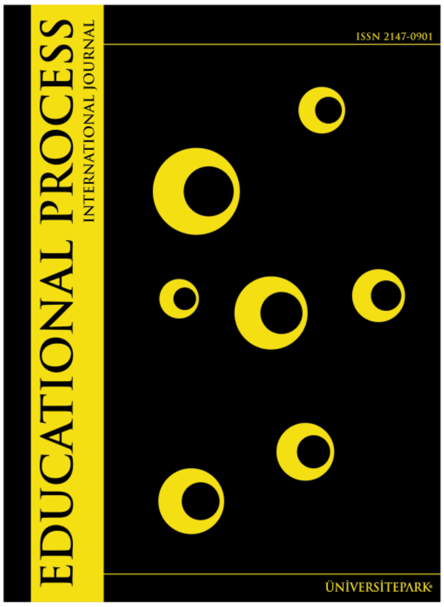

Educational Process: International Journal

ISSN: 2147-0901 | e-ISSN: 2564-8020 | www.edupij.com

Educational Process International Journal • Volume 6 • Issue 3 • 2017

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To cite this article: Kola, A. J. (2017). A Review of the Importance of Peer Instruction Argumentative Strategy (PIAS) in Science Learning. *Educational Process: International Journal, 6*(3), 42-55.

To link to this article: http://dx.doi.org/10.22521/edupij.2017.63.4

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EDUPIJ • Volume 6 • Issue 3 • 2017 • pp. 42–55.

A Review of the Importance of Peer Instruction Argumentative Strategy (PIAS) in Science Learning

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Abstract

The paper believes the method a teacher employed in science class for instruction makes students' learning difficult. A literature review of some common methods of teaching in science was done. The paper highlighted the conceptual framework of the Peer Instruction Argumentative Strategy (PIAS) and discussed the importance of PIAS to science learning. The paper recommended PIAS for science education classes based on its perceived advantages over the other teaching strategies.

Keywords: peer instruction, dialogical argumentation, authentic learning, coaching and scaffolding, constructivism.

DOI: 10.22521/edupij.2017.63.4

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EDUPIJ • ISSN 2147-0901 • e-ISSN 2564-8020

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Introduction

The erroneous belief that science is difficult and abstract may be due to the strategies teachers employ during classroom instruction. There are many methods used to teach science and the effectiveness of these teaching methods depend on the teacher's ability to master it. There are research-based strategies that engage students in a collaborative learning that are in vogue in developed countries today. These methods focus more on students' activities than the teachers simply supplying students with information. Students of today's generation need a classroom full of activities that support learning through social interaction. Learning is a social and collaborative activity where people create meaning through their interactions with one another (Schreiber & Valle, 2013). According to Kim (2001), individuals create meaning through their interactions with each other and with the environment where they live. The author argued that meaningful learning could only take place when students are engaged in social activities. Therefore, whatever type of method the teacher employs must be the one that promotes learning through social interaction and makes students critical thinkers. Students develop their thinking ability when they interact and make choices among different options.

The educational system, it is not only content information that is important but also the development of skills for thinking critically. Similarly, Flores, Matkin, Burbach, Quinn, and Harding (2012) support the shifting of education from teaching content to teaching students how to become critical thinkers. Today, it should be the concern of every teacher to develop the critical thinking skill of every student. Gone are the days when the teacher gives out any information to students to assimilate without properly examining the correctness of such information. Any method of instruction employed should allow the student to be able to identify relevant science tasks from the irrelevant. Students should be able to articulate their scientific understanding anywhere and at any time. To achieve this requires students with high critical thinking skills as observed by Al-Fadhli and Khalfan (2009) that educators are constantly emphasizing the importance of developing thinking skills that can be practiced in life experiences.

Unfortunately, many of the extant teaching strategies in science education cannot achieve the above but only promote rote learning. Given this, a literature review was performed of the common teaching methods in science, the conceptual framework and the importance of PIAS in science learning.

Literature Review: Commonly used Teaching Strategies in Science Education

Lecture-based Instruction relies on introducing new and complicated information to students in a familiar way. According to Gehlen-Baum and Weinberger (2014), the lecture method is an approach to delivering new information to a large group of students. The instructor must make extensive preparations in order to ensure that students learn maximally by employing different skills to interact with the information (Thomas & Israel, 2013). The preparation required by the instructor includes, but is not limited to, good lesson notes and preparing a classroom conducive for the lecture. Besides, it is expected that the instructor possesses both good language skills and motivational ability, else the class is likely to be considered boring since the teacher is the only one doing the talking in the lecture method. Students only sometimes ask the questions. Lecturing is a teacher-centered strategy. The method has been criticized for being a one-directional method of instruction that renders students passive (Gehlen-Baum & Weinberger, 2014). In the same vein, Afolabi, Izuagba, Obiefuna, and Ifegbo (2014) stated that the lecture method is teacher centered, which makes the student passive and learning superficial. According to Berry (2008), lecture-based instruction is efficient in the delivery of large amounts of information over a short timeframe, but lacks the effectiveness of an active learning method. Furthermore, the lecture method is frequently a one-way process unaccompanied by discussion, questioning or immediate practices; making it a poor teaching method (Hatim, 2001).

The lecture-based method concentrates on information rather than learners (Al-Rawi, 2013). In the lecture method, the teacher tells the students what to do instead of activating them to discover for themselves (Miles, 2015). The students in traditional lecture classes may learn enough to pass exams, but do not remember the topics for subsequent courses. Lectures are not sufficient for demonstrating practical skill but can be used to organize information and create interest in a subject (Hatim, 2001). Good lectures are capable of inspiring and motivating learning, yet some lectures make students bored, confused, anxious and frustrated.

Inquiry method is an active learning process employing problem solving and dialogue, as well as generating and answering higher order questions (Walker, Shore, & French, 2011). Inquiry is a method where the students are given tasks where they develop knowledge and understanding of scientific ideas by engaging in open-ended, student-centered, hands-on tasks and the teacher acts as a facilitator (Irinoye, Bamidele, Adetunji, & Awodele, 2015). Inquiry-based teaching includes practices that promote the learning of scientific concepts and processes, as well as “how scientists study the natural world” (Tatar, 2012, p. 248).

Inquiry learning has been described as enabling students to develop knowledge and skill in a successful learning experience. It has been observed that inquiry-based learning is essential for the development of critical thinking skills and developing the scientific contents (Apedoe, Walker, & Reeves, 2006). Similarly, Peffer, Beckler, Schunn, and Renken (2014) contended that inquiry is essential for the development of scientific reasoning skills. Inquiry method is a student-centered instruction. Inquiry in science includes asking questions, collecting evidence from a variety of sources, developing an explanation from the data, communicating the findings, and defending the conclusions (Hunter, 2014, p. 380).

The process of asking meaningful questions, finding information, drawing conclusions, and reflecting on possible solutions is known as inquiry (Milson, 2002). In inquiry learning, students are allowed to direct their investigative skills to complete all scientific processes like data gathering, analysis, hypothesizing, observation and experimenting (Keselman, 2003). According to Looi et al. (2011), in inquiry learning, learners are guided through a process of posting questions, gathering and assessing evidence, conducting experiments, and engaging in debate. This type of learning provides students with the opportunity to learn for themselves in a controlled environment where the teacher can help and guide the students (Schoffstall & Gaddis, 2007). Inquiry learning motivates students to learn. According to Löfgren, Schoultz, Hultman, and Björklund (2013), students are motivated to learn and develop positive attitudes towards science when participating in inquiry activities.

Inquiry instructions require that the students possess the needed skills before embarking on inquiry-based learning. If students lack the necessary skills, inquiry learning could, in fact, be counterproductive, leading to student frustration (Kuhn, Black, Keselman, & Kaplan, 2000, p. 496).

The *demonstration* is an elegant method of teaching because it improves the students' understanding and retention (McKee, Williamson, & Ruebush, 2007). In the demonstration method the teacher models whatever, he or she expects the learners to investigate at the end of the lesson (Daluba, 2013). The teacher shows them how to do it and explains the step-by-step process (Ameh, Daniel, & Akus, 2007; Chikuni, 2003). Mundi (2006) described it as a display or an exhibition usually done by the teacher as the learners watch with utmost attention. The technique is effective in teaching any skill through observation (Sola & Ojo, 2007). However, the time available to perform these demonstrations is continually not enough because it takes much instructional time. Therefore demonstrations are often designed to allow students to observe rather than enable them to participate in hands-on laboratory work (McKee et al., 2007).

Iline (2013) viewed demonstration as a direct means of explaining things to pupils. However, the author gave a caveat that it must be done in such a way to enable students to accurately copy the correct ways of doing things. This is important because the technique is based on the principle that we learn by "doing" (Sola & Ojo, 2007). It implies that when a teacher is not sure or does not have the expert understanding of the concept to be demonstrated, he or she should not be demonstrating it. The demonstration method emphasizes telling, explaining, and showing, with the main aim of preparing the learner for problem solving as a skill (Western Michigan University, 2006).

The demonstration is a teaching technique which provides a synthesis of formal lecture sessions and personalized systems of instruction (Maun & Winnitoy, 1980, p. 80). The demonstration method is a teaching technique that combines verbal explanation with "doing" to communicate processes, concepts, and facts (Sola & Ojo, 2007, p. 125). The demonstration is typically used to introduce a new skill to a whole group, but it can and should also apply to individuals or a small group whenever more support is needed for their learning (Owen, 2006, p. 11).

To make the technique effective, learners must actively participate in the learning process (Maun & Winnitoy, 1980). The demonstration method makes use of illustrations, visual aids, and the opportunity for questions, and demonstrations. The technique especially enables the class teacher/instructor to utilize activities which would be considered too dangerous for pupils themselves to perform within the usual classroom environment (Western Michigan University, 2006).

This technique affords the student the opportunity to come into direct contact with an instructor to clarify points missed in lectures (Maun & Winnitoy, 1980). Students can learn physical or mental skills when they perform those skills under supervision (Sola & Ojo, 2007).

Iline (2013) argues that the demonstration method gives pupils the opportunity to see and hear the details of what is being taught in order to become proficient themselves. Thus, the author recommends the method because it leaves nothing to chance. The demonstration is a method of teaching with both benefits and some disadvantages that should also be considered. The following are a few of the disadvantages:

- Teachers get into a pattern and overuse the strategy;
- The teacher decides what they want to "tell" the students rather than determining what students need to know;

- It is easier to prepare the daily lecture than it is to plan with the students and identify the kinds of learning experiences that will bring about the desired changes in insights and understanding (Western Michigan University, 2006, p. 4).

The project method is an in-depth investigation of a real-world topic worthy of a student's attention and effort (Chard, 2011). Project-based learning (PBL) is an instructional methodology in which students learn valuable skills by doing actual projects (Holubova, 2008). The project learning approach refers to teaching strategies that enable teachers to guide students through in-depth studies of real-world topics (Chard, 2011). In project learning students learn to take responsibility for their learning, this instruction helps the students to form a solid base through which they could work with others throughout their lifetime. This method places emphasis on building a comprehensive unit around an activity which may be carried out in or out of school (Pattnaik, Chakradeo, & Banerjee, 2014).

According to Knoll (1997), project learning is considered as a means by which students (a) develop independence and responsibility, and (b) practice social and democratic modes of behavior. Knoll stated that project learning was introduced to the curriculum in order to help students learn at school, to work independently and to combine theory with practice. The project method is a target-driven activity based on a challenge, fostering success and efficient cooperation during which the students' activity gains more weight than the communication of knowledge by the teacher (Szállassy, 2008, p. 49).

The project method is discussed under different headings such as project work, project approach, and project-based learning, and is considered one of the fundamental teaching methods. Project learning is an action-centered and student-directed learning and an enterprise in which students engage in practical problem solving for a given period. Projects, for example in Physics, may consist of the construction of a meter bridge, a ripple tank, designing a DC motor, or producing a video film of charges in motion. Many times, projects are initiated by the teacher while the planning and execution are entrusted to the students themselves, individually or in groups. Unlike the traditional methods, projects focus on applying, not imparting, specific knowledge or skills, and are more rigorous than lecture, demonstration, purposely for the enhancement of intrinsic motivation, independent thinking, self-esteem, and social responsibility (Knoll, 2014).

When teachers implement project learning successfully, their students feel highly motivated and actively involved in their learning, and this helps them produce high-quality work and to grow as individuals and collaborators (Chard, 2011). However, in project learning the knowledge is not acquired sequentially; also if not planned well and appropriately executed it may not be completed on time. These are some of the disadvantages of the project learning method as asserted by Pattnaik, Chakradeo, and Banerjee (2014).

Projects are used in education as a tool for teaching and as a means of achieving results and also used for acquiring various skills (Holzbaur, 2010). Holzbaur further argues that projects are a powerful method for teaching, training, and research in education. However, Holzbaur also said that there is much effort accompanied by academic and pedagogical challenges, which calls for a systematic approach to the planning and conducting of projects.

The role of the teacher in project learning should be a friend, guide, and working partner. The teacher should learn along with the students and should not claim to know everything (Pattnaik et al, 2014). If project learning is well planned and successfully executed, it has many benefits, some of which are promoting co-operative activity; arousing and maintaining the interest of students; and developing scientific attitudes.

Given the strength and the weaknesses of the various teaching strategies reviewed, more dynamic student-centered strategies are required. These are strategies that enhance collaborative dialog, articulation of understanding and where students control their learning, not the teachers or the curriculum.

Peer Instruction Argumentative Strategies (PIAS)

PIAS is a research-based teaching strategy developed by the researcher at a college of education in Nigeria to teach an introductory electromagnetism. PIAS is a hybrid of peer instruction and the dialogical argumentation. Peer instruction was developed by Eric Mazur of Harvard University to teach introductory Physics, and which has since been widely used in other subjects. Before discussing the potential of PIAS, the following is a review of peer instruction and dialogical argumentation.

Peer Instruction (PI)

As a research-based pedagogy, PI can be applied for the teaching of largescale introductory science courses (Fagen, 2003). It is a method created to help make lectures more interactive and to get students intellectually engaged with what is going on. It has been tested in many classes and found to be effective for improving students' performance and is also used to identify students' difficulty areas in many developed countries.

Peer Instruction is an instructional strategy for engaging students during class through a structured questioning process that involves every student (Crouch, Watkins, Fagen, & Mazur, 2007). PI provides a structured environment for students to voice their ideas and resolve misunderstandings by talking with their peers (Gok, 2012). Peer instruction is a cooperative learning technique that promotes critical thinking, problem solving, and decision-making skills (Rao & DiCarlo, 2000) and was designed to improve the learning process (Rosenberg, Lorenzo, & Mazur, 2006).

PI is more efficient at developing students' conceptual understanding than traditional lecture-based instruction (Lasry, Mazur, & Watkins, 2008). According to Crouch et al. (2007), PI increases student mastery of both conceptual reasoning and quantitative problem solving (Lasry et al., 2008). According to Gok (2012), PI encourages students to take responsibility for their learning and emphasizes understanding. It is not a rejection of the lecture format, but a supplement that can help engage students who have a range of learning styles (Rosenberg et al., 2006).

PI is grounded in the Constructivism theory which emphasizes the importance of prior experience as a springboard on which the construction of new knowledge stands. Both social and cognitive constructivism are relevant in PI. Students learn through social interaction as well as individual conceptions in the learning environment.

Dialogical Argumentation

Norris, Philips, and Osborne (2007) defined scientific argumentation as an attempt to validate or refute a claim by reasons in a manner that reflects the values of the scientific community. According to Bricker and Bell (2009), argumentation is a core epistemic practice of science. Therefore, the goal of science education must not only be to master the scientific concepts rather learning how to engage in scientific discourse. Science will be no different from any other subject if it depends only on how to master scientific concepts. Therefore, students must be able to engage in the scientific discourse. Scientific argumentation is grounded in the Constructive controversy theory. Constructive controversy exists when one person’s idea, conclusions, and opinions are not compatible with another person's ideas, conclusion and opinion, but the two seek to reach consensus on the solution to a problem or the course of action to take in given a situation (Johnson & Johnson, 2003). Constructive controversy should not be taken to be a debate or an individualistic approach to a controversial learning problem. It is a procedure for cooperative learning where individuals with different, incompatible views agree on the best position based on evidence and reasoning (Johnson & Johnson, 2007).

Abell, Anderson, and Chezem (2000) underscore the relevance of argumentation in science education because the goal of scientific inquiry is the generation and justification of knowledge claims, beliefs and actions taken to understand nature. It is therefore critical for the teachers to have a sound understanding of scientific argumentation. Teachers are required to give students more opportunities to craft scientific arguments and take part in discussions that require them to support and challenge claims based on evidence (Sampson, Enderle, & Grooms, 2013).

It is crucial to understand that scientific argumentation is different from a typical argument between people. In scientific argumentation, however, explanations are generated, verified, communicated, debated, and modified. The idea behind participating in scientific argumentation should be to hone and build consensus for scientific ideas, based on evidence (The Science Teacher, 2013). It has been widely approved that the concept of science as an argument and the view that engaging in scientific argumentation should play a vital role in science education (Kuhn, 2009).

Students working in groups, listening to each other and articulating their ideas are essential for argumentation to take place (Simon, Erduran, & Osborne, 2006). Engaging in scientific argumentation as part of teaching and learning makes students proficient in science. Proficiency requires every student to be able to articulate his or her scientific knowledge anywhere and at any time. The argumentation is significant in science learning as it helps the student to develop an improved understanding of the scientific nature.

Conceptual Framework

Students are at the center of learning in PIAS; whereas the teacher is only the coach and supports scaffolding. Figure 1 illustrates PIAS conceptually.

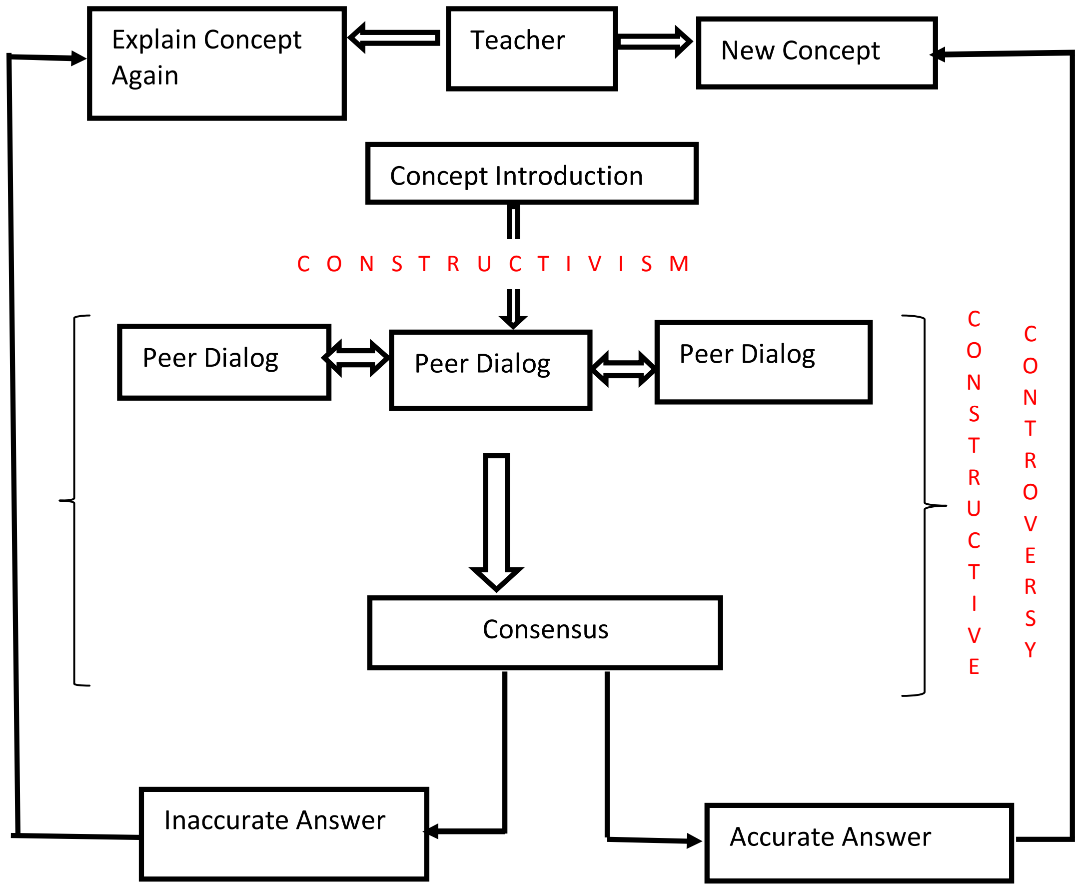

Figure 1. PIAS Model

The strategy begins with the teacher introducing the concept to be learned. The teacher will identify the important concepts in the topic to be discussed. The concepts are presented to the students in a question format with three or four multiple-choice answers. The answers should be constructed in such a way so that no answer is entirely wrong, but there should be one that most accurately interprets the concept.

The introduction is followed by peering the students, and if the class is large, they can be in a group of four or five. The number of students in a group should not be too many in order to avoid distraction and lack of concentration. The students in each peer or group are motivated to engage in a discourse to find the appropriate answer to the question posted by the teacher. The teacher can allow for consultation from one peer to another. The teacher needs to be very active and move around the class to ensure orderliness and full participation by all students. The students must be given time to get all the required information for an accurate answer. The teacher is not expected to meddle or interfere with the learning process, except to coach and scaffold.

After a specified period of argumentative discourse, the students come to a consensus with each peer or in each group. When the percentage of inaccurate answers are high for peers or groups, the teacher explains the concept to the whole class. Otherwise, when the percentage of accurate answer is high, the teacher summarizes and introduce a new concept, and the students follow the same procedure again.

It is important to understand that the students come into the class with some science knowledge because at the end of every lesson the teacher gives a reading assignment to the students. Students entering knowledge is paramount to science learning which a good teacher should take note of for a successful lesson and a student's personal interpretation of the world (Aina, 2017; Christie, 2005). It is this prior knowledge that formed the basis for the students' discourse in their group as they interact socially, thus the constructivism theory is applied. Students in peer or groups collaboratively dialog together through an argument with reasons and evidences in order to arrive at a consensus. The students would have different views about the concept under discussion, but harmonize their views so as to reach conclusions. Thus, the constructive controversy theory comes into play.

PIAS enhances students' understanding of science if the aforementioned procedure is followed. Based on research studies, PIAS has potential for science learning, which is discussed as follows.

Importance of PIAS in Science Learning

The teaching strategies employed for teaching science in most Nigerian schools had not provided students with what is known as an authentic learning experience. Most students learned by memorization and to recall for real-life application is a problem. Authentic learning is learning by doing. It is active learning, where students are not passive. It is an inquiry-based method of learning. This is a process of asking meaningful questions, finding information, drawing conclusions, and reflecting on possible solutions (Milson, 2002). According to Watters and Ginns (2000), any authentic learning environment should establish a sense of personal control over what and how the learner learns. Anderson and Anderson (2005) state that Authentic learning is built on participation, genuine interest, and interaction with more experienced people. *Authentic learning* focuses on connecting what students are taught in school to real-world issues, problems, and applications (Rule, 2006).

PIAS enhances the authentic learning experience in science because it promotes collaboration and articulation of understanding. The students' collaboration and articulation are two essential elements of authentic learning critical in PIAS.

Collaboration and the opportunity to collaboratively construct knowledge is an essential ingredient of authentic learning (Herrington, 1997). Collaboration allows students to "put their heads together" on problems, and to fully articulate their progress as they go about the task (Herrington & Kelvin, 2007, p. 9). Osborne, Simon, Christodoulou, Howell-Richardson, and Richardson (2013) made reference to the works of some social psychologists in that there is increasing empirical evidence that the knowledge and understanding of learners can be facilitated by collaborative dialog between peers. Collaboration is expressed in classrooms when students actively participate in discourses with each other as they attempt to make sense of their experiences and construct knowledge (Bell, Maeng, & Binns, 2013).

Students being able to verbalize what they have learned is consistent with Lave and Wenger (1991) views that being able to speak the vocabulary and tell the stories of a culture of practice is fundamental to learning. Articulation of ideas has been observed to be one of the discourse patterns in which students can potentially engage during scientific argumentation (Darner, Callis, & Wolf, 2013). Articulation provides students with an opportunity to speak and write about their growing understanding (Herrington, Reeves, & Oliver, 2010). Articulation enables the student to be able to make a public presentation to defend his or her position and ideas.

PIAS exposes misconceptions students had in science and gives students immediate feedback on their learning. Argumentation-based learning lowers the level of students' misconception (Sekerci & Canpolat, 2014). Garcia-Mila, Gilabert, Erduran, and Felton (2013) cited Cross, Taasoobshirazi, Hendricks, and Hickey (2008) that argumentation helps students to overcome misconceptions. Aina (2017a), in his recent study, confirmed that dialogical argumentation helped students to overcome misconception in current electricity.

PIAS promotes critical thinking skill of the students. The process of critical thinking involves, first, critical analysis of the information, then creatively considering the possible options, and finally constructing a new decision (Ramos, Dolipas, & Villamor, 2013). Exposure to dialogical argumentation can help learners to learn to think critically and independently about important issues and contested values (Sisebo & Ogunniyi, 2012). Helping students to learn through argumentation confirms the views of Aufschnaiter, Erduran, Osborne, and Simon (2008) in that students learn science while arguing. According to Acar (2015), argumentation-based learning enhances students' scientific reasoning. Learning science through argumentation is necessary to help students develop an improved their understanding of science.

Conclusion

Given the literature reviewed and the potential of PIAS, it is apparent that such a teaching strategy could enhance learning in science education. The collaboration and articulation as authentic learning elements are vital to learning because through these the problem of rote learning could be resolved. Additionally, it also makes students very active during learning. Moreover, based on the success recorded by the researcher when the strategy was used in a college of education in 2016, and the reviewed importance, PIAS is recommended for science education.

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