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Teaching with Socio-Scientific Issues in Physical Science: Teacher and Students' Experiences

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ABSTRACT

Socio-scientific issues (SSI) are recommended by many science educators worldwide for learners to acquire first hand experience to apply what they learned in class. This investigated experiences of teacher–researcher and students in using SSI in Physical Science, Second Semester, School Year 2012–2013. Latest and controversial news articles on sources of energy were chosen for analysis. Based on the findings, the teacher–researcher was able to choose issues based on a set of criteria and students related what they learned inside the classroom with real life situations and its positive and negative impact to people and environment. A model of learning approach for teaching SSI in Physical Science was proposed.

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1. INTRODUCTION

Physical Science is one of the general education courses that enable non–majors acquire scientific knowledge to explain and understand occurrence of natural phenomena. Topics discussed in this subject should deal with controversial issues that can be subjected to public debate [1] and will make the students aware that science is part of public policy issue [2] reflected by the growth in citizen responsiveness to scientific issued in the form of citizen juries [3]. Thus, science teaching should involve make students realize the connection between science and society [2] as they prepare themselves as future citizens [4].

One of the active strategies is socio–scientific issues (SSI) that calls upon a different type of pedagogy.SSI has been integrated in many science curricula worldwide [3] because of its potential for creating a more real, humane image of scientific activity and for promoting scientific literacy [5]. Likewise, it develops an awareness of the interdependency between science and society [6],[7] and allows students to be involved as active citizens [6].

Considering that to be scientifically literate one needs to have the ability to make thoughtful decisions about SSI [8] and many science educators shared that curricula in industrialized countries are incorporating SSI in their classroom supported by studies cited above, the researcher believes that study on teaching SSI in Physical Science: teacher's and non–majors' experiences particularly on the topic sources of energy will provide additional information and insights on how to implement and learn through this active teaching strategy. Likewise, the researcher being the one who will handle the subject has already been using SSI in the course of her teaching but failed to document them, thus, the researcher accepts the challenge to try this strategy in her classroom and propose a model of approach for teaching SSI in a Physical Science class having in mind that the need for the inclusion of SSI into science curricula has been generally accepted, but relatively few science teachers have incorporated SSI into their courses [9],[10]. A model of approach for teaching SSI will be the output of this paper becausethere is no monolithic approach to the teaching of SSI

[3].Moreover, this paper will also look into concept of Transformative Learning among General Education subjects in the La Sallian schools to attain its mission of teaching minds, touching hearts and transforming lives as the non-majors are being honed to become citizens who are are scientifically literate and able to engage effectively with controversial issues in everyday life. This approach of learning is based on constructivist framework that considers learning as a personal process that happens within, and to the learner. It does not only place the learner at the center of the process, but it also makes the learning process an authentic venue for personal growth and development [11]. Likewise, Zeidler and Nicols (2009) as cited by Aligaen (2012) pointed out that engaging students in SSI is personally meaningful and engaging that requires the use of evidence-based reasoning and provide a context for understanding scientific information [12].

2. RESEARCH METHOD

This study utilized qualitative method of research particularly participatory action research (PAR) to investigate how students' work with socio-scientific issues in the topic sources of energy in Physical Science class (Transformative Learning). Likewise, PAR was employed because it involves more documenting carefully and recording action and what people think about it in ways others found accessible [13]. Moreover, PAR offers a powerful and empowering approach to educational evaluation in which there is an active partnership between researchers and researched.

Two hundred twenty students who comprised the five sections of business courses of De La Salle Lipa enrolled in Physical Science (Transformative Learning Class) during the Second Semester School Year 2012–2013 werethe participants of this study with the researcher as the one conducting the lesson while observing them.An interview guide was constructed to investigate how students' work with socio-scientific issues in the topic sources of energy in Physical Science class (Transformative Learning). Likewise, documentary analysis (journal writing), observation and triangulation of data will be considered in the collection of data.Responses of students in the interview guide were analyzed using axial coding technique in which codes or themes were generated and related to one another.This study involved continuing spiral of planning, acting, observing, reflecting and then re-planning and so round the spiral again [14].

2.1. Planning

The researcher planned on what SSI will be given to the participants based on School and Social Issues Model for Teaching SSI [3] which considers hierarchy (scientist/teachers-student); source of knowledge (corpus of science and other disciplines); view of knowledge (science to be known is correct but the emphasis is on the methods and procedures of science rather than facts. Science diffuses out into social applications but there is some transparency about the scientific process); controversy (takes place within the classroom but might involve analyzing science in newspapers distinguishing rhetoric from evidence); pedagogy (teacher controls content but might be a facilitator in discussion); and assessment (tests argumentation abilities, use of warrants to support claims). Likewise, the teacher-researcher considered some characteristics of SSI as enumerated by Radcliffe & Grace (2003) as cited by Ekborg & Ottander (2006) as: they are important for society, have a basis for science, involve forming opinions, are frequently media reported, address local, national and global dimensions with attendant political and societal framework, involve values and ethical reasoning, may involve consideration of sustainable development and may require some understanding of probability and risks and there are "no right" answers.

2.2. Acting

After the researcher had chosen the issue on sources of energy, the researcher discussed the contents of the lesson and integrated SSI. The researcher grouped students to share their argumentation based on the guide questions for the said activity.

2.3. Observing

While participants were involved in group discussion, the researcher observed what will transpire during the argumentation.Note-taking was done in the process.

2.4. Reflecting

Participants were required to write and submit a reflection and focus group interview was conducted on experiences of non-majors in using SSI in learning sources of energy.

2.5. Re-planning

After considering all other stages, the researcher with the shared experiences of the non-majors revised or reconsidered the School and Social Issues Model for Teaching.

3. RESULTS AND ANALYSIS

In discussing the results of this study, the School and Social Issues model by Levinson (2008) was used by the researcher through axial coding to analyze experiences of the teacher and students [3]. Based on the findings of this study, a model of learning approach for teaching SSI was proposed.

3.1. Knowledge of Science will help students as citizens in the making to hold and express a view on issues which enter the arena of public debate and perhaps become actively involved in some areas

Most students were able to read comprehensively the articles.Some of them shared that they read the articles three to five times to understand the issue.Others shared that they had to scan, skim and jot down important points in the articles. One student shared that indeed extensive reading should be done that was the reason why he read the article 12 times. After reading, many students explained that they analyzed the issue through the help of guide questions given. They did this to gather important ideas that will help answer the questions. One student emphasized that:*"analyzing SSI required them to read between and beyond the lines that did not only require them to focus on the main issue or idea but careful explorationof the contents of the articles should be done*."Another student argued that:"*this activity entailed us to search for more facts particularly on the topic Bataan Nuclear Power Plant because the article was not enough to present pros and cons of harnessing this non-renewable source of energy."* He further emphasized that:

"*I really had to look on each of the very details of the issue.Thus, careful investigation should be done before one can make a stand on an issue like this".* They also shared that after analyzing the article, they even compared the contents of the articles they gathered and their notes in Physical Science. After doing this, most students conducted brainstorming activity with their partner. Other students shared that:"*in the process of brainstorming, they were able to discuss things on sources of energy that were not been discussed in the classroom and will no longer answer the guide questions before arriving at their stand on the SSI*."Others said they even experienced brainstorming within themselves. Some claimed that there are still questions in their minds that were left unanswered particularly on energy consumption.

In terms of consequences, most students shared that:*"analyzing SSI enabled them to look into the pros and cons of harnessing nuclear and hydroelectric energy as well as fossil fuels through relating issues to what they learned in class and the facts that they searched in the internet*."Several students shared that truly jumping into conclusion at once without first analyzing the issue will lead one to nowhere same with problems on energy.

In terms of meanings, the non-majors explained that learning SSI on sources of energy gave them the chance to express their own interpretations of the issues.One student further explained that:*"SSI also enabledme to widen my understanding why people keep on holding to what they believe in and fighting for like what happened in the construction of a hydroelectric power plant in Mindanao people sacrificed their lives to express that they opposed the building of thatsource of energy in favor of their ancestral landand cultural heritage".* Likewise, some students shared that through SSI they were able to learn that there are many differentplaces in the Philippines to obtain energy. Others added that some of these places are commonly heard and others are most unlikely. In addition to this, one non-major questioned why not all people know about where energy in our country comes from. She cited that*"I am just wondering whether we really have many places in the country where we can getenergy. I only heard about dams and falls. Why*y *until now not all citizens know where we get energy? We just thought that we really have to import from other countries."*To explain this further, one non-major said that:"*it is good to know that our country has these alternative sources of energy and familiarity with its history as well as their advantages and disadvantages are made known through analyzing SSI*."Another student said that:"*I came to realize that every conflict and issue our country is facing rooted from limited sources of energy.Thus, it is but proper to understandthat we can harness alternative sources of energy which analyzing SSI provided*."

As observed by the teacher–researcher, non–majors gathered a lot of information to analyze SSI. During classroom discussion, students actively participated by adding information to the lesson based on what they read and researched on. As an example, several students volunteered to explain how to generate energy from solar cells.They explained in their own words and through example advantages and disadvantages of solar power. They were able to enumerate provinces like in Cagayan de Oro in Mindanao, Philippines. It was also observed that students asked questions on the topic. One of the questions raised was on the construction of Pulanggi IV Hydroelectric Power Plant in Mindanao in which people had to sacrifice their lives to stop the construction of the power plant in the place where minorities live. Students also looked into the situation in Mindanao where power interruption is a problem especially during summer months. There were some of them who were in favor of relocating the minorities in favor of continuous and sufficient power supply. Through the use of SSI, classroom discussion made meaningful and lively. Likewise, when students were asked to rank all the sources of energy, students were able to rank and give reasons for considering them. It was also observed that non–majors who were able to express their views

and opinions on the topic.They even cited specific instances or examples of sources of energy and pointed out experiences in harnessing energy in the Philippines and different parts of the world. Students also expressed their views and opinions to defend each answer.Thus, SSI enabled non–majors to enhance or strengthen their knowledge in Physical Science particularly on sources of energy.

Figure 1 shows how teacher and students experienced the use of SSI in the classroom. Students expressed their views and opinions issues that on issues that affect society by considering what they learned during the discussion, read from articles and searched from the Internet.

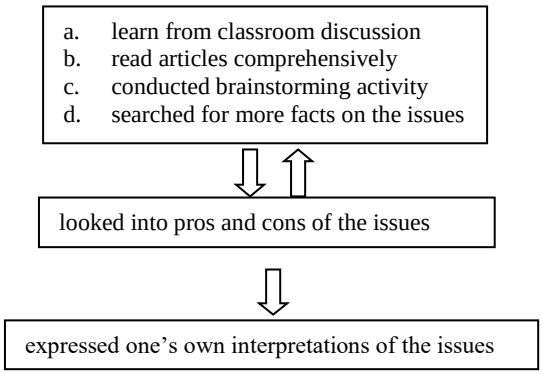

Figure 1. Summary of axial coding for expressing one's views or opinions on the issue

Morley (2011) supported the findings that the course should deal with controversial issues subjected to public debate [1]. Non–majors were confronted with issues on sources of energy which affect all members of the society. It is also important to consider that a key demand for contemporary science education is increasing awareness of science as a public policy issue [2] reflected by the growth in citizen responsiveness to scientific issued in the form of citizen juries [3]. This is related to the present study in which he non-majors were able to express their views and opinions on sources of energy in the country. Thus, stronger societal orientation in science teaching remains [2]. Likewise, being citizens of the near future, students will make decisions requiring an understanding of the interaction of science and technology and its interface with society [4]. Thus, teaching through SSI enabled the non–majors not only to learn more about the topic but more importantly they were able to express their opinions and views on the topic.

3.2. Individuals Understand The Method Which Science Derives The Evidence for The Claims Made by Scientists [3]

In terms of strategies, all students followed the steps involved in scientific method to analyze SSI. Aside from this, all students shared that while reading the articles; they listed down or jot down important points that will enable them to answer the guide questions. Others shared that after reading the article, they jotted down unfamiliar words and look for their meanings in the dictionary or connect these words to the situations. Others claimed that they remembered key words to analyze the issue. Some of them said that they did outlining particularly mental outlining. They did note-taking to collect important details. In relation to this, one student added that she outlined the facts that could be of great help in answer ring the guide questions. Others shared that when they first read the entire article and encountered difficult words or deep words, they managed to search for their synonyms. There were some students who shared that they constructed diagrams while reading the articles.After that they went back to the diagram and explain what the diagram means.Others constructed their own sentences and sometimes paraphrase parts of the articles to prove that we understand the SSI in the articles concerning energy. A group of students shared that they marked all the important points in the articles so that it would be easy for them to locate those points when they will answer the guide questions pertaining or related to that. There were students who emphasized that after reading, the article they thought first of the pros and cons of harnessing this sources of energy in that way they can understand the issues.It was found also that in following the steps in scientific method as what one student observed that:*"all students surf the internet to help them analyze the SSI and find additional information on hydroelectric power plant in Mindanao, Bataan Nuclear Power Plant and BernhamRise."*According to one of the students, "*information found in the internet helped her to understand words in the articles that are difficult to understand. Articles in the internet also provide background information on the topic*."It also supplements our discussion in the classroom so that when the

lessons in class, the articles and the researches gathered from the internet are combined, conclusions can be arrived at. Thus,a decision can be made regarding one's stand on the issues."*Likewise, one student added that from the gathered articles in the internet, she was able to carefully delineate facts on the articles with socio-scientific issues."* Moreover, another student explained that:"*after reading the articles several times particularly an article on Bernham Rise, I was able to browse other examples or similar scenarios all over the world andcompare their similarities and differences which could help me to come up with clear understanding of the topic and make a stand on the issue*." There were groups of students who claimed that they read many books related to the article. After reading, they evaluated the pros and cons of every decision made by personalities involved in the issues. Likewise, they classified important statements of each side whether opinion or fact.Indeed, the non-majors never stopped in finding ways to analyze SSI.They conducted big group discussions during their freetime. They shared each other's ideas and opinions and write them down. Through this, they proved that they understand the scenario and all the details from the articles, classroom discussion and researches from Internet and books. Others did small group discussion where they drew diagram consists of two columns for the pros and cons to differentiate one from another. They also shared that through the diagram, they were able to compare evidences to prove their arguments. There were also small groups that shared all the information they gathered.They believed that through sharing, they can understand the issues better.Another group shared that in their small group discussion they talked about each one's reactions to the articles that lead to arguments on possible causes and effects of harnessing alternative sources of energy.

In terms of participation, the non-majors explained that in order for them to understand SSI, "we *discussed with our classmates the contents.After we conducted our own readings severaltimes*, we *asked one another about our opinions and reactions on the topic*."Most students shared *that through brainstorming, they were able to answer the guide questions*.However, there were some groups of non-majors who claimed *that when we finalized our answers and already in the process of encoding them, we even changedour answers all of a sudden because either one of us or both of us will still argue and provide evidence or proof that there is still a possible answer to the question".* They added that in the process, they became very critical thinkers.

In terms of condition, non-majors observed that learning science through SSI is similar to a case digest that is part of the requirements of courses in Bachelor of Science in Legal Management. They also noticed that there were some guide questions that were difficult to comprehend requiring them to exert extra effort to understand. However, some students argued that *"instead of looking at learning through SSIas a difficult task, they just focus on gathering facts and opinions to better understand the issues and answer the questions because whywaste time for thinking that it is difficult to accomplish while in real life dealing with these issues on sources of energy is really very crucial".*

In terms of state, several students claimed that:"*teaching through SSI enabled us to readarticles that tackled issues not known to many before particularly on Bernham Risewhich when become officially part of thePhilippine Territory will be another possiblesource of alternative energy."* They said that in some way SSI made them grateful and hopeful that if there are possible alternative sources of energy somehow we can possibly find a solution to his problem.Likewise, most non–majors shared that SSI enhanced their knowledge on issues concerning energy in the Philippines that it should be given priority by the government.On the other hand, one student shared that he should analyze thoroughly issue before coming up with a conclusion regarding the topic.He was wondering if persons involve in harnessing alternative energy sources and those who protested against them analyze first their stand.

In terms of consequences, the non–majors shared that in order understand SSI, students should know first the articles–what are they all about. Some students elaborated that one should first read the articles carefully and put your heart into it.Most of them observed that these issues are everyone's concern because the topic is on energy and everyone is using it.Another student added that*"analyzing SSI made me feel that I should really study alternative sources of energy in our countryand be vigilant with what is going on in our country pertaining to this topic no matter what big or small their discovery or issue is".*Someone shared that:it made my imagination worked on so many *"what ifs"* in my mind like *"what if the government will not prioritize problems or concerns on energy sources; what if anothercountry will claim Bernham Rise; what if Bataan Nuclear Power Plant will be allowedto operate*". Based on the explanation above, many students gave the assurance that is easier to understand SSI if the issues presented are everyone's concern.

In terms of meaning, most non-majors claimed that teaching using SSI enabled them to become critical readers.This is so as one student stated that understanding SSI helped hera lot in understanding the whole content of each article assigned for them to analyze.Likewise, one student shared that through SSI, my knowledge on sources of energy was enhanced as this strategy gave her the opportunity to relate lessons in classto the things she had read, things she alreadyknow and insights from brainstorming sessionparticipated related to sources of energy to comply with the requirement in Physical Science. Moreover, one student

stated that SSI enabled her to answer questions not only based on books or lecturebut should be based on evidences.

Based on the experiences of the teacher–researcher, non–majors followed the steps in scientific method which they studied before. They were able to identify the problem in each of the articles given. This was evident during classroom discussion wherein students participated actively by giving the identified problem as examples.They even explained details on why these problems concerning energy occurred or happened. Some non–majors also mentioned sources or references from where they got those issues they shared. Through this, they were able to reflect on the issues.

Figure 2 shows that teaching SSI in a Physical Science class enabled students to apply what they learned in following steps involve in scientific method through reading a lot about the topic, jotting down notes, marking important points, defining unfamiliar words, remembering key words, outlining topics, note-taking, constructing diagrams,-surfing the net, conducting group discussions, consulting elderly and reflecting on issues concerning the topic. Extra effort had been exerted by the non-majors in analyzing issues which was similar to what scientists experienced when they discover, invent or prove their claims or hypothesis. It is also worthy to consider that non-majors are not expected to become scientists in the future but they are expected to explain issues being faced by the members of the society through the steps or process involve in scientific method. Through teaching SSI to understand sources of energy, non-majors were able to enhanced knowledge on the topic, enabled to answer questions based on evidences and used their imagination on what they learned. Thus, they became knowledgeable of the topic, felt the need to study the topic, became eager and interested to learn more, manifested gratefulness for people who exert effort to look for alternative sources of energy, expressed hope that someday alternative sources of energy will be discovered and felt assurance that the government will no longer depend on fossil fuel.

Hanley, et al (2007) supported the above findings that SSI encourages a focus on "ideas-about-science" (the processes and practices of science) and consideration of scientific evidence and values [2]. In the same way, the non–majors as participants in this study were able to identify problems in different articles or issues concerning sources of energy that affect members of the society through the use of steps in scientific method. They were able to explain why problems occurred similar to the way scientists do them. This is confirmed by Sunar and Giban (2011) who explained that being citizens of the near future, students will make decisions requiring an understanding of the interaction of science and technology and its interface with society [4]. Likewise, Physical Science seeks to develop students into well-rounded productive members of society, broadening their perspectives by exposing them to new ideas and a diversity of worldviews while giving them the tools to engage them [15].

3.3. Sub sectionAppreciate the strengths and limits of scientific evidence [3]

In terms of state, most non-majors agreed that:"*analyzing SSI although difficult at firstenabled us to understand sources of energyparticularly in the Philippines better becausethese issues are everybody's concern as everyone consumes energy".*Thus, there were several non-majors who claimed that they appreciated the use of SSI in the classroom. One student who said that in SSI, real life issues or happenings that affect everyone in the society whether rich or poor that only principles and concepts in science can explain explain this.Several students added that for them SSI is very effective for non-majors to understand lessons in Physical Science because details and needed information to understand the issue being analyzed. One student added that SSI opened her eyes on issues being faced by our country which not everyone are aware of although these issues affect everyone.

In terms of participation, non-majors realized that in order to appreciate SSI in the classroom, brainstorming activity should be done among students. One non-major shared that discussing the contents of the articles with her classmates can help them understand better the issue. Another group of non-majors claimed that: "*it is better to share ideas or opinions with group mates as well as reactions to the topics*." Another student added that through sharing she gained more information in the topic that she had not encountered while conducting research.

In terms of consequences, it was found that although most non-majors cited that: "*analyzing SSI was quite hard to do or accomplish and we realized that in the process many people are trying all possible means to discover alternativesources of energy in the Philippines*." Many agreed also that they are truly grateful to these people for they never stop searching for alternative sources of energy for present and future consumption.

In terms of meaning, many non-majors shared that SSI in class gave them concrete information about issues on sources of energy in the Philippines that tackle all their advantages and disadvantages. In addition, many of them believed that they were informed on what alternative sources of energy can be found in our country.

It had been observed that teaching through SSI was not easy on the part of the teacher and of the non-majors. On the part of the teacher, criteria should be met to make sure that the articles or issues to be used in class are worth analyzing. It means that the issues should be considered as subject for debate as this affect every member of the society and the solution for this can be solved or explained its occurrence through understanding science concepts or principles. On the other hand, students found that this strategy was difficult as they were required to spend more time to read, research and analyze the issues. However, all the time they spent were worth it because the teacher-researcher noticed that during classroom discussion they were able to give examples and point out places in the country where a particular energy source is found. As a result the non–majors were able to understand the issues and appreciate the use of SSI in a science class. Thus, they were able to see and appreciate the lesson as this can be applied in daily life.Likewise, non-majors were guided on which source of energy is fitted to be harness in the Philippines.

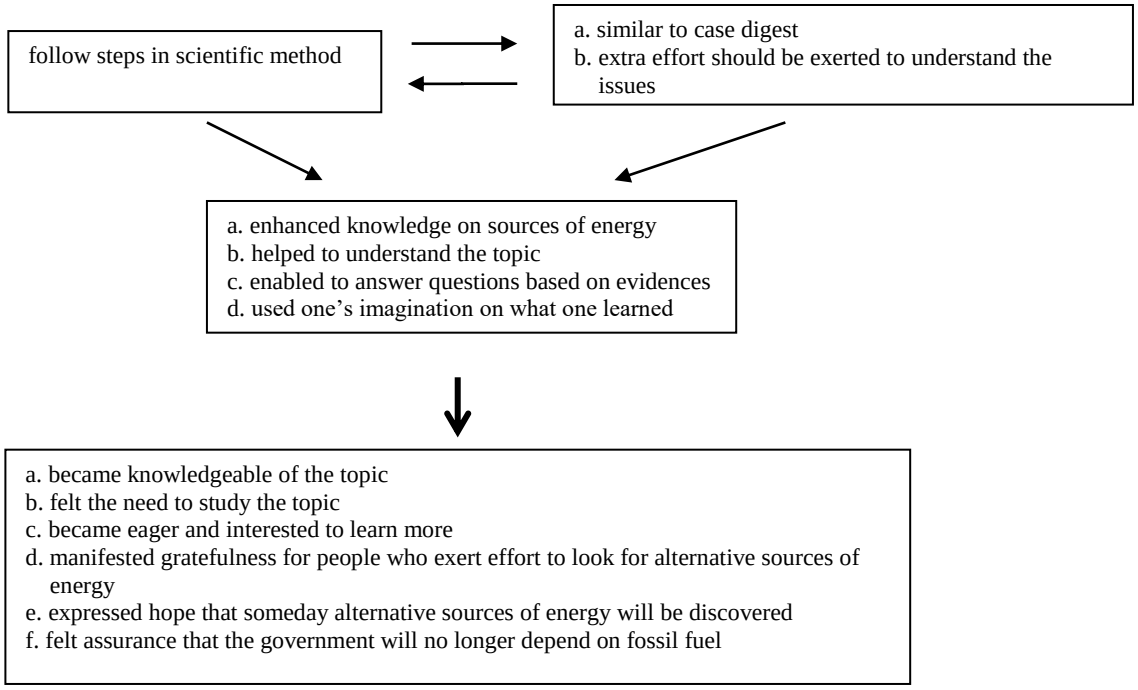

Figure 2. Summary of axial coding for applying scientific method in solving the issues

Figure 3 shows that analyzing SSI quite hard to accomplish and difficult to do at first. However, this enabled non–majors to give concrete examples and necessary information, understand the issues and appreciate the use of SSI in Science class.This is so because SSI has something to do with real life issues that affect everyone and only concepts and principles and Science can explain, is very effective to underst and lessons in Physical Science, opens one's eyes on issues concerning energy and informs everyone that there are experts who are trying their best to solve problems on energy.

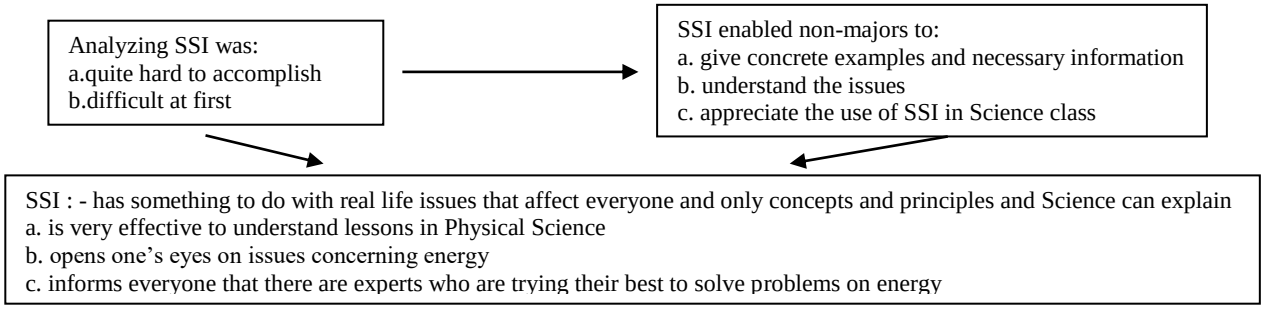

Figure 3. Summary of axial coding for accept limitations of science

Hyunji and Klaus (2009) and Klosterman, et al (2012) confirmed the above findings that teaching and analyzing SSI was difficult at first as they stated that the need for the inclusion of SSI into science curricula has been generally accepted, but relatively few science teachers have incorporated SSI into their courses [9],[10]. However, there are so many benefits that students and teachers got from using SSI in the classroom and this is proven by Zeidler and Nicols (2009) and Aligaen (2012) who pointed out that engaging students in SSI is personally meaningful and engaging that requires the use of evidence-based reasoning and provide a context for understanding scientific information [12].

3.4. Able to Make a Sensible Assessment of Risk [3]

In terms of state, many non-majors shared that some articles on SSI were really complicated. Some of the, mentioned that there were ideas hidden in the articles so it required them to read many times each of the contents of the articles. One non-major supported this statement by claiming that if reading the article was done twice, she is very sure that the reader understands nothing. On the other hand, some students shared that if one really read several times the articles, he or she will discover that some answers were already in the article. The same student added that important points were already implied. As what one non-major stated, what students need to do is to analyze.Another student commented that students are required to weigh the advantages and disadvantages of harnessing alternative sources of energy in which SSI requires.One student agreed that in SSI, pros and cons of each source of energy should be taken into consideration.

In terms of condition, some non-majors claimed that teaching through SSI helped them to think on causes and effects of sources of energy as well as places in the Philippines that have deposits of natural gas.

In terms of consequences, many non-majors stated that:"we *were able to assess issues pertaining toenergy problems in the country. We became aware of important issues that are really happening right now*."One student added that:"*it is also important to emphasize thatwe also learned about the possibilitiesand conflicts arising in discovering alternative sources of energy; that this issue is not that easy to solve and manage".* One student mentioned that they were able to look into every aspect concerning the issue. Thus, one student concluded that analyzing SSIs makes students critical thinkers as they are trained to come up with sound decision and judgment based on evidences and proof. In terms of meaning, many students believe that teaching SSI is really effective as what one student stated that: "*SSI enabled non-majors to gather information to supplement what had beendiscussed in the classroom for us to think in the most critical way."*

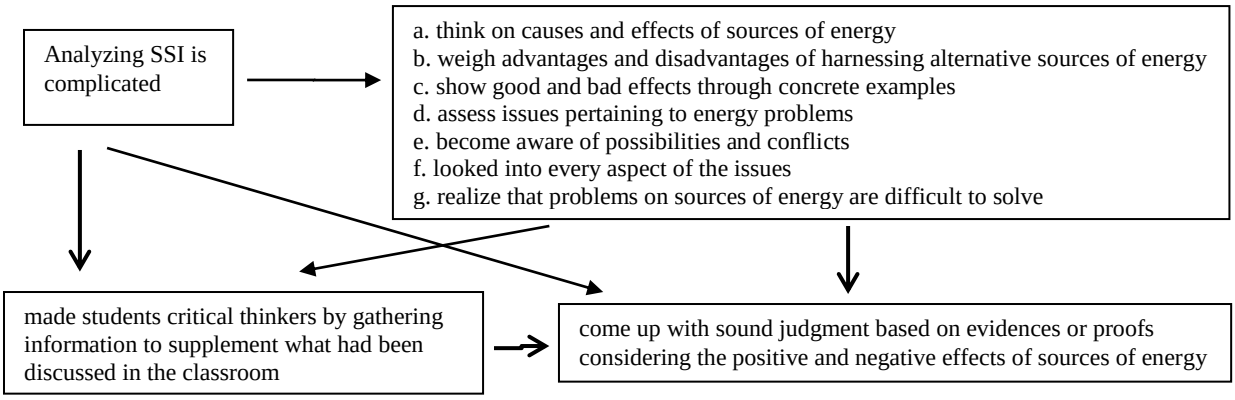

Figure 5. Summary of the axial coding for recognizing risks in making judgment

On the part of the teacher–researcher, it had been experienced that teaching Physical Science particularly on sources of energy through SSI was complicated.There were many things considered like issues to be used for the non–majors to be able to express their views and opinions as well as to come with sound decision and judgment. As what had been observed among students, they were able to participate in the discussion in class by emphasizing the advantages and disadvantages of each source of energy whether renewable or non–renewable. This was evident when students were asked to rank which source of energy is best source to harness and they did this by looking into the pros and cons of each source. They also thought of possibilities and challenges that may be encountered if people will still continue relying on non-renewable source like fossil fuels. They were also very curious on the possibility of opening again the Bataan Nuclear Power Plant.However, many non–majors expressed their views that this plant may only cause additional problems if allowed to operate. Thus, non–majors were confronted with a lot of "ifs" during the discussion

with the help of SSI. On the other hand, students never stopped thinking and in the process they became critical thinkers to come up with a decision thatis expected to be manifested by scientifically literate citizens.

Figure 5 shows that teaching through SSI among non–majors in a Physical Science class was a complicated process. However, if teachers will use this as part of the lesson particularly on sources of energy students will be able to think on causes and effects of sources of energy, weigh advantages and disadvantages of harnessing alternative sources of energy, show good and bad effects through concrete examples, assess issues pertaining to energy problems, become aware of possibilities and conflicts, look into every aspect of the issues and realize that problems on sources of energy are difficult to solve. Thus, this made students critical thinkers by gathering information to supplement what had been discussed in the classroom. As a result non-majors will come up with sound judgment based on evidences or proofs considering the positive and negative effects of sources of energy.

Grace (2010) supported the above findings that many issues facing modern citizens are underpinned by science making many people interested in it [16]. It is also worthy to consider that these issues such as sources of energy entails assessment of risks which requires citizens to make sound judgment in every decision they will make like considering the advantages and disadvantages of both sides. Thus, may people are focusing on them. Likewise, SSI develops an awareness of the interdependency between science and society [6],[7] and allows students to be involved as active citizens [6].

3.5. To recognize the ethical and moral implications of the choices that science offers for action [3]

In terms of consequences, some non-majors shared that SSI made students understand better the topic on energy particularly sources of energy in the Philippines as well as their advantages and disadvantages. Others commented that they were "*informed about past and current issues on energy sources and the accompanying possible conflicts among members of society.An example of this is the conflict that happened in Mindanao between the people who supported the construction of power plant and members of the tribe who livedin the site where the said power plant will be constructed."*There were some students who claimed that: "*we realized that all sources of energy have theirown advantages and disadvantages which increased our' knowledge because there weresituations given in each source*." One student added that there are issues that pertain to pros and cons of each energy source as well as possible consequences if it had been built in any country.

In terms of state, there were students, who expressed disappointment on the topic because she emphasized that:"*despite the good effects of generating energy,its negative side such as war also happened.This contradicted the fact that sources of energy should be used for everybody's welfare not only for a few."*Likewise, one student shared that she was wondering why generation of energy is always affected by political feuds. One student concluded that generating energy is done for the good of all however, there are a lot of problems occur in planning, constructing and operating power plant.

Based on the experiences of the teacher-researcher, non-majors were able to analyze SSI through what they learned in class and on what they read and researched on. This was evident during the discussion in class wherein non-majors actively participated by sharing their views on the effects of harnessing different sources of energy such as in the in the building or construction of dams. Students expressed their grief when many people died when a dam collapsed. They were also upset with the effects of radiation from nuclear power plants. They even questioned decision over too much dependence on fossil fuel as source of energy. Thus, when students asked to rank the different sources of energy in the country, it was observed that they prioritize human welfare and the environment even that source is too expensive.

Figure 6 shows that students realized the advantages and disadvantages, pros and cons of harnessing a certain source of energy through teaching SSI in Physical Science. Likewise, they considered the possible consequences of harnessing each energy source. In this way, non-majors were able to see the effects of each energy source in the lives of people or members of the society.

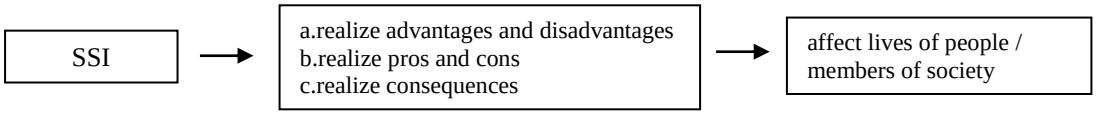

Figure 6. Summary of axial coding for identifying moral and ethical implications of the issue

Sunar and Geban(2011) confirmed the above findings that being citizens of the near future, students will make decisions requiring an understanding of the interaction of science and technology and its interface

with society [4]. It is worthy to consider that knowledge gained in Physical Science during classroom discussion enabled students to see the negative and positive sides of harnessing each source of energy. On the other hand, when SSI was also used in the classroom, non-majors' knowledge was strengthened in such a way that concrete scenarios were given. This proves that this is really happening and affecting the society. Thus, this is the reason why the study of contemporary socio-scientific issues (SSI) is now established in the science curricula in many industrialized countries [3] because of its potential for creating a more real, humane image of scientific activity and for promoting scientific literacy [5]. Additionally, students are interested in working withcomplex issues with a more humanistic perspective. This had been observed among non-majors when they discussed about what happened in a country where a dam was built and it suddenly collapsed when the dam started to operate.

3.6. Based on the assumption that what we learned in school can be transferred to every day living [3]

In terms of state, the articles for analyzing SSI made students aware on sources of energy particularly in the Philippines. For others their knowledge on the topic was strengthened. There were students who commented that they learned not just theories but also its application in real life. Some students commented that they imagined things that apply theories learned inside the classroom. One student added that the issues were realistic and gave concrete explanation on the advantages and disadvantages of sources of energy to organisms in this planet. There were students who commented "*I came up with a lot of thoughts after reading the articles, recalling the discussions andconducting research on the topic on alternativesources of energy and how to harness andconserve them*."A student cited that:"*through SSI my knowledge was widened not just by learning about sources of energy in the Philippines but also around worldas well as its advantages and disadvantages and its effects on people and environment."*Another student who shared that the knowledge obtained is very useful and we became aware of what is happening around confirms this. This is confirmed by one student who explained that:*"before I don't have any idea about sourcesof energy in the Philippines even in our neighboringcountries but now I know the issue in our countryand I believe that this topic is truly the concern of everyone because everyone is consuming energy."*As what one student confirmed that: *"my knowledge on sources of energy was strengthened because when I read the articles given, they were not familiar to me. I do not know that there were issues like these. I amnotaware of these articles. It made me gained more knowledgeabout our country and its sources of energy."*

In terms of condition, the non-majors shared that *"prior knowledge on the topic helped a lot in analyzing the socio-scientific issues"*. Likewise, a student added*"by being aware on sources of energy, disputes and arguments have been produced by the conflicts about the issues in the articles".* In relation to this, a student emphasized that *"though some information may not be directly stated in the articles, one can still be able to identify conflicts and arguments".*

In terms of consequences, many students "*became aware of the issues on the availability of resources."*There are students who shared that "*they also learned the benefits and possible solutions concerning sources of energy in the country".* Another student commented that "*I gained knowledge about sources of energy-I learned howit works and its functions and the advantages and disadvantagesof the said topic. Through analyzing SSI, it gives me newidea about the lesson on energy."* One student commented that *"teaching through SSI kept us updated in all the issues about sources of energy and what is happening in our surroundings especially in terms of energy".*This statement was confirmed by another student who stated that "*teaching through SSI is related to real life situations. It did not only give us information but also made us aware of the current issues our country is facing right now."*Another student agreed the former statement by saying that *"through SSI, I gain more knowledge on sources of energy and the issues related to it which I believe is the main topic of debates in the government resulting to conflict."*

In terms of meanings, teaching socio–scientific issues for non-majors helped them a lot in learning concepts in Physical Science. One student shared that for her teaching SSI means: "*a new way of learning a lesson in Physical Science particularly sources of energy that is not confined in what is written on the book but analyzing and reflecting on what is happening around that affects every member of the society."*Another student explained that teaching SSI means that "*analyzing SSI in Physical Science class means providing evidence on what students learn about the topic like sources of energy through putting together what knowledge one gained on the topic during classroom discussion and what onelearned while reading and analyzing articles related to the topic so that students can make ajudgment or stand on the issue."*

The teacher-researcher observed that in teaching Physical Science particularly on sources of energy through SSI, non-majors became very much aware on what is happening around them including the subjects of debate and conflicts which have something to do with energy. This is so because the issues presented to them affect themselves in one way or another as stated in their activity wherein they were asked to rank the most reliable source of energy in the country.It is also worthy to consider that during the discussion, students

actively shared their personal experiences particularly power interruptions especially during summer and the high cost of electric consumption. They even shared that even they conserve energy in the form of electricity at home; they still cannot understand why from time to time there will always be news on the increase in electric bill. There was a student who commented that Filipinos are already immune of this issue and there is nothing new.On the other hand, there were students who said "*Why not the government through the Department of Energy harness alternative sources of energy which have also advantages as what had been discussed in class*?" Indeed, non-majors have seen the relevance and the application of lessons in every day living. They were able to formulate questions to supply need for energy especially in the form of electricity.Likewise, students were able to give suggestions based on what they learned in class.

Figure 7 shows that teaching SSI in the classroom in the form of realistic or concrete issues like in the topic sources of energy enabled students to become aware/updated on the issues; enhance or strengthen their knowledge on the topic including its benefits, advantages and disadvantages, pros and cons, availability and possible solutions; come with a lot of thoughts; confirm their belief that the topic affects everyone; realize that one is lucky with the learnings gained and being aware on what is happening around; reflect on what is happening around that affects every member of the society; identify conflicts, arguments and issues; guide students to come up with a judgment or stand on the issue and summarize what they learned through the application of knowledge in analyzing issues affecting members of the society which only concepts in sciencecan explain.

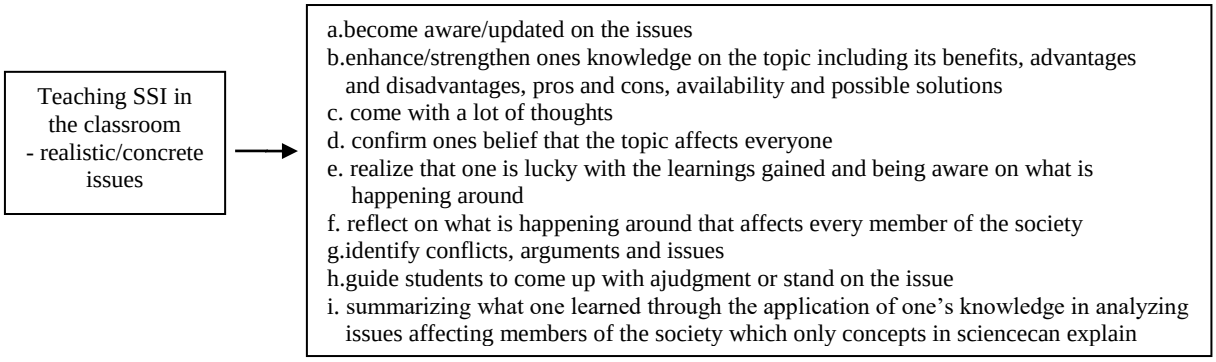

Figure 7. Summary of the axial coding for applying one's learning in day to day living

Levison (2008) confirmed the above findings that science is a powerful, rational and authoritative means of understanding nature [3]. Like in discussing sources of energy, non–majors should understand where energy in the form of electricity or fuel come from and be able to explain processes involve in generating them.Thus, Zeidler and Nicols (2009) as cited by Aligaen (2012) pointed out that engaging students in SSI is personally meaningful amd engaging that requires the use of evidence–based reasoning and provide a context for understanding scientific information [12]. Likewise, a key demand for contemporary science education is increasing awareness of science as a public policy issue [2]. However, the findings of this study contradicted with the statement of Lindahl (2003) as cited by Ekborg and Ottander (2006) that students often express interest in science but they find science in school difficult and without relevance for them. In addition, students feel that the content is set and that there is nothing to discuss.

It can be said that teaching Physical Science through SSI among non–majors will be an effective strategy to make them scientifically literate citizens in the future. Likewise, Zeidler and Nicols (2009) as cited by Aligaen (2012) pointed out that engaging students in SSI is personally meaningful and engaging that requires the use of evidence–based reasoning and provide a context for understanding scientific information [12]. Thus, the need for the inclusion of SSI into science curricula has been generally accepted, but relatively few science teachers have incorporated SSI into their courses [9],[10]. Likewise, teachers still arranged SSI as something special and they generally did not seem to know how to facilitate the students' work. This is the reason why a proposed model of learning approach for teaching SSI in Physical Science class is forwarded based on the findings of this study.It is also worthy to remember that there is no monolithic approach to the teaching of SSI [3]. Therefore, the proposed model will guide teachers in using SSI in their science classes.

Figure 8 shows the proposed model of learning approach for teaching SSI in Physical Science class. As can be gleaned from Figure 8, teaching through SSI is found at the center. Surrounding outside the teaching approach in Physical Science are the six identified competencies that non-majors demonstrate in the

process such as express one's views or opinions on the issue; apply scientific method in solving the issue; accept limitations of science; recognize risks in making judgment; identify moral and ethical implications of the issue; and apply one's learning in day to day living.

The identified competencies indicate what will be the effects of teaching SSI among non-majors. These competencies are related to one another as represented by solid lines that if one will not be manifested or demonstrated teaching SSI will not be considered effective. Therefore, for teaching SSI to be effective, all of these competencies should be manifested by the non-majors.

Teaching through SSI in Physical Science enabled non-majors to express their views or opinions on the issue; apply scientific method in solving the issue; accept limitations of science; recognize risks in making judgment; identify moral and ethical implications of the issue; and, apply one's learning in day to day living. Thus, a model of learning approach for teaching SSI is being proposed.

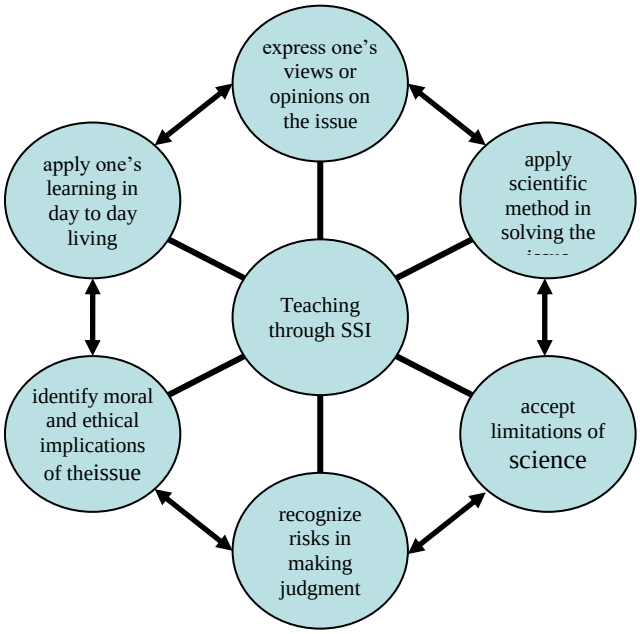

Figure 8. Model of learning approach for teaching SSI in Physical Science class

4. CONCLUSION

A set of criteria and students related what they learned inside the classroom with real life situations and its positive and negative impact to people and environment had been established to identify SSI to be used in Physical Science. Teaching through SSI enabled non-majors to express their views or opinions on the issue; apply scientific method in solving the issue; accept limitations of science; recognize risks in making judgment; identify moral and ethical implications of the issue; and, apply one's learning in day to day living.Thus, a model of learning approach for teaching SSI is being proposed.

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REFERENCES

[1] E. Morley, "It's time to end "physics for poets"," 2011. [cited 2012. Aug 22]. Available from: http://www.insidehighered.com/views/2006/04/13/morley.
[2] P. Hanley, *et al.*, "Teachers' experiences of teaching 'ideas about science' and socio-scientific issues," 2012. [cited 2012. Aug 10]. Available from: https://secure.eprints.soton.ac.uk/soton/secure/00.
[3] R. Levinson, "Towards a pedagogical framework for the teaching of controversial socio-scientific issues to secondary schools in the age range 14–19," 2012. [cited 2012. Aug 10]. Available from: http://eprints.ioe.ac.uk/47/.
[4] S. Sunar and O. Geban, "Prospective science teachers' perceptions on socio-scientific and technological phenomena,"*Eurasian Journal of Physics and Chemistry Education*, pp. 9-24, 2011.

[5] P. Reis and C. Galvao, "Teaching controversial socio-scientific issues in biology and geology classes: a case study," 2012. [cited 2012. Aug 22]. Available from: www.academic.research.microsoft.com.
[6] A. W. Subiantoro, "Socio-scientific issues and its potency on biology instruction for character education in Indonesia," 2012. [cited 2012. Aug 22]. Available from: http://staff.uny.ac.id/sites/default/files/Agung%20WS_Socioscientific%20Issues_CoSMEd%202011.pdf.
[7] P. Nuangchalerm, "Development of socio-scientific issues-based teaching for preservice science teachers," 2012. [cited 2012. Aug 10]. Available from: http://www.biomedsearch.com/article/Development-sociocientific-issues-based-teaching/208209154.html.
[8] S. D. Kolsto, *et al.*, "Science students' critical examination of scientific information related to socio-scientific issues," 2009. [cited 2012. Aug 10]. Available from: http://folk.uib.no/pprsk/Dankert/Handouts/2005_Kolsto_et_al_Science_students'_critical_examination_ev.pdf
[9] H. Lee and K. Witz, "Science teachers' inspiration for teaching socio-scientific issues: disconnection with reform efforts,"*International Journal of Science Education*,vol/issue: 31(7),pp. 931-960, 2009.
[10] M. L. Klostrman, et al., "Science teachers' use of mass media to address socio-scientific and sustainability issues," *Research in Science Education*,vol/issue: 42(42), pp. 1-74, 2012.
[11] J. Talens, "Strengthening students' understanding of environmental concepts through fan-based art-making (Cosplay)," *International Journal of Education and Research*, vol/issue: 1(6),pp. 1-11, 2013.
[12] J. Aligaen, "Climate change integrated model; building adaptive capacity for the next generation (Malaysia, Indonesia, Thailand, Philippines and Lao PDR)," Asia-Pacific Network for Global Change Research, 2012. [cited 2012. Aug 10].Available from: http://julitoaligaen.wikispaces.com/file/view/IISOCIO+SCIENTIFIC+LEARNING+FRAMEWORKbiodiv.pdf.
[13] P. Crane, "A framework for participatory action research in the reconnect and home advice programs," 2012. [cited 2012. Aug 10]. Available from:http://www.cmy.net.au/Assets/540/1/PARinReconnectandHomeAdvice,pdf.
[14] G. Banfield and M. S. C. Gicain, "Qualitative approaches to educational evaluation: a regional conference-workshop," vol/issue: 7(4),pp. 510-513.
[15] P. T. McPhearson, *et al.*, "Increasing scientific literacy in undergraduate education; a case study from frontiers of science at Columbia University," 2011. [cited 2012. Aug 10]. Available from: http://www.columbia.edu/cu/biology/faculty/Pollack/publications/essays-and reviews/increasing_scientific_literacy.pdf.
[16] Grace, M."Teaching citizenship through science: socio–scientific issues as an important component of citizenship", 2012 [cited 2012. Aug 10].Available from: http://www.civnet.org/2010/03/teaching-citizenship-through-science-socio-scientific-issues-as-an-important-component-of-citizenship/.

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Joy Talens is a graduate of Doctor of Philosophy in Educational Management in 2009 and Master of Arts in Education with Specialization in Science Education in 2002 at the Philippine Normal University–The National Center for Teaching and Learning. She earned Bachelor of Secondary Education major in General Science in 1994 at Sacred Heart College, Lucena City, Philippines. She was a former high school teacher for four years before teaching in the college and former Director for Research and Development. Presently, she is an Associate Professor at De La Salle Lipa teaching Physical Science, General Biology and Environmental Science among non–majors. Science teaching and development of research culture are the focus of her research works.