Investigating the effectiveness of an active learning based-interactive conceptual instruction (ALBICI) on electric field concept

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Received 22 Feb., 2016
Revised 24 Jun., 2016

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Abstract

The aim of this study was to develop an Active Learning Based-Interactive Conceptual Instruction (ALBICI) model through PDEODE*E tasks (stands for Predict, Discuss, Explain, Observe, Discuss, Explore, and Explain) for promoting conceptual change and investigating its effectiveness of pre-service physics teachers' understanding on electric field concepts. The ALBICI model consists of four phases; 1) Conceptual focus 2) Use of texts 3) Research based materials (PDEODE*E tasks) 4) Classroom interactions. The ALBICI teaching model was implemented to seven pre-service physics teachers who took the Physics course for a second time. The effectiveness of ALBICI model was evaluated by administering a Field Conceptual Change Inventory (FCCI) comprised of 13 three-tier test items to seven pre-service physics teachers as pre- and post-tests. Moreover, students' ideas were also elicited using worksheets about seven PDEODE*E tasks. The test and worksheets were analyzed by using a qualitative approach/research. The data analysis has mainly focused on electric field concepts with its subordinate concepts such as Coulomb law, static electric field, parallel plat capacitors, Ohm law, Kirchhoff law and RC circuit. The findings suggested that ALBICI teaching model enhanced pre-service physics students' conceptual understanding and reduced most of their misconceptions despite a few misconceptions still occurred.

Keywords: Active Learning Based-Interactive Conceptual Instruction (ALBICI) model, PDEODE*E task, conceptual change, misconceptions, pre-service physics teachers, electric field

Introduction

More than a few years ago, researchers around the world have been established considerable attention on active learning (e.g. Hillyard, Gillespie & Littig, 2010; Buckley, Pitt, Norton, & Owens, 2010; Meltzer & Thornton, 2011; Smith & Sodano, 2011). Repeatedly supposed as a fundamental change from traditional teaching to active learning model, the issue often differentiates research interest among researchers in higher education (e.g. Prince, 2004; Smith & Lytle, 1999; Fabry, 2010; Reed, Kennett, Lewis, & Lucas, 2011). Moreover, Karaçam & Digilli Baran (2015) stated that several negative effects of traditional approach on students' performance about electricity and due to traditional approach, students' conceptual understandings are distinguished. Physics education members thought that alternatives teaching models to promote conceptual understanding in higher education, even though active learning was esteemed as educational trends by other incredulous members (e.g. Başer, 2006; Hsu, Wu, & Hwang, 2008; Etherington, 2008).

"Why is active learning effective to promote conceptual understanding for pre-service physics teachers?" and "How does it differ from traditional physics education learning which was persisted questions by incredulous physics education members?" They assumed that physics education learning has already been "active" through coursework, homework and laboratory activities as usual. Moreover, incredulous physics education members did not understand how to utilize active learning in physics education context. They expected that active learning seems as traditional teaching and it might not be effective to promote conceptual understanding in higher education setting. These cases occurred because physics education members did not seek the active learning literatures for proving the problems.

Based on several references (e.g. Prince, 2004), instructional methods that actively engage students in the learning process are generally defined as active learning. Briefly, active learning entails pre-service physics teachers to do meaningful learning activities and think about what they are doing (Bonwell & Eison, 1991). However this meaning includes that traditional teaching activities such as homework and doing some tasks, actually active learning which refers to activities that are presented into the class. Pre-service physics teachers' activities and engagement are the main fundamentals of active learning in the instructional process. The traditional lectures where pre-service physics teachers inactively obtain knowledge from the lecturer is contrasted to active learning which facilitate pre-service physics teachers to engage and active in the learning processes.

Many active learning models have been utilized in the higher education level as reported in several references (e.g. Prestridge, 2014; Cambell & Monk, 2015; Hébert & Hauf, 2015), however; there have been few studies (Kaczynski, Wood, & Harding, 2008, Saunders, Brake, Griffiths, & Thornton, 2004) related to utilizing these models in physics' course. There are limited studies about electricity concepts in higher education level. Hence, we especially used electric field in Physics course to be implemented an Active Learning Based-Interactive Conceptual Instruction (ALBICI) model with PEODE*E tasks. The ALBICI model with PEODE*E tasks we used is very useful to promote conceptual understanding for pre-service physics teachers, because all phases in the model supported enhancing students' understanding, such as, 1) conceptual focus (concepts are introduced through multimedia before the ALBICI model was utilized), 2) use of texts (reading many textbooks and e-books before the intervention), and concept maps design, 3) research-based materials (the use of ALBICI with PEODE*E tasks on electric field contexts), and 4) classroom interactions (peer instruction through collaborative grouped activities in the model). An example of the ALBICI model with PDEODE*E tasks was given in the Appendix A and B. The model was assumed as a "house" for PDEODE*E tasks where the students actively involved in changing their misconceptions and enhance their conceptual understanding.

As described by Samsudin, Suhandi, Rusdiana, & Kaniwati (2015), PDEODE*E tasks utilized in the ALBICI model has originally been developed and it consists of seventh steps. Firstly, "P (Prediction)" phase, a conceptual phenomenon was presented to pre-service physics teachers via sheets and invited them to write a prediction independently, and to confirm their prediction. Secondly "D (Discuss)" phase, in each group, the pre-service physics teachers discussed in their groups and shared their thinking to group-mates. Thirdly "E (Explain)"phase, pre-service physics teachers in each group probed in order to grasp a conciliation and deduction about phenomenon given in the first phase, and present their concepts to other groups through whole class discussions. Then, they worked in groups to accomplish a hands-on experiment and separately recognized their observations. Fourth "O (Observe)" phase, the pre-service physics teachers observed changes in the phenomenon and the lecturer lead them to concentrate on observations relevant concepts. Fifth "D (Discuss)" phase, the pre-service physics teachers were requested to reconcile their predictions with the genuine observations made in the earlier step. Here, the students were asked to analyze, compare, contrast and criticize their classmates in the groups. In the sixth "E* (Explore)" phase, the students were facilitated to explore the concepts deeper and more comprehensive way. The E* phase embedded into PDEODE as previous version (e.g. Coştu, 2008; Coştu, Ayas, & Niaz, 2010; Coştu, Ayas, & Niaz, 2012; Savender-Kolari, 2004; Kolari-Savender, 2005) eliminated a few disadvantages and empowered. Furthermore, we utilized exploration sheet (E*) separately, to be explored the concept in order to change students' misconceptions towards scientific conceptions. Lastly "E (Explain)" phase, the pre-service physics teachers confronted all discrepancies between observations and predictions. At this point, the students had to attempt and determine any contradictions. The role of the lecturer in all phases was to challenge student/s and to organize proper discussions in each group or in the whole class.

Facilitating conceptual change in pre-service physics teachers' misconceptions, the ALBICI model with PDEODE*E tasks was grounded upon Conceptual Change

Model (CCM) proposed by Posner, Strike, Hewson, & Gertzog (1982). The changing process as follows; 1) dissatisfaction of students with the existed concept, 2) plausibility of new concept, 3) intelligibility of new concept and 4) fruitfulness of new concept. Those necessities succeed by tracking the ALBICI model based on CCM. The ALBICI model preserved four phases such as 1) conceptual focus, 2) use of texts, 3) research-based materials and 4) classroom interactions. As it seen the steps, the teaching model is adjacent to CCM. Elucidating the relation between two models, in the first phase, *conceptual focus*, pre-service physics teachers realized and felt dissatisfactions about their earlier conceptions. To achieve this, we operated multimedia computer consisting of simulations and videos. Multimedia computer which were showed consisted of many new concepts such as Gauss law simulation, charged object simulation, electric field interaction between positive and negative charged objects through vector field simulation, etc. Moreover, multimedia computer also shows many video related to electric field such as electric potential video, experiment about electric dipole with charged-fluid material, vector of electric field in electric wire and so on. They invited the pre-service physics teachers to learn more about the concepts, as consequence, they feel that their existed concept did not enough to explain the new concepts that can be shown an example in Figure 1.

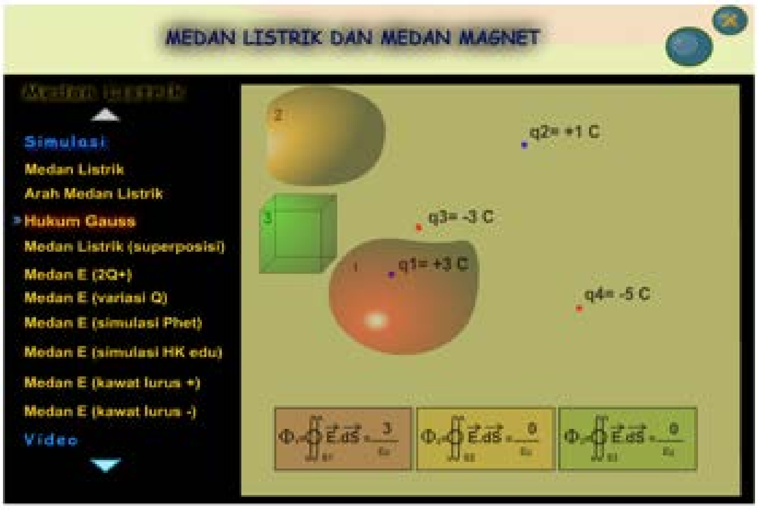
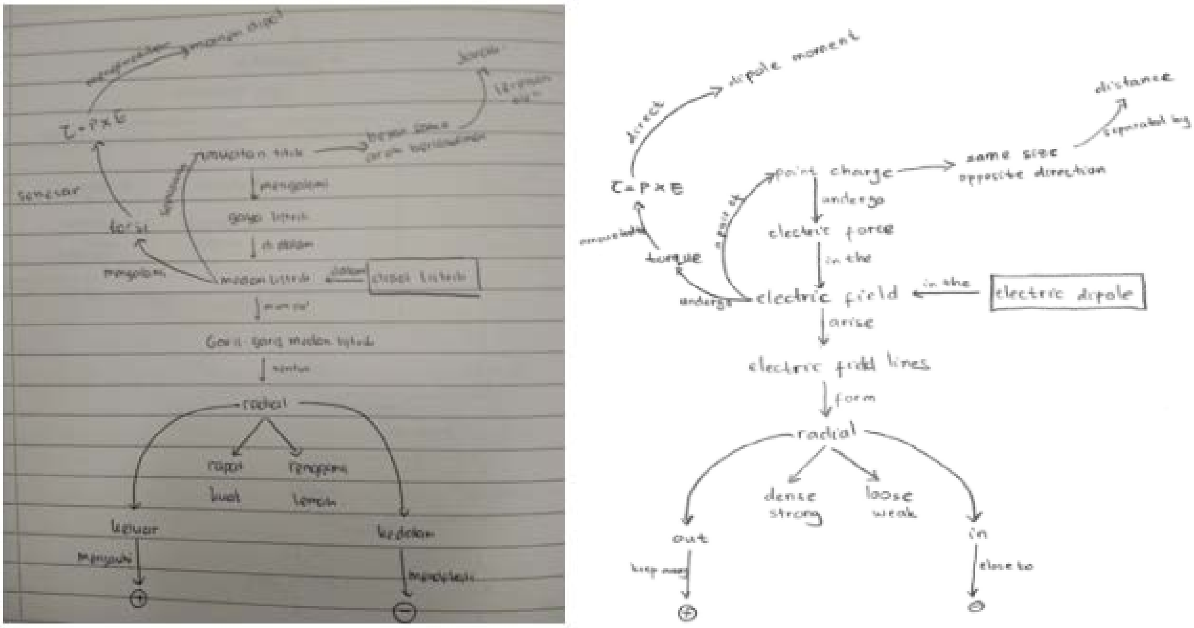


Figure 1. Multimedia computer based in the first phase of the ALBICI model

In the second phase, *use of text*, we aimed to providing the pre-service physics teachers to see their dissatisfaction about concept and their problems or misconceptions. To achieve this, we utilized textbooks and concept maps. The pre-service physics teachers read some textual material (books and e-books) about electric field before the concept mapping. After they learn about electric field, they construct a concept map in each sub concepts both individually and groups. Through designing concept mapping, lecturer (the first author of the paper) guided and advised the pre-service physics teachers to enhance their existed-knowledge because lecturer knew that they had several problems about their earlier conceptual understanding. Pre-service physics teachers made seven concept maps related to seven sub-concepts on electric field concepts such as concept maps about charged-objects and their interactions, vector of electric field from two and more charged-objects' interactions, parallel plat capacitor, etc. As can be seen in Figure 2: an example about charged-object sub-concept from student's concept map.



(a) (b)

Figure 2. Student's Concept map ((a) originally one and (b) translated in English) on electric field after reading textual materials made in the second phase of the ALBICI model

In the third and fourth phase, we provide other necessities to promote conceptual change, namely *conceptual conflict, plausibility, intelligibility and fruitfulness of new concept* by using PDEODE*E tasks based on POE. In the literature, a wide variety of strategies have been used to provide conceptual change such as "anomaly", "Socratic dialogue", "prediction-observation-explanation (POE)" strategies and so forth. The anomaly strategy uses unexpected events for students to provide conceptual conflict (e.g. Chinn & Brewer, 1993; Chen, Pan, Sung, & Chang, 2013), whereas Socratic dialogue employs conversation that encourages learners to recall existing concepts and then guides the learners to recognize inconsistencies in their deduction process (e.g. Chang, Lin, & Chen, 1998; Chang, Wang, Dai, & Sung, 1999; Chang, Sung, Wang, & Dai, 2003). Those methods emphasize only on the learner-perceived conceptual conflict provided by coaching with instructor/s involvement seems as passive learning activities. However; conceptual conflict, students' or their classmates actively involved do not necessarily empower active learner investigations (e.g. Chen, Pan, Sung, & Chang, 2013; Eryilmaz, 2002; Liégeois, Chasseigne, Papin, & Mullet, 2003). Conversely, the POE strategy facilitates the reorganization of knowledge structures by exposing learners to cognitive conflict through inconsistencies between existing knowledge structures and the new concepts (e.g. Gunstone & White, 1981; Coştu, Ayas, & Niaz, 2012). The experience is a sequence of prediction, observation, and explanation activities that scaffold self-explanation in conceptual learning. The scaffolding mechanisms that prompt for self-explanation might present the greatest benefits in producing deep understanding by removing misconceptions (e.g. Chen, Pan, Sung, & Chang, 2013; Chi, 1996; Chi, Bassok, Lewis, Reimann, & Glaser, 1989). Moreover, several physics educations experts such: Ding, Chabay, Sherwood, & Beichner. (2006); Furio & Guisasola (1998); Galili (1995); Tornkvist, Pettersson, & Transtromer (1993) stated that the students' conceptual knowledge on electricity and magnetism concepts occurred misconceptions. The POE strategy constructs a scenario of conceptual conflict for adaptation and reorganization of knowledge structures by engaging a learner to observe, comprehend, and then self-explain a new concept within an interactive learning environment.

In this study, researchers only focused on electric field views, particularly the concepts about Coulomb law, static electric field, parallel plat capacitors, Ohm law, Kirchhoff law and RC circuit. The concept of electric field is very important for students for being "back-bone" of the concept of electricity (Samsudin, Suhandi, Rusdiana, Kaniawati, & Coştu, 2015). Furthermore, this concept is very necessary to be learned by pre-service physics teachers because the concept of electric field is very abstract and complex (e.g. Dori & Belcher, 2005; Cheng, Lin, Chang, Li, Wu, & Lin, 2014). Furthermore, those concepts are often founded several misconceptions on students' minds, for instance: 1) "A charged object put in the uniformed electric field, it will stay on its position or it does not move". This misconception often occurred in students' mindset because they do not think that electric force acted on the object, as consequence the object will move. 2) "The velocity of current flow is determined very fast". Students mostly think that current flow fast because they attempt to implement their pre-conceptions about electric switch which turn on and the lamp suddenly is on. They were convinced that the electric current flow very fast. Unfortunately, we should analyze in microscopic view that the electric current flows very slow. The phenomenon is entitled "drift speed". The velocity of drift current is closed to 10-5 up to 10-4 m/s. Why does it happen? Because the wire has randomly electric dipole before the voltage is connected. After the voltage is connected to the circuit, all electric dipole will be oriented by electric field which is produced by the different voltage. As consequence the electric dipole will be re-constructed well-ordered.

Electric field concept mastery has been achieved through ALBICI model which constitutes experimental exploration guided by various learning sources such as text books, multimedia computer, and research material, described in the previous paragraphs. On that account, it was expected that pre-service physics teachers showed a sound understanding about electric field and related concepts.

The purpose of this study was to develop the ALBICI model with PDEODE*E tasks that is able to promote conceptual change and to investigate its effectiveness on pre-service physics teachers' understanding about electric field.

Methods

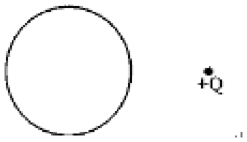
Participants

The seven pre-service physics teachers (three females and four males, whose ages were average of 21 years-old) were involved in this study as samples. They were introduced from different cities and re-registered in physics course as *Educational University* (a pseudonym). The respondent was purposely chosen from a class and all pre-service physics teachers participated in the study willingly. All of the pre-service physics teachers took to the pre- and post-tests and they were divided into two groups. The reason why we decided to divide the participants into two groups was based on pre-test results through FCCI. The pre-test result reported that first group had more comprehensions in minds without misconceptions conditions rather than second group. The teaching duration was four 50-minutes periods. The ALBICI model was utilized in this study will be described in detail.

The test items of FCCI instrument

To measure pre-service physics teachers' conceptual change before and after to the intervention through ALBICI model, a Field Conceptual Change Inventory (FCCI) involving of thirteen test items was utilized by using a qualitative approach. The authors have developed and published the test items of the instrument at international journal (Samsudin, Suhandi, Rusdiana, Kaniawati, & Coştu, 2015). The test items were organized in the form of semi open-ended named as three-tier test items. The Figure 3 shows an example of test item on electric field.

The figure below shows a hollowed conductor ball which initially is charged positive (+) and is apportionment on its surface. Then a positive charge $+Q$ is closed to a conductor ball as figure. Where is the direction of electric field in the center of ball after the positive charge $+Q$ is closed to the conductor ball?



a. To left.
b. To right.
c. To upper.
d. To under.
e. The field is zero.

Explanation:
1. There is no electric field in inner part of conductor ball as long as there is no a charged object in the hollowed conductor ball.
2. Because the conductor ball's charge is positive and is closed to a positive charge so the electric interaction of them repelled each other.
3. Because a charge in the ball is positive and the second charge($+Q$)also is positive so the electric field should be to left. As consequence two balls repelled each other.
4. Because a positive charge ($+Q$), which is closed to the conductor ball, will induced the conductor ball to be negative charge so that attracted iteraction occurred.
5. ....

The rating of confidence for the chosen answers:
a) Sure b) Not sure c) Do not know.

Figure 3 .A FCCI instrument test item on electric field concept

As it can be seen from Figure 3, the FCCI is divided into three tiers. The first tier is in the format of multiple choices, the second tier is in the format of semi open-ended and the last tier is confidence rating for instants: "sure", "not sure" and "do not know" (as agreed in the several literatures, such as, Caleon & Subramaniam, 2010; Peşman & Eryılmaz, 2010; Kutluay, 2005; Vatansever, 2006). In the first tier, the correct answer was given and four others choices were incorrect answers which dealt with misconceptions about electric field concepts. In the second tier, pre-service physics teachers chose their explanations connected to their responses in the first tier as in the references (Maloney, O'Kuma, Hieggelke, & Heuvelen, 2001; Dega, 2012; Vatansever, 2006; Allain, 2001). Additionally, pre-service physics teachers were able to write their explanations apart from papers which have already been presented to them. Consequently, they were able to comprise their conceptions freely in the fifth-blank. As a final point, in the third tier, pre-service physics teachers selected confidence rating correlated with their answers in terms of analyzing the consistency of their ideas in the previous tiers (the first and the second tiers). All test items of the instrument were initially experimented on thirty pre-service physics teachers who were registered in the physics course. The FCCI was validated by a panel comprising of three physics educators. The newest format of the instrument test was administered, in identical form, to the respondents one semester before (pre-test) and after the intervention (post-test) on the study of physics education. At a first glance, using the same test as pre-test and post-test, it could be seen as some weaknesses. One of the most weaknesses is the time duration between pre-test and post-test. The time duration is plausible for pre-service physics teachers to be unable to remember the instrument test, i.e. whereas post-test was administered three months after pre-test. Taking into description the discrepancy of pre-service physics teachers' performance in the pre-test and post-test, conceptual change was perceived from the changes in their responses from pre-test to post-test and the changes in their misconceptions from pre-test to post-test as coding based.

We also analyzed each test items (thirteen test items in the FCCI) in terms of learning indicators and Anderson & Krathwohl (2005)'s Taxonomy, is detailed in Table I.

Table 1. FCCI test instrument specification on electric field concept

Learning Indicators (LI)	**Anderson's Cognitive Aspects**		
	C2	**C3**	**C4**
• Analyzing the correlation between several electric charged objects' positions and Coulomb force.			✓
• Analyzing the correlation between several electric charged objects' positions and electric field.			✓
• Predicting the movement of a charged object which is caused by the effect of a uniformed electric field.		✓	
• Predicting a potential energy of charged object in the uniformed electric field.		✓	
• Comparing several electric forces which are located in the uniformed electric field.			✓
• Identifying the electric field direction for electric charged-conductor ball.	✓		
• Comparing sum works of electric charged object in the equipotential area.			✓

• Comparing the electric field for several electric charged objects.			✓
• Translating the graphic correlation of electric potential toward distance into electric field toward distance.	✓		
• Determining the graphic correlation of electric potential and distance.	✓		
• Distinguishing the highest electric field of several positions in the lines of equipotential areas.			✓
• Distinguishing the lowest electric field of several positions in the lines of equipotential areas.			✓
• Analyzing the correlation of electric field, electric potential and electric potential energy.			✓

Note: C2, C3 and C4 stand for understanding, applying and analyzing on Anderson et al.'s Taxonomy (1999)

The Active Learning Based-Interactive Conceptual Instruction (ALBICI) Model

Among conceptual change teaching strategies, researchers decided to utilize the Active Learning Based-ICI model, based on our perceptions of its relevance for the educational perspectives in this research. All phases in the ALBICI model supported enhancing of pre-service physics teachers' understanding, such as, 1) conceptual focus (before the ALBICI model was implemented, the electric field concepts are introduced via interactive multimedia), 2) use of texts (reading comprehensions several textbooks and e-books before the intervention and designing the concept maps), 3) research-based materials (the use of ICI learning model with PEODE*E tasks on electric field contexts through students' worksheet and explorations' sheet), and 4) classroom interactions (peer instruction through collaborative grouped activities in the model). We established the learning activities about electric field's thinking schema (see Appendix A and B) which are detailed in Table II.

Table II .Teaching activities in the ALBICI model with PDEODE*E tasks and their context

The ALBICI model	**PDEODE*E Tasks**		**Context**
Teaching Activity I	Task 1	Part 1	• Coulomb law (The interaction of charged objects: plastic ruler is rubbed with plastic and wool)

		Part 2	• Coulomb law (The interaction of charged objects: rubber ruler is rubbed with plastic and wool).
Teaching Activity II	Task 2		• Static electric field for several shapes (i.e. single point, double points, and parallel plats) with an electron gun.
Teaching Activity III	Task 3a	Part 1	• Parallel plat Capacitors (different distance and area for two plat capacitors).
		Part 2	• Parallel plat Capacitors (different dielectric materials between two plat capacitors: i.e. vinyl chloride, wood and glass).
Teaching Activity IV	Task 4	Part 1	• Ohm law (Analyzing about the combinations of series' resistors).
		Part 2	• Ohm law (Analyzing about the combinations of parallels' resistors).
Teaching Activity V	Task 5	Part 1	• Kirchhoff law (a simple electric circuit of serial lamps).
		Part 2	• Kirchhoff law (a simple electric circuit of parallel lamps).
		Part 3	• A serial circuit of batteries.
Teaching Activity VI	Task 6		• Wheatstone bridge circuit.
Teaching Activity VII	Task 7	Part 1	• RC circuit (Recharging the capacitors).
		Part 2	• RC circuit (Discharging the capacitors).

Note: [a]Appendix A and B are related to Task 3.

Prior to the ALBICI model, the FCCI instrument was given to pre-service physics teachers to depict their thoughtfulness to the core knowledge of the activities (i.e., electric field). Afterwards, completing the tasks, the FCCI was then re-given to participants if they show understanding of the concept. The teaching intervention was administered to groups of students (a total 2 groups: 1st group consisted of three (S1, S2 and S3) and 2nd group consisted of four (S4, S5, S6 and S7)). At the beginning of each teaching activity, the PDEODE*E tasks and the Exploration sheet was handed out to each students. Pre-service physics teachers worked collaboratively in each group, and they filled in their worksheet independently. The teaching activities were introduced during a normal scheduled class of four 50-minutes duration—the instruction language was non-English. The instruction was given by the first author; hence we assumed that he expertly engaged in the ALBICI model. He was able to interact with the groups' members, especially discussions phase in the PDEODE*E tasks. In other words, discussions phase were guided by the lecturer properly. In the second discussion (D) and exploring phase (E*), the lecturer visited the two groups, requested some follow-up questions and gave some suggestions to lead students.

ALBICI model with PDEODE*E tasks was obtained from the previous development of learning strategy on vector field. One of the vector field concepts, electric field, consisted of seventh main concepts such as: Coulomb law, static electric field, parallel plat capacitors, Ohm law, Kirchhoff law, Wheatstone bridge circuit and RC circuit. Here, we only explain in detail about parallel plat capacitors as an example (Task 3, see Appendix A & B) as follows:

1. Predict (P): The pre-service physics teachers predicted which was related to parallel plat capacitors' concepts individually.
2. Discuss (D): They discussed about the results of personal prediction with his or her group's members to obtain group's predictions related to parallel plat capacitors' concepts.
3. Explain (E): A representative of each group explained their discussion to whole students so that the other group knew the concepts which have been discussed.
4. Observe (O): Pre-service physics teachers in each group performed and observed parallel plat capacitors phenomenon qualitatively to predict and to validate their group's prediction.
5. Discuss (D): They discussed in each group for a second time (twice) to resolve contradiction between prediction and observation qualitatively.
6. Explore (E*): Using exploration sheet, they explored the phenomenon of parallel plat capacitors quantitatively and qualitatively. Then, they re-discussed with their group members to correlate, analyze and criticize the result from earlier phases.
7. Explain (E): A representative student in each group explained for a second time about the results findings and conclusions from exploration which was obtained by presenting the data and conceptual analysis.

Procedures for Data Analysis

The test items was analyzed using five criteria (given in Table III) to categorize the pre-service physics teachers' responses. Table III detailed the criteria. Similar criteria were used in the literature (Samsudin, Suhandi, Rusdiana, Kaniawati, & Coştu, 2015).

After that, all the drawings were coded and then scored using the Barman's (1997) DAST Checklists. To address inter-rater reliability issues, all drawings were scored by two colleagues who have extensive background and experience with coding and scoring such drawings. Frequency analysis was completed on the scores of subsets examining the differences between the scores given by the researchers to the drawings. The instrument's reliability is KR-20 = .72. The validity was determined via review of drawings by authors. The second part of questionnaire regarding source of scientist image was measured by ANOVA to represent descriptive analysis and any statistical differences between groups. The reliability of the instrument was documented at .89.

Table III. Criteria for analyzing the three-tier test items in FCCI

Criterion	Descriptions of Criterion
Misconception (M)	Tier I and Tier II are wrong and confidence rating is "sure".
Understanding (U)	Tier I and Tier II are correct and confidence rating is "sure".
Partial Understanding (PU)	Following responses are categorized in PU. 1) Both of two (Tier I and Tier II) are correct but respondents chose confident rating "not sure" or "do not know" (hesitating position/un-stable conceptions). 2) Only one (Tier I or Tier II) is correct and respondents chose confidence rating "sure" or "not sure" or "do not know".
No Understanding (NU)	Tier I and Tier II are wrong and the confidence rating is "not sure" and "do not know".
Uncodable (UC)	Respondent do not fulfill (response) all or part of tiers in instrument test items.

As it can be seen in the Table III, pre-service physics teachers' responses were examined thematically and the following criteria were used: Understanding (U), Partial Understanding (PU), Misconceptions (M), No Understanding (NU) and Uncoddable (UC). Pre-service physics teachers' conceptions and misconceptions were elicited from three-tier test items. We also presented changes of pre-service physics teachers' conceptions in order to see conceptual change before and after the ALBICI model. Using the changes, we also identified different schema on changing pre-service physics teachers' understanding or misconceptions.

Findings and Discussions

The Table IV shows that the results of three-tier test items. All of students (namely; S1, S2, S3, S4, S5, S6 & S7) presented for the pre- or post- tests, they were completely extracted from the analyzing procedure.

Table IV. Students' responses in each criterion and their changes from pre-test to post-test

No.	Understanding (U)		Misconceptions (M)		No Understanding (NU)		Partial Understanding (PU)		Uncodable (UC)	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
1	S7	S2, S5, S6, S7	S1, S2	S1	S3, S5	-	S4, S6	S3, S4	-	-
2	-	S1, S2, S3	S5, S6	-	S2, S4, S6, S7	S4	S3	S5, S6, S7	S1	-
3	-	-	S1, S5	S1, S4	S2, S4, S6, S7	S6, S7	S3	S2, S3, S5	-	-
4	-	S1	-	-	S3	S2	S2, S4, S5, S6, S7	S3, S4, S5, S6, S7	S1	-
5	-	-	S1	S1, S2, S4	S2, S4	-	S3, S5, S6, S7	S3, S5, S6, S7	-	-
6	S1, S7	S1, S3, S4	S2	-	S3, S6	S5, S7	S4, S5	S2	-	S6
7	S1	S1, S2, S3, S4, S6	S5	S5	S6, S7	-	S2, S3, S4	S7	-	-
8	S1, S7	S1, S7	S2, S3, S4, S5, S6	-	-	-	-	S2, S3, S4, S5, S6	-	-
9	S7	S7	S3, S5, S6	-	S4	S2	-	S3,S4, S5, S6	S1, S2	S1
10	-	S3	S2, S4, S5, S6	-	S3	S7	S7	S2, S4, S5, S6	S1	S1
11	S1, S5	S1, S2, S3, S5, S6	S4	-	S2, S3, S6, S7	-	-	S4, S7	-	-
12	S2	S2, S3, S4, S7	S3	-	S4, S6, S7	S5	S5	-	S1	S1, S6
13	S1, S5, S7	S1	-	-	S2, S4, S6	S2	S3	S3, S4, S5, S7	-	S6

Note: *S1, S2, S3… refer to the particular students in the study*

As it can be seen from the Table IV, most of the changes were positive ways. For example, number of the students gave responses that were classified in the understanding (U) and partial understanding (PU) category increased after the ALBICI intervention. Similarly, the Table IV reveals mostly positive conceptual changes, that is, number of the students gave responses that were classified into the misconceptions (M) category decreased after the ALBICI intervention. This means that the pre-service physics teachers changed their misconceptions towards scientific conceptions. On the other hand, only a few case (e.g. 7th three-tier test item especially S5), student's responses were not changed over time in his misconception condition. This means that the ALBICI teaching model was inefficient to change students' conceptions. Main reason of this issue should be that researchers had a limitation problem related to control and to handle whole psychological problems or incorrect students' schema (i.e. students' thinking, engagement in collaboratively grouped work and students' motivations). As a consequence, a few pre-service physics teachers could not change their misconceptions toward scientific conceptions. Similar result could be seen in the conceptual change studies (e.g. Coştu, Ayas, & Niaz, 2012; Srivastava, John, Gosling & Potter, 2003; Dass, 2005).

Since the main research problem was to determine whether or not pre-service physics teachers' misconceptions change towards to scientific conceptions, the "Misconceptions (M)" category in the Table IV was detailed. Students' responses were further analyzed in term of unveiling their misconceptions based on three-tier test (the FCCI) items of pre- and post- tests. These are presented in Table V.

Table V. Students' misconceptions about electric field and their changes from pre-test to post-test

Students' Misconceptions (M)a	**Pre-Test**	**Post-Test**	**Conceptual changes from pre-test to post-test**
M1b: The interaction between electrically charged objects by the Coulomb force is not considered a vector interaction.	S1 S2	S1 -	No change (0) Positive (+)
M2: The interaction between electrically charged objects with the electric field is not considered a vector interaction.	S5 & S6	-	Partial positive (+)
M3: Charged objects were initially stationary and be at a uniform electric field is considered to have	S1 S5	S1 -	No change (0) Partial positive (+)

no electric force.	-	S4	Negative (−)
M5: The electric forces that are located in several points scattered in a uniform electric field are considered equal.	S1 -	S1 S2 & S4	No change (0) Negative (−)
M6: The electric field in the centre of electric-charged conductor ball scattered on the surface is considered not zero.	S2	-	Partial positive (+)
M7: The number of works a charged body is considered to be not influenced by displacement of equipotential surface.	S5	S5	No change (0)
M8: Magnitude of electric field for some electrically charged objects is considered to be influenced by the density of electric field lines.	S2, S3, S4, S5, S6	-	Partial positive (+)
M9: Graph of the displacement and the electric potential in the electric field to the distance is perceived differently.	S3, S5, S6	-	Partial positive (+)
M10: Graph of the displacement and the electric potential in the electric field to the distance is not considered to correlate with area under the curve.	S2, S4, S5, S6	-	Partial positive (+)
M11: The magnitude of electric field in the several positions of equipotential area is considered to be the biggest value in the centre position or in the density positions of lines area neither that has the biggest of electric potential.	S4	-	Partial positive (+)
M12: The magnitude of electric field is considered null if it is not located on equipotential lines.	S3	-	Positive (+)

Note:
[a]Number 2 in M2 (Misconception 2) relate to learning indicator, namely LI.2 (given in the Table II) or questions number 2 (given in the Table IV)
[b] A few misconceptions (e.g. M4) were not seen in the table because of lacks of students' minds based on three-tier test items.

As it can be seen from the Table V, most of the changes in pre-service physics teachers' misconceptions were affirmative (positive or partial positive). Number of the students who held misconceptions decreased after the ALBICI intervention (M1, M2, M3, M5, M6, M7, M8, M9, M10, M11 and M12). This means that the pre-service physics teachers changed their misconceptions towards scientific conceptions. Conversely, the Table V reveals only two conceptual change was unfavorable way, that is, students (coding as S4) held misconceptions (M3) and (coding as S2 and S4) held misconception (M5) after the intervention although the students did not understand (no understanding) the concept before the intervention. The case about M3 and M5 was seen only two students. This originated from that only two students, from the participated students, did not actively involve not only exploration sheet but also the instruction and they had low motivation to do whole the tasks. Moreover, the students should be experienced group partner/s' misconception/s and influenced and finally accepted their misconception/s. Negative change occurred when the students did have a high motivation and they did not serious to involve in group discussion and to fulfill all answers in sheets. The issue was noticed by the first author of the paper especially in the discussion phase of PDEODE*E tasks.

The Table V, interestingly, also showed that students' misconceptions did not partly change after the intervention (M1, M3 and M5). Many studies on conceptual change (e.g. Lin, 2015; Shen, Liu, & Chang, 2015; Jan Kock, Taconis, Bolhuis, & Gravemeijer, 2013; Safadi & Yerushalmi, 2013; Boujaoude & Jurdak, 2010; Leppavirta, 2011; Engström, Gustafsson, & Niedderer, 2010; Çalık, Ayas, & Coll, 2007; Aufschnaiter, 2006; Friege & Lind, 2006; Vosniadou, 1994) found that conceptual change is a time consuming process because misconceptions are well embedded in students' earlier mind schema.

Based on the data presented in the Table IV, possible types of changes from pre-test and post-test were constructed and given sample of pre-service physics teachers' responses (see Table VI).

Table VI. Possible types of changes in criterion of students' responses based on Table IV

Change' Category	Pre-test		→	Post-test	Examples of Students' Conceptions	Students & Test Number
Acceptable (A)	**1**	M	→	PU	**S1 for no. 1:** "At the pre-test, S1 considered that The interaction between electrically charged objects by the Coulomb force is not considered a vector interaction. After treatment, his understanding of the concept partially enhanced and when the post-test he response correctly on the first tier was the Coulomb law is considered a vector interaction that is the total forces should increase but its direction is still same. Unfortunately, his response for the second tier is the total forces should increase but its direction is the opposite one".	• S1 for (No. 1); • S2 for (No. 6, 8 & 10); • S3 for (No. 8 & 9); • S4 for (No. 8, 10, & 11); • S5 for (No.2, 8, 9 & 10); • S6 for (No. 2, 8, 9 & 10).
	2	M	→	U	**S2 for no. 1**: "At the pre-test, S2 considered that The interaction	• S2 for (No. 1); • S3 for (No. 12).

					between electrically charged objects by the Coulomb force is not considered a vector interaction. As consequence, he chose the wrong answer for first tier and second tiers and he chose "sure" for confidence rating. Afterward, his understanding about Coulomb law completely enhanced and when the post-test he chose correctly on the first and the second tiers was the Coulomb law is considered a vector interaction that is the total forces should increase but its direction is still same. Because of that, he unveiled his misconception toward scientific conceptions about Coulomb law".	
	3	NU	→	PU	**S4 for no. 9**: "In the pre-test, S4 totally did not understand the concept about the graph of the displacement and the electric potential in the electric field to the distance is perceived differently. After the post-test, she held partial understanding and was able to response the correct answer in the first tier but the reason that was still incorrect".	• S2 for (No. 3); • S3 for (No. 1 & 4); • S4 for (No. 9 & 13); • S6 for (No. 2); • S7 for (No. 2 & 11).
	4	NU	→	U	**S3 for no. 6**: "During the pre-test, S3 thought that the electric field in the center of electric-charged conductor ball scattered on the surface is considered not zero, while the post-test, S3 realized to change her thinking about the hallowed-conductor ball concept that the electric field in the center of the conductor ball was zero because no charged part".	• S2 for (No. 2, 11); • S3 for (No. 6, 10 11); • S4 for (No. 12); • S5 for (No. 1); • S6 for (No. 7, 11); • S7 for (No. 6 & 12).
	5	PU	→	U	**S2 for no. 7**: "During the pre-test, S2 response the correct answer on the first tier and his reason that were not correct on the second tier of the concept about the number of works a	• S2 for (No. 7); • S3 for (No. 2 & 7); • S4 for (No. 6 & 7); • S6 for (No. 1)..

					charged body is considered to be influenced by displacement of equipotential surface, surprisingly, while the post-test S2 chose a correct answers in the first and the second tier with the confidence rating was sure. It is indicated that his understanding enhance from partially to totally understanding about the work of a moving charged object in the uniformed electric charge is influenced by displacement of equipotential surface".	
Not Acceptable (NA)	**1**	M	→	NU	-	-
	2	NU	→	M	**S4 for no. 5**: "During the pre-test, S4 assumed that the concept about the electric forces that are located in several points scattered in a uniformed-electric field are considered equal and she chose wrong reason referred to the first tier, but she chose "did not know" in the third tier. It means that she did not understand the concept in the pre-test. Afterward, in the post-test she began to feel very confident when in answer to first and second tiers were incorrect. She changed confidence rating from "did not know" to "sure", consequently she held negative change from no understanding to misconception".	• S2 for (No. 5); • S4 for (No. 3 & 5).
	3	PU	→	M	-	-
	4	PU	→	NU	**S5 for no. 12**: "During the pre-test, S5 has chosen tier one correct answer, the reason was not appropriate and the confidence rating was chosen "did not know" about the magnitude of electric field is considered null if it is located on equipotential lines. It means that he had partial understanding in the pre-test. Unfortunately, in the post-test, he actually changed his answers for the second tier from	• S2 for (No. 4); • S5 for (No. 6 & 12); • S7 for (No. 10).

					the correct reason to incorrect reason based on the first tier's answer. Afterward, he chose the confidence rating "not sure".	
	5	U	→	PU	**S5 for no. 13**: "During the pre-test, S5 has chosen the correct answers in the first and second tiers and he chose the confidence rating "sure". It means that he held understanding the concept about the relationship among electric field, electric potential and electric potential energy in the uniformed equipotential area is not considered to be influenced by direction. Unfortunately, in the post-test, he hesitated and changed his confidence rating from "sure" to "not sure". As consequence, he held negative change from understanding the concept to partial understanding".	• S5 for (No. 13).
	6	U	→	NU	-	-
	7	U	→	M	-	-
No Change (NC)	**1**	PU	→	PU	**S7 for no. 4**: "During the pre-test until post-test, S7 response confidence rating "not sure" although her answered in the first and second tiers were correct about the potential energy of a moving charged object in the uniformed electric field is considered unchanged, so she did not change her understanding. For this case, no change process sound "moderate understanding" because she still held partial understanding and she has potency to enhance her knowledge".	• S3 for (No. 3, 5 & 13); • S4 for (No. 1 & 4); • S5 for (No. 4 & 5); • S6 for (No. 4 & 5); • S7 for (No. 4 & 5).
	2	NU	→	NU	**S6 for no. 3**: "On the concept about a charged object were initially stationary and was located at a uniform electric field is considered to have electric force, S6 did not change her	• S2 for (No. 13); • S4 for (No. 2); • S6 for (No. 3); • S7 for (No. 3).

					conception because she did not understanding from pre-test until post-test. This case sounded "no understanding". She chose incorrect answers for first and second tiers and response "do not know" the concept for third tier. She thought that only for moving charged object which had electric force".	
	3	M	→	M	**S1 for no. 5**: "During the pre-test until post-test, S1 held misconception about the electric forces that are located in several points scattered in a uniform electric field are considered equal. The treatment could not change his misconception about this concept."	• S1 for (No. 1, 3, & 5); • S5 for (No. 7).
	4	U	→	U	**S7 for no. 8:** "The S7 held good understanding on the concept about the magnitude of electric field for some electrically charged objects is not considered to be influenced by the density of electric field lines. She chose the correct answers for first and second tiers and never changed her response for confidence rating "sure".	• S1 for (No. 6, 7, 8, 11, 13); • S2 for (No. 12); • S5 for (No. 11); • S7 for (No. 1, 8 & 9).

Note:
1) S1, S2… refer to the particular students in the study
2) M, U, PU, NU & UC stand for Misconceptions, Understanding, Partial Understanding, No Understanding and Uncodable respectively (see Table V)

The changing processes were divided into three categories in order to facilitate researchers in analyzing conceptual change that occurred in the pre-service physics teachers' thinking. As it can be seen from the Table VI, four types of possible changes were observed in each change category (A, NA and NC). In the "A" category, students' understanding on "electric field" changed from the pre-test to the post-test with some improvement. Pre-service physics teachers' understanding enhanced as a result of the ALBICI model. Interestingly, in the "A" category, while pre-service physics teachers' responses in misconception (M) criterion changed as partial understanding category, they did not change as understanding (U) criterion. This means that misconceptions are resistant to change and that conceptual change is a time consuming process as given in the plethora of earlier researchers (e.g. Vosniadou, 1994).

As for "NA" category, students' understanding changed from pre-test to the post-test in unfavorable ways. For example, 13th changes, only one (S5) student' responses in understanding (U) criterion changed as partial understanding (PU) category. Similarly; while S2 and S4 gave response in accordance partial understanding (PU) category in the pre- test, they changed their responses as misconceptions (M) category. In the same way; while S2, S5 and S7 response in accordance partial understanding (PU) criterion changed as no understanding (NU). This change especially can be seen in Table VI, was not occurred dramatic change. Although the changing process sounded negative but all change drop only one grade (i.e. negative change from understanding to partial understanding). The reasons of this case were explained at the bottom of the Table V.

As for "NC" category, pre-service physics teachers' understandings were not changed from pre-test to the post-test. We mainly aimed, in this study, to changing students' misconceptions towards scientific conceptions. However; students' misconceptions did not change from the pre-test to the post-test after the intervention. This case should seem as conceivable, because pre-service physics teachers' misconceptions are deeply rooted into their existing knowledge structures (e.g. Srivastava, John, Gosling & Potter, 2003; Dass, 2005; Tuberty, Dass, & Windelspecht, 2011; Berti, Barbetta, & Toneatti, 2015).

In order to validate data from three-tier test items in FCCI, we sought other aspects of qualitative data derived from PDEODE*E students' worksheet and exploration sheets in the ALBICI model. Only two qualitative data which are presented from seven activities, those are Coulomb law and parallel plat capacitors is presented in Table VII as follows:

Table VII. Students' group responses on Coulomb law

	Exploration Sheet: Part 1			
	Group Prediction	Observation	Analysis	Research Comment
Group Ia	• The results of discussions, electrically neutral black ball which	• The ruler which was rubbed with a plastic would repel the black ball	• The ruler which was rubbed with a plastic would repel the black ball and pull with the ruler	In the group prediction, students only predicted about influence of the charge object to other object without

	was closed by ruler which was rubbed with a woolen cloth (giving a negative charge to the ruler) so that the ruler is negatively charged, contrary to the rubbed with a plastic ruler.	and pull with the ruler was rubbed with a woolen cloth.	was rubbed with a woolen cloth. • The distance also affect the deviation of the black ball, the closer a ruler with a black ball, the greater the deviation.	the interactions of them. Meanwhile, in the observation and analysis, they described about the interaction between black ball and ruler which was rubbed by woolen and plastic cloths.
	Exploration Sheet: Part 2			
	• If the rubber ruler was rubbed with a woolen cloth, it would repel each other because a ruler under loading and if rubber ruler was rubbed by a plastic, the ruler would be overloaded.	• Rubber ruler was rubbed with plastic, would be mutual attraction and would repel each other when it was rubbed with the wool.	• Based on the exploration results, the electric force-distance relationship was inversely proportional. This was shown by the further separation distance between two objects which were charged, the electric force would decrease.	The grouped prediction, observation and analysis were the same. This group has already learned to change their prediction from generally to precisely. Because a ball which was closed by a charged rubber ruler would be repeal.
Group IIb	**Exploration Sheet: Part 1**			
	Group Prediction	Observation	Analysis	Research Comment
	• The black ball hanging when was closed by ruler rubbed with a woolen cloth, would cause the black ball is moving	• The black ball moving away from plastic ruler rubbed with plastic. • While the ruler is rubbed with a woolen cloth, black ball	• The interaction between the ball with a ruler decreases when the distance between the two is quite far.	In the group prediction, students has already predicted about influence of the charge object to other object without the interactions of them. Because of that, the prediction, observation and analysis have the

	closer to a ruler. This is because the ruler becomes positively charged. • When plastic ruler rubbed with plastic, the ball going away from the ruler as ruler becomes a negative charge.	moving toward a ruler.		same result.
	Exploration Sheet: Part 2			
	• Rubber ruler was rubbed with a plastic, it would attract each other and the ruler would tend to negatively charged so as to attract the black ball. • Rubber ruler was rubbed with wool. It would repel each other and the ruler was likely to be charged positive.	• Rubber ruler which was rubbed with a woolen cloth would repel a ball and ruler rubber was rubbed with plastic, would pull the ball as well as the interaction was very weak.	• Interaction between black balls and rubber ruler was weak because of tough rubber loaded.	This group only analyzed the distance factor but in the prediction, they have predicted and described about the interactions. It would be un-complete analysis or partial understanding.

Note:
*[a]In this group, S1, S2 and S3 performed PDEODE*E tasks.*
*[b]In this group, S4, S5, S6 and S7 performed PDEODE*E tasks.*

Table VIII. Students' group responses on parallel plat capacitors

Group Ia	**Exploration Sheet (See the Appendix B) Part I**			
	Group Prediction	Observation	Analysis	Research Comment

	• The potential difference (ΔV) and the capacity of the capacitor (C) were affected by the distance (d) between the two plats. • (ΔV) ∞ (d) and C ∞ 1/d.	• The farther distance between the two plates, the potential difference will decrease and capacitance also decreases.	• The capacitance is directly proportional to 1 / d (C ∞ 1/d). • The potential difference is proportional to 1/d (ΔV) ∞ 1/d.	The prediction, observation, and exploration phases were the same. This grouped members explained by using the interaction of mathematics symbols properly to explain the concept about area and distance factors toward capacitance of capacitors.
	Exploration Sheet (See the Appendix B) Part II			
	• Glass> Wood> vinyl chloride (VC) $\geq$ glass objects more positive than wood and VC.	• There was a difference between a dielectric material is equal to the predicted results. • Glass> Wood> VC. • Due to the positive charge on the glass more than wood and PVC	• Capacitance glass> capacitance wood> VC capacitance. • The greatest capacitance was a combination of wood and VC.	Capacitance of glass> capacitance of wood> capacitance of VC. The greatest capacitance only between the combinations of wood-VC. Observation and exploration same as the input.
Group IIb	**Exploration Sheet (See the Appendix B) Part I**			
	Group Prediction	Observation	Analysis	Research Comment
	• The greater distance, the greater the electrical potential and decreasing the capacitance.	• Observations indicate that the potential difference was not increased but rather decreased.	• The greater distance, the potential decrease and the capacity decreases	This group focused to analyze the qualitative correlations between the electric potential and capacitance capacitor.

				Unfortunately, the result became worse because the conclusion was different with the prediction. It indicated that students held several misconceptions before the intervention.
	Exploration Sheet (See the Appendix B) Part II			
	• Sequence K from the greatest to the smallest values were Glass> VC> Wood.	• In accordance with predictions C before being added dielectrics <C after a big plus dielectric with dielectric material timber> glass> VC. • The reason is C ~ K. • The difference between predicted to exploration because students do not know the estimated value of the dielectric material.	• Could be analyzed that the C with a dielectric material wood> glass> VC and C of combined dielectric material between the wood-glass> VC-air. • according to the K combination of K1 + K2 = K and C ~ K.	Results of observation, exploration and prediction are the same.

Note:
[a]In this group, S1, S2 and S3 performed PDEODE*E tasks.
[b]In this group, S4, S5, S6 and S7 performed PDEODE*E tasks.

As it can be seen from the Table VII and VIII as samples, the groups' members had partial understanding on electric field concept especially in the task 3 about parallel plat capacitors, nevertheless the general result leads to the sound understanding for both groups after exploration sheet. It showed that the ALBICI model with PDEODE*E tasks could lead to a comprehensive understanding of the concepts. The pre-service physics teachers who initially hold misconceptions and no understanding of electric field concepts showed sound understanding of the concept after utilizing and exploring concepts with the sheets. The changing process performed by the pre-service physics teachers was affirmative especially fruitfulness principle referred to Posner, Strike, Hewson, & Gertzog (1982). The conceptual change mostly occurred because pre-service physics teachers realized that their earlier conceptions (mind's schema) were not enough to explain and to explore the concepts. As a consequence, they needed new knowledge to re-conceptualize their previous schema from misconceptions to scientific conceptions (e.g. Coştu, Ayas, & Niaz, 2012; Coştu, Ayas, & Niaz, 2010, Coştu, Ayas, Niaz, Unal, & Çalık, 2007; Aydin, 2012). Therefore, the reconstruction of the concept was to build and to strengthen the existing conceptions. This was no misconceptions in both groups during the learning process. It indicates that the ALBICI model with PDEODE*E tasks did not lead the students' misconceptions. Unfortunately, as mentions in previous analysis, a few misconceptions still occurred in some pre-service teachers' minds. We experienced that in teaching process the students changed their misconception towards scientific one, however; a few students (for example S4) hold misconception in the post-test. This indicated that student(s) was mostly affected his/her fellowships and their understanding. Hence, researchers who use group discussion or group works take into account the mentioned problem (e.g. Can & Boz, 2014; Coştu, Ayas, Niaz, 2012; Çalık, Ayas, & Coll, 2011; Enghag, Gustafsson, & Jonsson, 2009).

Conclusion and Suggestion

The main purpose of this study was to develop the ALBICI model based on PDEODE*E tasks for promoting conceptual change and investigating its effectiveness of pre-service physics teachers' understanding on the electric field. Results showed that the ALBICI model was an effective means of changing misconceptions students held. Data presented in the tables clearly showed that after the intervention, pre-service physics teachers enhanced their understanding. However; a few misconception still occurred in students' mind, especially, M1, M3, M5 and M7 (see Table V) about electric field occurred in the pre- and post- tests. This possibly arise from some reasons such level of students' seriousness (personal motivation aspect) are involved in PDEODE*E tasks. This case is conceivable, because students' misconceptions are deeply rooted into their existing knowledge structures. Hence, misconceptions were proven to be highly resistant to change, in other words, they are most robust (e.g. Goris & Dyrenfurth, 2010; Lombardi, Sinatra, & Nussbaum, 2013). On the other case for M3 and M5, that is, the students changed their scientific and partial understandings as misconception and no understanding.

That is why the students' negative changes possibly arise from unwilling to participate in PDEODE*E activities. They also experienced partners' misconception/s and influenced negatively and finally accepted their misconception/s (e.g. Srivastava, John, Gosling & Potter, 2003; Dass, 2005).

To sum up, this research proved that the ALBICI model with PDEODE*E task which was utilized was effective in changing students' misconceptions and enhancing students' conceptual understanding. Moreover, the ALBICI model with PDEODE*E tasks indicated that it is possible to change the traditional classroom setting in terms of ease conceptual change. Nonetheless, many multifarious factors such as: cognitive, motivational, ontological, and epistemological affected conceptual change process (e.g. Havu-Nuutinen, 2005). Based on this thoughtfulness, it is possible to utilize our model in teaching electric field concepts by focusing on problem about group discussion given earlier. Unfortunately, one of the most limitations of this study is sample size. Thus, we advise if we want to implement this model in our learning environments, we should be aware about subject size. A precise size of subject is able to guarantee that the implementation of ALBICI model is the strongest factors that influence the learning situations.

Lastly, we suggest here that the success of the pre-service physics teachers was mainly arisen from the fact that the PDEODE*E tasks helped them to evaluate their prior knowledge and to re-checked their ideas within their groups or whole-class discussions and to construct new concept in their minds especially by using exploration sheet known as conceptual change model proposed by Posner, Strike, Hewson, & Gertzog (1982). Hence, we suggest that the ALBICI model with PDEODE*E tasks should be used to promote conceptual change.

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Appendix

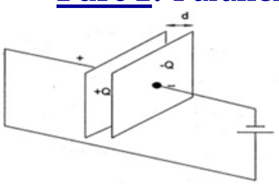
Appendix A: An example of PDEODE*E task on parallel plate capacitors

PDEODE*E TASK 3
(STUDENTS WORKSHEET)

Name : ……………………………………………………………
Date : ……………………………………………………………
Group : ……………………………………………………………

Topic : Parallel Plat Capacitors

Part 1: Parallel plat capacitors on different distances and area of two plats



- ✓ Given a set of experiments on parallel plat capacitors equipped with capacitance-meter.
- ✓ The first plat capacitor was permanently set whereas the second plat was changeable set in accordance with the tracks have already given and in the different area but in the same distance.
- ✓ Connecting the wires between electric voltage and parallel plat capacitors to the capacitance-meter in serial circuit.

- Given a set of experiments on parallel plat capacitors equipped with capacitance-meter.
- The first plat capacitor was permanently set whereas the second plat was changeable set in accordance with the tracks have already given and in the different area but in the same distance.
- Connecting the wires between electric voltage and parallel plat capacitors to the capacitance-meter in serial circuit.

- Predict the phenomena that should occur to the capacitance-meter when the second plat was set to the first, second and forth tracks and was set in the same distance but in different area of two plats? Indicate and explain the reason for your prediction!

………………………………………………………………………………………
………………………………………………………………………………………

- Discuss the reasons of your prediction with your group members. Then, explain your reasons in detail!

………………………………………………………………………………………
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- Observe the phenomena that occur in the capacitance-meter when the second plat was set to the first, second and forth tracks and was set in the same distance but in different area of two plats! What should occur? Is there any difference between the two phenomena? Indicate the results of your observations!

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- Why does this happen? Discuss it with your group members! Then, explain your reasons in detail!

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- Perform further exploration of your observations by using the equipment given! Write the conclusion on Exploration Sheet below! (Exploration Sheet was attached)

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- Compare to the results of your observation, exploration and prediction! Whether they are similar or different? Explain your reasoning! What can you conclude from this phenomenon? Please write your reason below!

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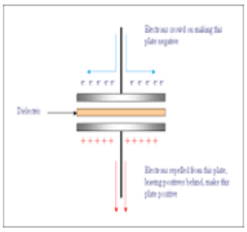
Part 2: Parallel Plat Capacitors which is filled by dielectric materials (glass, wood and vinyl chloride)



- ✓ Given a set of experiments on parallel plat capacitors equipped with three dielectric materials (glass, wood and vinyl chloride) and its capacitance-meter.
- ✓ The first plat capacitor was permanently set whereas the second plat was set in the second track.
- ✓ Connecting the wires between electric voltage and parallel plat capacitors to the capacitance-meter in serial circuit.
- ✓ Filling in the middle of two plat capacitors (i.e. glass, wood and vinyl chloride) alternately.

- Predict the phenomena that should occur to the capacitance-meter while was filled by dielectric materials (i.e. glass, wood and vinyl chloride) alternately? Indicate and explain the reason for your prediction!

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- Discuss the reasons for your prediction in your group. Then, explain your reasons in detail!

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- Observe the phenomena that occurred on the capacitance-meter while was filled by dielectric materials (i.e. glass, wood and vinyl chloride) alternately? Are there any differences between the three events? Indicate the results of your observations!

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- Why does it happen? Discuss with your group members! Then explain your reasons in detail

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- Perform further exploration related to your observations by using the equipment given! Write the conclusion on Exploration Sheet below! (Exploration Sheet attached)

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- Compare the results of your observation, exploration and prediction! Whether they are same or different? Explain your reasoning! What can you conclude from this phenomenon? Please write your reason below!

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Applications in Everyday life:

- Identify the examples of the real phenomena (daily phenomenon) of the application of parallel plat capacitors!

………………………………………………………………………………………
………………………………………………………………………………………

Appendix B: An example of exploration sheet of parallel plate capacitors

EXPLORATION SHEET
PREDICT, DISCUSS, EXPLAIN, OBSERVE, DISCUSS, EXPLORE& EXPLAIN
(PDEODE*E)
#Parallel Plat Capacitors#

Name : ………………………………………………………………
Date : ………………………………………………………………
Group : ………………………………………………………………

The Purpose of Experiment:
The purpose of the experiment in this exploration is to:

1. Analyzing the electric field based on different distances between two plat capacitors.

2. Analyzing the electric field based on different area between two plat capacitors.

3. Analyzing the electric field based on different dielectric materials (glass, wood and vinyl chloride) which is filled in the middle of two plats.

Experiment Steps:
Experiments steps in the parallel plat capacitors on different distances and areas of two plats as below:

1. Given a set of experiments on parallel plat capacitors equipped with capacitance-meter.

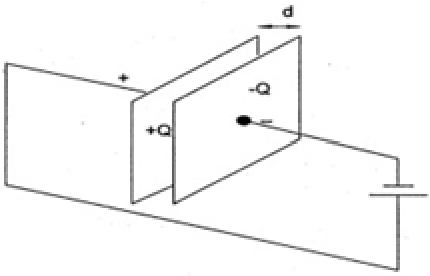

Figure 1. Experimental design of parallel plat capacitors

2. The first plat capacitor was permanently set whereas the second plat was set in the first track which has already given.

3. Connecting the wires between electric voltage and parallel plat capacitors to the capacitance-meter in serial circuit.

4. Repeating the second and the third steps in the different tracks (2, 3, and so forth). Observe the phenomenon that occurred! Record the observations in the table provided!

5. Furthermore, setting the first plat permanently and the second plat in the first track!

6. Moving slide the second plat to create different area from the first plat and so forth. Observe the phenomenon that occurred! Record the observations in the table provided!

Data Experiment:

Part 1: The parallel plat capacitors on different distances and areas of two plats

I.1. The data results of parallel plat capacitors on different distances

Table 1. The data of parallel plat capacitors on different distances
(The Area of two plats is same)

No.	**Distance of two plats *(cm)***	**Capacitance/C *(mF)***	**The Electric field in the middle of two plats *(mT)***	**The Electric field in the out-sides of two plats *(mT)***
1				
2				
3				
4				
5				

I.2. The data results of parallel plat capacitors on different areas

Table 2. The data of parallel plat capacitors on different areas
(The distance of two plats is same)

No.	**Distance of two plats *(cm)***	**Capacitance/C *(mF)***	**The Electric field in the middle of two plats *(mT)***	**The Electric field in the out-sides of two plats *(mT)***
1				
2				
3				
4				
5				

Part 2: The Parallel Plat Capacitors which is filled by dielectric materials (glass, wood and vinyl chloride)

Table 3. The data of parallel plat capacitors on different dielectric materials such as wood, glass and vinyl chloride
(The distance of two plats is same)

No.	**Distance of two plats *(cm)***	**Capacitance/C *(mF)***	**The Electric field in the middle of two plats *(mT)***	**The Electric field in the out-sides of two plats *(mT)***
1				
2				
3				
4				
5				

Data Analysis:
(Analysis of the data based on observations)
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Conclusions:
Based on the analysis of the data obtained, it can be concluded that:

……………………………………………………………………………………
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