Directions:

Journal of Educational Studies

Volume 32, No. 1, 2017

School of Education

The University of the South Pacific

Experiential Learning and Climate Change Education: Effect of Predict-Observe-Explain Strategy on Pre-Service Teachers' Understanding of Sea Level Rise

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Abstract

This action research study examined the effectiveness of experiential learning on the understanding of climate change concepts. A Predict-Observe-Explain strategy was used to allow students to actively explore the reasons for sea level rise through teacher-guided experiments. The study employed a two-phase embedded experimental model within the framework of a mixed method design. The study sample was purposive and included all the participants of a 'Coping with Climate Change' workshop organized for the third-year pre-service teachers enrolled in the Bachelor of Education Primary program at the Fiji National University. The study findings indicate that the use of Predict-Observe-Explain strategy was useful in addressing pre-service teachers' misconceptions on the reasons for sea level rise. Study results also show that experiential learning promotes enjoyment and insight about the execution of teaching techniques in a classroom context.

Keywords: Climate change, Conceptual change, Experiential learning, Predict-Observe-Explain, Sea level Rise

Background and Introduction

Climate change education is gaining momentum in the Pacific Island Countries, including Fiji, given the vulnerability due to their small isolated nature, food insecurity and limited basic services (Pelling & Uitto, 2001). A majority of the Pacific's population live in coastal areas which makes them susceptible to the impacts of sea level rise, storm surges and cyclones (Vize, 2012).

Formal, informal and non-formal education is seen as an important way to develop within the present and future generation the skills of mitigation, adaptation and resilience to climate change. The United Nations Educational, Scientific and Cultural Organization (UNESCO, 2011, p. 221) succinctly puts in their Education for all (EFA) Global monitoring report that:

> *Introducing education on climate change… through formal schooling…can and should play an active role in stimulating the next generation to demand, generate, interpret and apply information on current and future climate changes, and also help in bolstering people's abilities to cope with the challenges of global warming as well as build adaptive capacity.*

Primary level education is perceived as an important beginning for climate change education as all the Pacific Island Countries (except Papua New Guinea and Solomon Islands) have approximately 90% primary school enrolment rates (UNESCO, 2011) which would make this knowledge accessible to a large population.

The Republic of Fiji National Climate Change Policy (Fiji, 2012) was developed to address the issue of climate change awareness in all sectors in Fiji . Its policy objective four focuses on education and training, including the integration of climate change in school curricula, tertiary courses, and vocational, non-formal education and training programmes. The document identifies two critical strategies among others relevant to the achievement of the above objective. These strategies are as follows:

> *1. Review and update the current primary and secondary curricula, and the tertiary and vocational education courses to ensure inclusion of local, accurate and current climate change information, and to encourage student research around the issue of climate change.*
>
> *1.1 The Curriculum Development Unit to assess and review teaching materials on climate change regularly, given the dynamic nature of climate change science, research and international progress.*
>
> *2. Develop appropriate educational materials and learning tools on climate change for students with special needs in early intervention programmes, in special and mainstream primary and secondary schools, and in tertiary institutions.*
>
> *(Fiji, 2012, p. 23)*

Since the implementation of the National Climate Change Policy in Fiji, the Fiji Ministry of Education, Heritage and Arts has strengthened the presence of climate change and disaster risk management within the primary and secondary curriculum. Since then, several training workshops for teacher educators from all the Universities and teacher training colleges in Fiji have been conducted to best integrate climate change, climate change adaptation and disaster risk management aspects into teacher education curriculum (SPC & GIZ, 2015).

The integration of climate change education demands that pre-service teachers have adequate content knowledge and the knowledge and use of appropriate pedagogical skills to help develop conceptual understanding in learners about climate change, climate change adaptation and disaster risk reduction. Prior research (Council, 2000; Martin, 2009; Schibeci & Hickey, 2000) demonstrates that good content knowledge is necessary, however, is not the only quality of an effective teacher. These authors further assert that both content and pedagogical knowledge are important if what teachers teach is to be understood well by the learners through their own construction.

However, educating and communicating about climate change is challenging, as climate change concepts are complex and subject to unexpected feedback. Cognitive constraints are seen to be the biggest obstacles working against the adoption of mitigation and adaptation behaviours (Pruneau, Khattabi & Demers, 2008). This may imply that if teachers do not have correct subject matter knowledge about climate change phenomena and pedagogical skills, they may experience internal cognitive constraints which would then translate into their teaching and then to the learners.

This paper therefore presents the findings of an action research project concerning the effectiveness of experiential learning on pre-service teachers' content knowledge about the reasons for the climate change topic of sea level rise.

Conceptual and Theoretical Framework

This study is underpinned by the constructivist view of learning. The concept of experiential learning and the conceptual change model both served as a foundation upon which the study was grounded conceptually and theoretically.

Experiential Learning

Experiential education is a philosophy of education, described as '… a process through which a learner constructs knowledge, skill and value from direct experience,' (AEE, 1991, p. 1). Experiential learning, defined in the words of Lewis and Williams (1994, p. 5) is:

> *…learning from experience or learning by doing. Experiential education first immerses learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking.*

In the same vein, Chapman, McPhee, & Proudman (1995) define it simply as active learning that may be field based or classroom based. They caution, however, that all active learning activities may not be considered experiential learning. They postulate a list of characteristics that determine the effectiveness of activities in providing experiential learning. All experiential learning activities must include and expose learners to: a mixture of content and process, absence of excessive judgment, engagement in purposeful endeavors; encouraging the big picture perspective, the role of reflection, creating emotional investment, the re-examination of values, the presence of meaningful relationships, and learning outside one's perceived comfort zones (Chapman, et al., 1995, p. 243). It could be argued that learning must involve pre-service teachers in activities that are 'hands-on', 'minds-on' (Llewellyn, 2002) and 'hearts on' to promote learning with understanding.

Facilitating learning through experience should be the goal of higher education. Kolb (1984), Knowles (1978) and others (Giddens, 1991; Heneveld, 1988; Schofield & Caragata, 1999) posit that adults learn best when engaged in individual–centered, multisensory, experiential, and collaborative lessons. Teaching through experiential learning to pre-service teachers is considered most effective in training pre-service teachers (Schwartz, 2014). Fink (2003) asserts that the quality of higher education can only be improved if one can identify ways and create learning experiences that pre-service teachers and others consider to be truly significant. This could occur in a myriad of ways, including intellectual development, cross–cultural development, career exploration, and personal growth (NSEE, 2007).

In order to develop pre-service teachers who will use experiential learning in their practice, pre-service teachers need to experience experiential learning themselves. Schwartz (2014) and Darling-Hammond (2000) argue that the most effective method of training instructors to use experiential learning in the classroom is itself, experientially. This research therefore attempts to employ this principle with the pre-service teachers who were participants of the 'Coping with Climate Change' workshop in order to develop in tandem their content and pedagogical knowledge necessary to teach about sea level rise (Abell, Rogers, Hanuscin, Lee, & Gagnon, 2009).

Predict-Observe-Explain (POE)

This research employed the Predict-Observe-Explain (POE) as a form of experiential learning in order to investigate the effectiveness of the POE strategy as one form of experiential learning that could help pre-service teachers in understanding and teaching about sea level rise. POE is a learning and teaching sequence developed by White and Gunstone (1992) and was initially used by them to unravel pre-service teachers' understanding of science concepts. It has been widely used with student groups for development of conceptual understanding (Haysom & Bowen, 2010; Mthembu & George, 2001).

Moreover, POE is a teaching strategy that probes understanding by requiring learners to carry out three tasks. First, learners must predict the outcome of some event and justify their prediction (P: Predict). Then they describe what they see happen (O: Observe), and finally they must reconcile any conflict between prediction and observation (E: Explain) (Mthembu & George, 2001, p. 1). The POE therefore involves the following steps: 1. Orientation and motivation; 2. Introducing the experiment; 3. Prediction: the elicitation of Student's Ideas; 4. Discussing their predictions; 5. Observation; and 6. Explanation (Haysom & Bowen, 2010). This study followed the same sequence in the implementation of the POE activities. Research studies, which used POE with secondary and primary science children to probe children's understanding of science concepts, have been widely reported (Kearney, Treagust, Yeo, & Zadnik, 2001; Liew & Treagust, 1998; Tao & Gunstone, 1997; White & Gunstone, 1992). Palmer (1995) and Coştu, Ayas, and Niaz (2010) have used the POE strategy with pre-service teachers. It is suggested by these researchers that POE is an effective teaching and learning sequence (Liew & Treagust, 1998; Mthembu & George, 2001; White & Gunstone, 1992). In addition, Haysom and Bowen (2010) have suggested that POE technique has dual benefit in the learning and teaching process: this technique not only helps pre-service teachers to develop conceptual understanding, but is also a useful assessment tool for pre-service teachers/instructors to diagnose and address a learner's misconceptions.

Discussions also play an important role in the prediction, and especially in the explanation phase of POE (White & Gunstone, 1992) as learners tend to reconcile their prior knowledge with the observation. This is consistent with the constructivist epistemology. In essence, constructivism–oriented teaching believes that learners learn science through active involvement in the learning process (Duit, 2004; Martin, 2009). Doing experiments, participating in activities, and engaging in group discussions provide classroom-based experiential learning that allows learners to bring to the learning arena their prior knowledge, upon which, subsequent learning events rely for conceptual change to take place (Piaget, 1985).

Constructivist–oriented teaching and learning therefore aims to help learners construct their own scientific knowledge and build up their schema. It involves students' own activity, and the guidance, mediation or intervention of the teacher (Duit, 1999). As such, learning becomes a personal as well as a social process, and social constructivism embraces this process well (Vygotsky, 1978).

Moreover, verbal communication among learners and adults is a powerful force to help students acquire conceptual knowledge. The role of the teacher is important in creating a platform where learners bring their prior knowledge to deliberate amongst each other and with the teacher in the zone of proximal development to bring about conceptual change. The learner's prior knowledge strongly influences the nature of communication that would take place in the zone of proximal development (Llewellyn, 2002). POE is an important teaching activity that creates an atmosphere that fosters discussion and diversity of views (Coştu, et al., 2010). Learners' science background, amongst other factors, is equally significant in the development of conceptual understanding, however this falls beyond the purview of this study.

Conceptual Change Model

Conceptual change model (Kuhn, 1970; Lakatos, 1970; Piaget, 1985; Posner, Strike, Hewson, & Gertzog, 1982) places learners in an environment where they are encouraged to confront their own preconceptions, as well as of their peers, and then work towards developing and reconciling ideas through conceptual change. POE teaching strategy starts by eliciting learners' prior conceptions, followed by learners' re- examining their ideas in their groups and during whole class discussions. The sequence ends with attempts to resolve the contradictions between prior knowledge and the observation. As such, it is asserted that the use of POE would lead to conceptual change and conceptual understanding (Kolari & Savander-Ranne, 2003) by creating cognitive conflicts.

A plethora of science education research studies have focused on identifying and addressing pre-service teachers' misconceptions on a variety of subject matters (Duit, 2009). The area of research for this study however, is new by virtue of the topic, as climate change education has gained momentum only recently. Other studies (Gautier & Rebich, 2005; Rebich & Gautier, 2005) have explored misconceptions of learners and the general public concerning the phenomenon of global warming, ozone depletion and greenhouse effect. These studies affirmed that learner-centred instructional approach enabled leaners to overcome their misconceptions.

The purpose of this study was to investigate the effectiveness of experiential learning, specifically the use of POE strategy, in facilitating conceptual change amongst pre-service teachers concerning the reasons for sea level rise. All participants were part of the 'Coping with Climate Change' workshop. The following research questions guided the study:

1. Does the POE strategy help pre-service teachers to correct their alternate conceptions of the reasons for sea level rise?
2. How do pre-service teachers perceive the use of POE technique as a teaching strategy?

Methodology

Action research was the chosen methodological approach because it makes way for instructors to translate values into practice, and gives voice to those values (Cipora, 2008). Action research has proven to be a powerful protocol for enhancing best-practices pedagogy and for guiding reflective practitioners in becoming effective change agents. Through action–reflection activity, the embodied values become clear as they emerge through inquiry (McNiff & Whitehead, 2005, p. 23). The use of POE suits action research well as it involves action–reflection activity cycles.

Cipora (2008) has used action research to investigate misconceptions and test the effectiveness of teaching strategies in science inquiry learning. Several climate change education research studies have used action research in providing experiential learning to develop conceptual understanding on phenomenon such as greenhouse effect (Duenkel & Pratt, 2013; O'Connor, Greene, & Anderson, 2006; Pruneau, et al., 2008).

Research Design

Action research falls predominantly within the realm of qualitative research (McNiff & Whitehead, 2005), this study however, employed a mixed method design. The basis for employing a mixed method design is well documented in the research methodology literature (Creswell, 2008; Davis, Smithey & Petish, 2004), Including the fact that this method expands the scope or breadth of research to offset the weaknesses of either approach alone (Zembal-Saul, 2009, p. 19). A two-phased embedded experimental model in the mixed method design (Creswell, 2008) was suitable to answer the different research questions of this study.

To answer research question 1. *Does the POE strategy help pre-service teachers to correct their alternate conceptions of the reasons for sea level rise?* data was collected and analyzed in three steps: 1) Pre-testing of pre-service teachers' conceptions on the reasons for sea level rise (qualitative); 2) An intervention (POE activities to address misconceptions; qualitative + quantitative); 3) Post-test of pre-service teachers' conceptions of the reasons for sea level rise (qualitative), and; 4) Reflection on the intervention strategy (qualitative + quantitative) to answer research question 2. *How do pre-service teachers perceive the use of POE technique as a teaching strategy*?

The study embedded the quantitative data collection and analysis techniques within a qualitative data collection and analysis framework, which is common to a mixed method design (Creswell, 2008).

The study employed quantitative and qualitative methods concurrently to collect data specifically to answer research question 2. An open ended and unlimited comment field was explicitly linked to the structured response question set immediately preceding it in the form of instruction: 'explain your choice above'. According to Driscoll, Appiah-Yeboah, Salib, and Rupert (2007) and Zembal-Saul (2009) this data collection strategy has several advantages for mixed-methods applications, such as it provides an overt link to the responses of the preceding question. This technique is also 'fairly intuitive' for the participants' (Zembal-Saul, 2009, p. 21). As such, the structured question is augmented by the participants' responses to a linked unstructured question.

Study Instruments

This study collected and analyzed three forms of data:

1. Open-ended written record of participant's prior knowledge and voice recordings of informal interviews;
2. Completed POE task sheets and voice recordings of in-class group discussions; and
3. Written responses to reflection questions.

Instrument use and analysis is explained in detail below.

Firstly, to assess participants' prior knowledge, an initial engagement activity was conducted to elicit discussions on the participants' explanations for what they thought were the reasons for the rise in sea level due to global warming. Participants recorded their thoughts in writing. The researcher informally and randomly interviewed, and voice recorded participants' views to clarify ideas as they individually worked on their reasoning. A qualitative data analysis technique was used at this stage.

Secondly, a POE worksheet was developed, and the participants were divided into eight working groups. The POE activity and worksheet was completed in groups for three sets of activities designed to develop participants' understanding of the reasons for sea level rise. The analysis technique employed here was the merging of qualitative data with quantitative data to add meaning to participants' developing concepts.

Thirdly, after the completion of the POE task, students were given readings on how increasing temperature affected the different geological environments on earth. After this, students completed a set of reflection questions individually (open ended and extended response type questions) aimed at finding out whether participants could relate the concepts from the POE activities to the reasons for rise in sea level and their perception of the use of POE as a pedagogical tool. The reflection activity had the following three questions:

1. What do you think will have a greater effect in your lifetime on sea level? Melting land-based ice, melting floating ice or thermal expansion of the ocean. Explain your choice.
2. Are there any questions that you would like to ask in order to learn more about issues related to sea level rise?
3. How would you rate the POE technique in helping you understand the reasons for sea level rise? (This question used a Likert-type rated response choice of very useful, useful, somewhat useful, and not useful). Explain your choice.

In must be noted that the POE activities had intentionally not used proper science apparatus, in order to model to participants, who later would be classroom practitioners, that locally available resources can be readily used to conduct hands-on activities in primary science lessons. The activities are described below.

The Intervention: POE Activities

Participants partook in three instructor-mediated hands-on activities to investigate the reasons for sea level rise. Research (Davies, 2014; Joughin & Alley, 2011; Lythe, Vaughan, & Consortium, 2001; Ollier, 2010) reveals that misconceptions exist about the reason for sea level rise. The most common misconception is that melting icebergs cause sea level to rise when in fact the melting land-based ice (such as glaciers) and thermal expansion of the oceans is causing the sea level to rise. These misunderstandings may create a cognitive conflict (Pruneau, et al., 2008) which may impede a learner's adaptation and mitigation skills in the Pacific.

Based on the above research data on reasons for sea level rise, the following activities, drawn from the text, *Learning about Climate Change the Pacific Way: A Guide for Pacific Pre-service teachers –Fiji* (Lebars & Sabass, 2013) were implemented:

Activity 1: Investigating the effect of melting floating ice on sea level

The investigation method:

1. Filled a plastic glass with water.
2. Added 5-6 ice cubes in the glass until the water overflowed.
3. Dried the side of the container after the water was spilled over.
4. Observed the water level in the glass as the ice melted.

(Lebars & Sabass, 2013, p. 18)

Activity 2: Investigating the effect of melting land-based ice on sea level

The investigation method:

1. Filled a baking tray with water.
2. Placed a rock in the middle of the tray to represent land/mountain. Marked the water level in the tray.
3. Placed large block of ice on the Rock (the ice represented the ice sheet such as the one that covers the Antarctica).
4. Observed the water level in the baking tray as the ice melted.

(Lebars & Sabass, 2013, p. 19)

Activity 3: Investigating the effect of heat on sea level

The investigation method:

1. Took of the stopper or lid of a juice bottle and made a small hole in it.
2. Put a straw through the hole and sealed the hole carefully, underneath and on top with a small amount of Blu-Tack.
3. Filled the flask almost to the brim with water and added a few drops of colouring to it.
4. Put the stopper/ lid, tightly closed the bottle and sealed it carefully with Blu-Tack.
5. Placed the sealed bottle in the sun for 2 hours and observed.

(Lebars & Sabass, 2013, p. 18)

For each of the activities above, participants had to complete a POE task sheet in their groups. Participants were instructed about the three activities and were asked to complete the prediction with their reasoning components for each of the three activities before commencing with the activities, one after the other. After every activity, participants were given time to complete their POE task sheet. During the explanation phase, when the participants were reconciling their predictions with their observations, they were encouraged to analyze, compare, contrast, and criticize fellow group member's views. The researcher made observations and interacted with the groups during this phase.

As participants were engrossed in dialogue during the predict and explain phase of the POE, the researcher voice recorded in-class discussions. Where necessary, the researcher asked probing questions to clarify thoughts, however, always keeping in mind not to divulge the answers, but lead the participants to the accepted idea.

Sampling

For this study, the researcher considered it methodologically sound to target a specific group – in this case, the participants of the 'Coping with Climate Change' workshop fully funded and supported by SPC/GIZ Coping with Climate Change in the Pacific Island Region (CCCPIR) Program. The participants were comprised of 52 primary pre-service teachers who were final year students enrolled in the Bachelor of Education (Primary) program at the Fiji National University, Lautoka Campus. As such, the sampling was purposive. All participants of the workshop were included in the study to contribute uniquely towards the study findings. This sampling technique is very suitable to qualitative studies such as this study which dominantly employs qualitative data collection and analysis techniques within the framework of a mixed method design (Davis, et al., 2004).

Ethics

In accord with the usual protocols for research ethics, the participants were informed about the researcher's intent to conduct a research during the workshop activities and sought written consent to their inclusion in the study and confirmed their willingness to participate. Assurance was given that the data collected were only for the purpose of research, and participants' confidentiality and anonymity were fully protected (Bogdan & Biklen, 2003). They were also told that they could refuse to participate at any point during the research and could even decline to respond to any question with which they felt uncomfortable.

In addition, since the workshop was fully funded and co–facilitated by SPC/GIZ CCCPIR, approval was sought for conducting this study during the workshop. It must be noted that the researcher, among others, was a key facilitator for the workshop.

Moreover, participation in the workshop was voluntary and was not a component of the participants' academic requirement as a student enrolled in the Bachelor of Education (Primary) program at the University.

Significance of the Study

This study was important for several reasons.

Firstly, it provided a platform to unveil participants' preconceptions on the causes of sea level rise. Recognition of learner preconception is well supported in the literature for effective science learning and teaching, which recommends a constructivist view of learning where science lessons begin by acknowledging prior knowledge of learners (Duit & Treagust, 2003; Skamp, 2004).

Secondly, since Fiji, like many other Pacific Island Countries is vulnerable to climate change, and most affected by sea level rise, this study addressed misconceptions the participants had on the reasons for sea level rise. As a result, it is anticipated that the participants will become sensitive to the issues of climate change, and in their capacity as future classroom teachers be curious to learn more about climate change. Capacity building of teachers is an objective in Republic of Fiji National Climate Change Policy (Fiji, 2012).

Thirdly, this study provided an opportunity for the researcher, who is a primary science educator, the opportunity to implement and reflect on the experiential learning in the form of POE strategy. Since the purpose of action research is to improve practice, the lessons learnt from the implementation of the POE activities could be purposefully used to reconsider and revise content and pedagogical approaches to science education currently practiced at the university.

Findings and Discussions

Initial activity – Participants' prior knowledge and explanation for the reasons for sea level rise

The result from the pre-service teachers' open ended written responses to the initial engagement activity revealed that all the participants identified melting icebergs and/or ice caps or glaciers as the prime cause of sea level rise. Random informal interview of 30 participants showed that most participants simply used the terms icebergs and or ice caps and or glaciers synonymously. As one participant explained:

> P1: Icebergs, ice caps and glaciers are ice that is found in the North and South Pole which is melting due to global warming.
>
> P2: Glaciers are glassy ice, and ice caps and icebergs are same… they are found in the sea.
>
> P3: They are ice that floats on frozen sea.
>
> P4: Glaciers are found on the mountains.
>
> P5: Ice caps are icebergs in the oceans near the poles.

The participants innocently thought that glaciers, icebergs, and icecaps were frozen water and location of the ice did not make a difference as long as it was in the Polar Regions and was melting due to heat. During class discussion and rounding up of the initial engagement activity, all participants affirmed that the earth is heating up due to global warming. As a result, this excess heat is absorbed by the ice causing it to melt. It must be noted that none of the participants related the cause of sea level rise to thermal expansion which contradicted their predictions for activity three on investigating the effect of heat on sea level.

Analysis of the POE Tasks

Activity 1 -Investigating the effect of melting floating ice on sea level

Prediction:

87.5% of the sample groups (n=7) predicted that water will flow out of the cup, while 12.5% (n=1) predicted that water level will go down. The common reasons for the prediction are summarized in Table 1.

Table 1

	Water level will rise/Water will flow out of the cup	Water level will go down
Predictions	87.5%(n=7)	12.5% 9 (n=1)
Reasons for Prediction	-ice will melt and change to liquid -will add to the water in the glass	when water is in solid form it takes more space than in liquid form
Explanation and reconciling	-the ice melted but did not overflow because melting ice covers up the space that was taken up by the frozen ice (75%; n=6) -*when water is in liquid form there are spaces within it and when the ice melts, the water particles from it move into the space in the liquid water, therefore it accumulates with in the cup and does not overflow (12.5%; n=1)	Amount of space taken by the ice is equal/less than to when it liquefies (12.5% n=1)

It was interesting to note that all participants were unaware of the concept of displacement. This is a common misconception in science where pre-service teachers appear to ignore the amount of space taken up by objects when immersed in a volume of liquid, as reported elsewhere (Allen, 2014; Duenkel & Pratt, 2013).

The group that had predicted that the water level would go down, however, gave reason for their explanation that was quite sensible and showed evidence of scientific thinking. This group, through informal interview explained their reasoning:

> G1: When ice freezes, its volume increases, so when it melts it will occupy less space in liquid form, so the volume should decrease.

These responses from participants is evidence that POE encourages learners to acknowledge their prior knowledge and think scientifically, thus actively engaging pre-service teachers mentally and physically in the learning process (Duit, 2004; Martin, 2009; Posner et al., 1982).

Observation:

The pre-service teachers were surprised to observe that the ice that was floating in the cup that was full to the brim with water did not overflow as it melted. They observed the glass until all the ice had melted to believe the result. There was an air of excitement as pre-service teachers were in a state of disequilibrium (Posner, et al., 1982).

As was expected, this initiated a lot of in class discussions as it contradicted their predictions. Many groups sought confirmation from the workshop facilitators about the accuracy of their observation. This action of participants clearly portrays that preconceptions are passionately held by learners and often resistant to change (Duit & Treagust, 2003; Skamp, 2004).

Explanation:

In this stage, participants appeared compelled, intrinsically, to discuss and look for plausible explanations of the observations made. This is arguably what Posner, et al. (1982) described in the third stage of the conceptual change model - learner's re-examine their ideas. Cognitive conflict appeared to excite the participants to engage in dialogue (Kolari & Savander-Ranne, 2003), and this was an important phase for conceptual change to occur.

Table 1 above summarizes the common explanations negotiated by the group. The table shows that 12.5% (n=1) of the sample had misconceptions on particle theory of liquids and could not recognize the concept of displacement. They assumed that when the ice melts it fitted itself in between the particles of liquid water. However, 75% of the groups (n=6) were able to correctly explain the concept of displacement while another 12.5% (n=1) appeared to develop a partially correct notion of displacement. They could not recognize that the ice does not displace all its volume in water as part of it is still above water.

The explanations phase made implicit ideas explicit. For conceptual change to occur, students' ideas and thoughts regarding their observation in relation to their prediction is critical. POE provides the platform to consciously think about their own ideas. As participants were engaged in dialogue during this phase, looking for plausible explanations for their contradictory observation, it unearthed other misconceptions held by participants' such as in the particle theory of matter. This type of information is very useful to teachers when planning to teach, indicating the usefulness of the POE strategy.

Activity 2: Investigating the effect of melting land-based ice on sea level

Prediction:

100% of the sample groups (n=8) predicted that water level in the tray would increase. The groups were absolutely sure that water level will increase.

Reason for Prediction:

All the groups' reasonings were common. They all reasoned that the ice, when it melted from the land, would add extra water into the tray. Given below is a response from one of the groups:

> G1: melting ice from the land as it melts and flows adds extra water to the tray.

Observation:

The water level in the tray had increased after the ice had melted.

Explanation:

The explanation for the observation was simple as the observation did not create any conflict between the participants' prior knowledge. Some of the explanations are as follows:

> G1: The water was excess and was on land that flows into the sea. So it adds to the volume of water in the ocean.
>
> G2: The melted ice from the land drains into the sea. This causes sea level to rise because melted ice from land is added to the sea level already present.

At this point the researcher gave additional reading on icebergs and glaciers to clarify and confirm to participants the reason why melting icebergs do not cause a rise in sea level whilst melting glaciers and land-based ice sheets do.

Activity 3: Investigating the effect of heat on sea level

Before introducing this activity, the researcher had shown statistical information on how the different surfaces of the earth absorbed heat due to global warming. The data showed that the ocean absorbed about 93.4% of all the heat trapped in the earth's atmosphere (Cook, 2011). Having done that, it set a platform for investigation and discussion on how water behaved due to heat absorption.

Prediction:

37.5% of the sample groups (n=3) predicted that the sun will absorb water through the tube/ the water will evaporate. While surprisingly 62.5% of the sample groups (n=5) indicated that the water level will increase and or the water will climb up the tube. This prediction was correct, but it contradicted participant's lack of association of thermal expansion to reason for sea level rise from the initial engagement activity.

Reason for Prediction:

Although most groups had made correct predictions, the same was not true for their reasons. Many groups (n=3) associated the increase in volume to particle expansion due to heat. Misconceptions associated with the notion of particle expansion are shown in the expressions below:

> G1: when particles of water get hot they expand….
>
> G2: the particles become bigger…so take up more space.

This shows, yet again, misconception on the particle theory of matter. Several studies on understanding of particle theory indicate this to be a common misconception amongst learners (Niess, 2011; Perkins, 1993).

Through informal discussion it was noted that participants were familiar with this activity. As succinctly articulated by many participants as a reason for their correct prediction:

> P1: Oh… I know it because we did this experiment in primary school…

This is an indication that hands-on activities done in school lack meaningful connections to real life experiences. Implying that participants' prior experiences in science education in primary schools did not link 'hands-on' with the 'minds-on'. Scientific investigations must relate to real life context for meaningful learning to take place. Although, most participants recalled the activity and its result, which they used to make their prediction, the underlying concept of the observed result was not understood. Hence, distinguishing learning with understanding from learning without understanding. In this case, implying that 'hands-on' activities alone are a not a guarantee that learning with understanding will take place. Instead, mental engagement in the form of predictions, explanation, and discussion along with hands-on activities provide a stimulating environment in which learners acquire knowledge.

Observation:

The water rose up the straw when kept in the sun for two hours.

Explanation:

All the groups (n=8) explained that sunlight made water particles gain heat energy, thus it expanded. The use of particle theory of matter was evident in the student's explanations albeit the notion of expansion of particle was contradictory. The researcher noted this but did not see it appropriate to address the misconception just yet.

The POE activity made the participants think critically when predictions did not match observation. For instance, the group that had earlier predicted that water level will go down, ruled out the possibility of evaporation after a critical reflection of the way the bottle was sealed to prevent water evaporation. The disequilibrium that predict and observe stage creates in the POE is very useful in mental and physical engagement of learners.

Reflection Activity

Reflection from the learning experience was important to gauge the effectiveness of the POE on participants' understanding of sea level rise. The result of the reflection is discussed below.

Question 1

What do you think will have a greater effect in your lifetime on sea level? Melting land-based ice, melting floating ice or thermal expansion of the ocean.

The result showed that 22.5 % indicated both melting land based ice and thermal expansion of the ocean affected sea level, 32.5% indicated that melting land based ice will contribute greatly to sea level, whilst, 45% attributed thermal expansion as having the greatest effect on the sea level.

Interestingly, none of the participants indicated that melting floating ice in the ocean was a contributor to sea level rise. This indicated that participants were able to correct their misconception about the reasons for sea level rise. In activity one, all participants were sure that melting floating ice (icebergs) was responsible for rise in sea level, but in this reflection exercise none of the participants indicated melting icebergs to have an effect on sea level. This shows that conceptual change has occurred.

Question 2

Are there any questions that you would like to ask in order to learn more about issues related to sea level rise?

The open-ended nature of the item brought about many questions worthy of further investigation. Many participants (80%) responded to this question. This response rate suggests that the experiential learning had encouraged inquisitiveness and eagerness to learn more about related climate change concepts. Some interesting questions such as the following were asked:

P1: Are the glaciers different from Greenland ice sheet?

P2: Why are the countries in the Pacific mostly affected by sea level rise… such as Kiribati?

P3: Is sea level rise affecting Fiji….which places?

P4: Does thermal expansion harm sea creatures?

P5: Doesn't greenhouse effect cause sea level rise?

P6: What about ozone depletion…does it have any effect on the sea level rise?

These questions reflect the effectiveness of the use of POE activities on participants' personal learning. The nature of questions asked reflects elements of critical thinking and inquisitiveness to learn more. These characteristics in learners develop only when learning with understanding has taken place. This indicates that conceptual change about the reasons for sea level rise had taken place, hence the desire to learn more. The questions posed by participants would encourage further inquiry.

Question 3

This question focused on participants' perception on the use of POE to investigate their understanding of sea level rise.

Question 3a

How would you rate the POE technique in helping you understand the reasons for sea level rise?

All the participants found the use of POE very useful. Since POE employs a 'hands-on' and 'minds-on' approach to learning, it was aesthetically appealing as indicated in their extended responses.

Question 3b

Explain your choice above.

In their justification to the opinion of the POE technique, some common responses from participants were:

P1: It was interesting and simple to do.

P2: It showed me my misconception… relates to the principles of constructivism…

P3: Its hands-on….and organized.

P4: I will use it in my teaching when I get posted.

P5: I learnt science through active learning; POE is cool way of learning…

P6: POE is so easy to use…children will find it interesting too.

P7: There is a lot of group talk and thinking…

P8: … not only is it engaging…it also promotes further inquiry.

These comments indicate that mental stimulation through organized hands-on activities were appreciated by pre-service teachers. Through their experiences they understood how the POE can be executed with children. This is the aim of experiential learning: giving pre-service teachers experiences in the context of learning science concepts so that they can feel the effect of the activity as well as reflect on the instructional demand necessary to replicate this technique in their classroom practice.

Conclusion

The POE strategy is a useful strategy and has significance in addressing misconceptions. It also is a potential pedagogical tool to provide experiential learning to pre-service teachers. This study shows that the use of experiential learning improves and deepens trainee pre-service teachers' understanding of the concept of the sea level. The POE strategy provides pre-service teachers with hands-on and minds-on engagement which has aesthetic appeal (hearts-on). Therefore, experiential learning provides a fun learning environment and reveals and addresses pre-service teachers' misconceptions. It also encourages critical thinking.

Although, this study is limited by the size of sample, its implication is immediate and can be used to inform practice (Cipora, 2008) because the purpose of action research is to inform and enhance the teaching and learning process. Continuous repetitions of these snapshots would, however, provide a better idea of what is going on. Despite this limitation, the use of POE strategy has proven to be significant to addressing misconceptions. Therefore, the use of experiential learning via use of POE is recommended as worth exploring in teacher training institutes where didactic instructional practice is dominant (Pruneau et al., 2008) because experiential learning provides pre-service teachers with lived experience of teaching techniques that can be replicated in their classroom teaching.

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