics teachers can identify the elements needed to draw reasonable conclusions, to form guesses and hypotheses, to consider relevant information. In the aspect of evaluation, prospective physics teachers can assess the credibility of statements, representations, descriptions, perceptions, experiences, situations, judgments, beliefs, or opinions. The final aspect of critical thinking is being able to decision making, that is the process of choosing choices or actions between a set of alternatives on the basis of criteria or strategy. Achieving these aspects are caused by learning that emphasizes the exploration of scientific creativity through inquiry activities. Strengthening the scientific inquiry aspects of reasoning has helped prospective physics teachers in their tendency to think critically. According to Bailin [24], the objectives in inquiry activities focus a lot of critical thinking, for example; identifying assumptions, using logical thinking, analyzing direct events and phenomena, critical analysis of secondary sources, analyzing

arguments by reviewing current scientific understanding, considering evidence, and examining the logic.

The results of this study, in general, have shown that ICP learning models have been effective in promoting the critical thinking ability of prospective physics teachers. The ICP learning model uses a systematic and well-organized learning activity through some experimental activities which involve scientific creativity and scientific process skills in it. Scientific process skill has a great effect on learning because it helps the learner to improve higher mental skills, such as critical thinking, decision making, and problem-solving [25, 26]. It can be an instrument that improves critical thinking ability. For the sake of a broader teaching and learning results, it is important to teach some steps to reach and conquer the knowledge itself, in which it is definitely needed whey the learners conducting a scientific experiment during the learning process.

4. **Conclusion**

The ICP learning model has proven its effectiveness in promoting the critical thinking ability of prospective physics teachers. Moreover, this model has also consistently improved the critical thinking ability when implemented in different subjects in several higher education institutions administering the educational programs that produce prospective physics teachers. The findings in this study are also important reasons for using the ICP learning model as an alternative learning model that can be used by educators in general to promote critical thinking ability.

Acknowledgment

This study is a part of a decentralized research grant that organized by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia, research contract number of 7/E/KPT/2019.

References

[1] Mok F KT & Yuen T W W 2016 A critical evaluation of the understanding of critical thinking by school teachers: The case of Hong Kong *Citiz. Soc. Econ. Educ.* **15** (1) 28-44
[2] Prayogi S, Yuanita L & Wasis 2018 Critical inquiry-based learning: Model of learning to promote critical thinking ability of pre-service teachers *J. Phys. Conf. Ser.* **947** 1-6
[3] Sendag S, Erol O, Sezgin S & Dulkadir N 2015 Pre-service teachers' critical thinking dispositions and web 2.0 competencies *Contemp. Educ. Tech.* **6** (3) 172-187
[4] Warburton E C 2008 Changes in dance teachers' beliefs about critical-thinking activities *J. Educ. Humanit. Dev.* **2** (1) 1-16
[5] Bensley D A & Murtagh M P 2012 Guidelines for a scientific approach to critical thinking assessment *Teac. Psych.* **39** 5-16
[6] Abrami P C, Bernard R M, Borokhovski E, Wade A, Surkes M A, Tamim R & Zhang D 2008 Instructional interventions affecting critical thinking skills and dispositions: A stage 1 meta-analysis *Rev. of Educ. Res.* **78** (4) 1102-1134
[7] Bissell A N & Lemons P P 2006 A new method for assessing critical thinking in the classroom *BioScience* **56** (1) 66-72
[8] Thompson C 2011 Critical thinking across the curriculum: Process over output *Int. J. Humanit. Soc. Sci.* **1** (9) 1-7
[9] Arends R 2012 *Learning to teach (9th Ed)* (New York: McGraw-Hill)
[10] Philley J 2005 Critical thinking concepts *Prof. Safety* **50** 26-32
[11] Türkmen H & Sertkahya M 2015 Creative thinking skills analysis of vocational high school students *J. Educ. Instruc. Stud. in the World* **5** (1) 74-84
[12] Ayas B & Sak U 2014 Objective measure of Scientific creativity: Psychometric validity of the creative Scientific ability test *Elsevier: Thinking Skills and Creativity* **13** 195-205
[13] Hu W & Adey P 2010 A scientific creativity test for secondary school students *Int. J. Sci. Educ.* **24** (4) 389-403

[14] Aktamis H & Ergin O 2008 The effect of scientific process skill education on student's scientific creativity, science attitudes, and academic achievements *Asia-Pacific Forum on Science Learning and Teaching* **9** 1-21
[15] Rotteram K 2014 *Teaching, learning and creativity (TLC) Model for science* SSR **95** 79-84
[16] Adams K 2006 *The sources of innovation and creativity* (USA: National Center on Education and Economy)
[17] Ennis R H 2011 *The nature of critical thinking: An outline of critical thinking dispositions and abilities* Presentation at the Sixth International Conference on Thinking of MIT, Cambridge, MA.
[18] Hassard J 2005 *The art teaching science* (New York: Oxford University Press)
[19] Reid J C 2006 *Mengajar Anak Berpikir Kreatif, Mandiri, Mental dan Analitis* (Jakarta: Prestasi Pustakaraya)
[20] Prayogi S, Yuanita L & Wasis 2018 Critical inquiry-based learning: A model of learning to promote critical thinking among prospective teachers of physics *J. Turkish Sci. Educ.* **15** (1) 43-56
[21] Wahyudi, Verawati N N S P, Ayub S & Prayogi S 2019 The effect of scientific creativity in inquiry learning to promote the critical thinking ability of prospective teachers *Int. J. Emer. Tech. Lear.* **14** (14) 122-131
[22] Prayogi S, Muhali, Yuliyanti S, As'ary M, Azmi I & Verawati N N S P 2019 The effect of presenting anomalous data on improving student's critical thinking ability *Int. J. Emer. Tech. Lear.* **14** (6) 133-137
[23] Wahyudi, Verawati N N S P, Ayub S & Prayogi S 2018 Development of inquiry-creative-process learning model to promote the critical thinking ability of prospective physics teachers *J. Phys. Conf. Ser.* **1108** 1-6
[24] Bailin S 2002 Critical thinking and science education *Sci. Educ.* **11** 361-375
[25] Lee A T, Hairston R V, Thames R., Lawrence T & Herron S S 2002 Using a computer simulation to teach science process skills to college biology and elementary education majors *Comp. Simul. Bioscene* **28** (4) 35-42
[26] Koray Ö, Köksal M S, Özdemir M & Presley A I 2007 The effect of creative and critical thinking based laboratory applications on academic achievement and science process skills *Element. Educ. Online* **6** (3) 377-389