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Evaluation of Open Inquiry Learning Model for Physics Teachers

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Abstract This research responded to the need to provide teachers with a clear model of inquiry-based instructions to help teachers implement this learning approach and take advantage of its benefits. The study employed an action research design, wherein the researcher designed and evaluated an Open Inquiry Learning Model in Physics (OILMP). The learning model was implemented to Grade 12 students under STEM track (n=30). The model defined the roles of teachers and students in an open inquiry learning approach. Findings revealed that teachers should orient, elicit questions, facilitate in the learning process, motivate the students, validate information, ask questions, summarize lesson, assess students and provide immediate feedback. Students' roles are to complete KWL chart, conduct research, validate or evaluate information, ask questions, plan for investigations, investigate, and report research and findings. This model provided complete details on how open inquiry may be facilitated in the Philippine setting.

Keywords: *inquiry, open-inquiry model, Physics*

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Introduction

The inquiry-based approach is rooted in constructivist approach, where knowledge is developed by the students based on their prior knowledge and observations (Zion & Mendelovici, 2012). Besides, the constructivist approach focuses on learning than teaching, on how to think than what to think (Taneri, 2010). The actual implementation of inquiry particularly the open inquiry learning approach may not be clear and comprehensible to many teachers, counting me as one of those not so familiar with the approach. Even so, I was able to implement structured inquiry in my Physics classes, wherein my students were given the procedures. They followed the procedures, answered the questions and came up with conclusions. There were also lessons in Physics where I was able to integrate guided inquiry approach. In this approach, I asked students questions in which they had to answer through investigations.

Prior to this study, open inquiry which is considered as the highest form of inquiry in teaching Physics concepts is far from my reach. There were literatures introducing different methods on how the approach is implemented, however I could not find a model which suits the Philippine setting, given the minimum resources that Science classrooms have. In the Philippines, there is still a gap in the effective implementation of inquiry-based teaching in the classroom (Gutierez, 2015), despite the efforts of the Department of Education (DepEd). In 2012, DepEd has included scientific inquiry in the design of K-12 Science curriculum. Since then, inquiry-based teaching has been promoted in the Philippines through the conduct of Science teacher professional development trainings. However, its effective implementation in the Philippine setting is not observed. Such gap may be due to the following reasons: a) difficulty in sustaining teachers' practices after a short term professional development related to inquiry teaching, b) insufficient resources and facilities, c) time constraints in conducting inquiry teaching, d) lack of understanding about inquiry -based curriculum framework and e) lack of skills in delivering the teaching plan adopting inquiry approach. In addition, the absence of a clear model and lack of examples on how it should be facilitated in a classroom hinder teachers from implementing this learning approach (Campbell, Neilson, & Zhang, 2011; Danaia, Fitzgerald, & McKinnon, 2019; Weiland, 2012).

The use of scientific inquiry in instruction has long been emphasized in curricular reform movements in K-12 Science. These movements toward scientific inquiry were observed in countries such as United States, Australia, Ireland, Singapore, South Africa and Taiwan (Erduran, 2006, as cited by Coban, 2013; Danipog, 2018). However, in Southeast Asia there is a minority of empirical studies supporting the claim of positive effects of authentic, inquiry based learning or instruction in the field of Science education. In the case of Singapore, authentic inquiry based learning has been endorsed but are not readily accepted by the teachers due to the following problems: a) introduction of authentic inquiry based learning, b) teachers' skills in facilitating inquiry process, and c) the culture of performativity within Singapore's education system (Fernandez, 2017). Having made the case above, I developed and evaluated an open inquiry learning model in Physics that might be of help to Physics teachers like me in concretizing the aforementioned approach in the Philippine physics classroom.

Inquiry-based Approaches

Inquiry approaches differ in the degree of teacher involvement in the inquiry process. In structured inquiry, teachers provide questions and procedures, and students present their own explanations (Pizzolato, Fazio, Sperandeo-Mineo, & Persano Adorno, 2014). In guided inquiry, the teacher asks the questions and students design the experiment that will aid in making conclusions (Pizzolato, Fazio, Sperandeo-Mineo, & Persano Adorno, 2014). Open inquiry is the most complex level of inquiry-based learning. Students face continuous decision-making through the inquiry process from identifying their inquiry questions, designing experiments or procedures, redesigning the experiments, and making conclusions (Sadeh & Zion et al., 2012). A number of studies have claimed that inquiry approaches have positive effects on science education. In fact, inquiry-based learning resulted to improved engagement in science learning, deeper conceptual understanding (Fernandez, 2017), and improved learners' metacognitive skills (Arslan & Ahwal, 2016). There are different models used in the conduct of open inquiry learning. The 5E model involves: engagement, exploration, explanation, elaboration and evaluation. Another model introduced in inquiry instruction is the EIMA model, involving four phases: engage , investigate, model and apply (Danipog, 2018). There are different models established for conducting inquiry approaches however, according to Danipog (2018), the teachers are still responsible to evaluate alternative instructional models and employ the most appropriate approach in their classrooms. Moreover, Danipog (2018) found out that inquiry practices of Chemistry teachers in selected schools at the National Capital Region are mostly teacher-centered which contradict the aim of inquiry approach. His findings suggest that their inquiry practices are more related to engaging in questioning and communicating information rather than the practice of collecting data, designing experiments, analyzing data and developing explanations. Thus, there is still a need to further evaluate teacher's practices in conducting inquiry approaches to prevent mismatch between what the curriculum dictates and what the actual classroom practice is. The majority literature suggests positive effects of open inquiry however, I cannot find a model fitting the Philippine context and Philippines lags in the actual implementation of the open inquiry approach. Thus, I conducted an action research to address this problem.

Purposes of the Research

In this action research, I developed an open inquiry learning model in Physics. Specifically, this action research sought answers to following specific objectives:

1. Develop and evaluate an open inquiry learning model in Physics.
2. Identify the difficulties encountered by the students and the scaffolds provided by the learning model.

Methodology

Research Design

I employed the educational action research design which can address my problem on the proper implementation of open inquiry in a Physics classroom. The identified design developed, validated and further improved the OILMP through series of reflections during its implementation. Using action research, each cycle of plan, act, observe and reflect dictated the necessary actions taken to further improve the OILMP. I applied qualitive methods to evaluate the model in terms of the learning experiences of the students. Open-ended questionnaire, focus group discussions, observation and document analyses were employed in the study.

Data Gathering Procedures and Analyses

I mean to present this section using the plan, act, observe and reflect cycle format, a four-step model for implementing change.

Plan

I, myself as a teacher had no prior experience on conducting open inquiry in my classes. Usually, I use lecture method, and in conducting laboratory activities, I implement structured inquiry approach. With the aim of improving my practice in using inquiry approaches in the classroom, I initially planned to conduct open inquiry learning approach. I reviewed various literatures on the conduct of open inquiry. Based on the review of related literature, I prepared the draft of the open inquiry learning model focusing on the roles of teachers and students in open inquiry. To evaluate the developed OILMP, I applied it in my Physics class, covering the topics work, power and energy. After applying the model, I investigated their learning experiences focusing on the difficulties they encountered, and the scaffolds that the model provided them.

Act

The participants of the study have no prior experience on open inquiry learning. My Grade 12 students, who are under the STEM track were my participants. My class consists of seven female students and twenty-three male students. After the literature survey, I drafted the initial OILMP. To evaluate the model, I implemented it in our class during the discussions on work, power and energy. Before the implementation of OILMP, I have conducted an orientation regarding this approach. I explained to the students that I will use a different teaching strategy because this time I want them to discover the concepts. They were well informed that implementation of this strategy is part of an action research. Respondents participated on the basis of informed consent. They were provided with sufficient information about the implications of their participation in the study. They were assured that their answers to the open-ended questionnaire, and focus group discussions will not affect their performances in the class.

Observe

During the implementation of OILMP, students were observed. Their outputs were also analyzed. To further describe the learning experiences of the students, I asked them to answer an open-ended questionnaire. Focus group discussions were also conducted to validate their answers in the open-ended questionnaire. A thematic analysis was used to analyze the learning experiences of students and to identify the difficulties they had during the implementation of OILMP. I also identified the scaffolds provided to the students by OILMP.

Reflect

The results of the analysis determined the next action. The learning experiences, the difficulties and scaffolds, determined the revisions which should be incorporated in the model. If there are positive outcomes in terms of their learning experiences, this open inquiry learning model can serve as guide for teachers who are interested to implement open inquiry learning in their Physics class. Otherwise, findings will dictate how to further improve the learning model.

Findings

Developed Open Inquiry Learning Model in Physics

Figure 1 shows the developed OILMP that summarizes the roles of teachers and students in an open inquiry learning. This model resulted from literature review on the conduct of open inquiry learning. With the related literatures I have reviewed and with the insights I have gained from my teaching experience, I came up with the following OILMP.

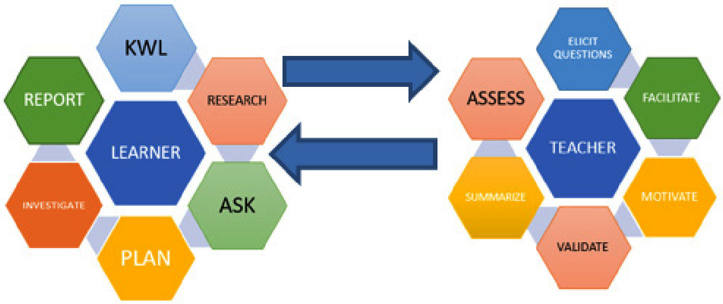


Figure 1. Open Inquiry Learning Model in Physics.

This model describes the roles of teachers and learners. The learners should complete the KWL chart, conduct research, ask questions, plan for investigations, investigate, and report findings and conclusions. Teachers on the other hand, should elicit questions, facilitate the learning process, motivate the students, summarize and validate information and assess students' performances.

Implementation of OILMP

Figure 2 shows one group completing the KWL chart at the start of the open inquiry learning. After completing the KWL chart, researches were conducted to find answers to what they wanted to know.

Figure 2. Students Drafting the KWL Chart.

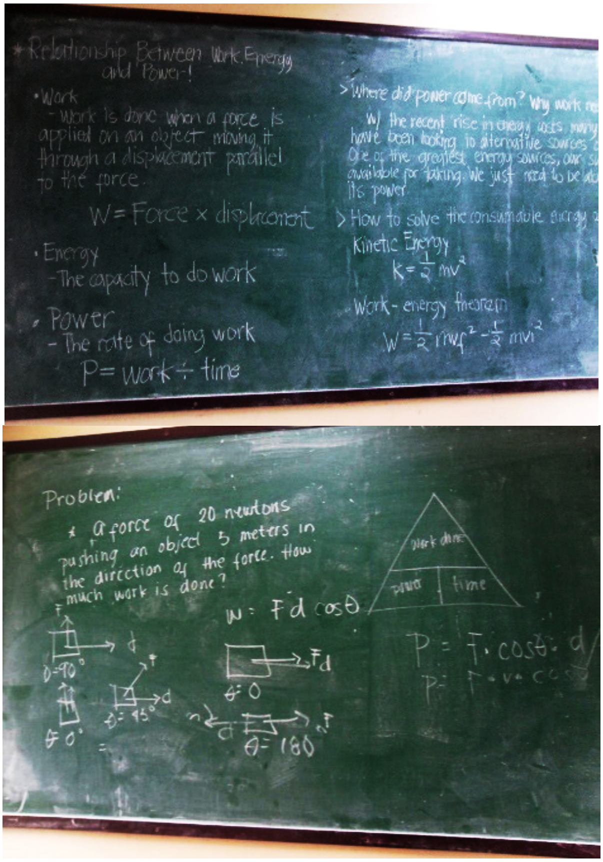


Figure 3. Sample Presentation of Students after Completing the KWL.

Figure 3 shows sample outputs of students during the presentation. Despite the fact that there were no lectures on these topics, students were still able to accurately define work, power and energy. They presented the mathematical relationship between, force, displacement and angle. Work energy theorem and some sample problems were also presented by the students. Indeed, through KWL and research, along with the aid of online resources, they can already learn and construct the meaning of the concepts. Even so, I still had to validate the concepts presented by the students to avoid confusion and also to ensure that the topics are within the context of the lessons. For example, in Table 1, students defined power in the context of electrical power, therefore I had to let them think that the context of the power that we were discussing is the power involved in mechanical work.

Table 1.

Completed KWL Chart of Selected Groups

What I know	*What I want to know*	*What I learned*
The power is your capacity to do work, when you're doing work, you consume energy.	Where did power come from? What is the relationship of these three?	In physics, power is the rate of doing work, the amount of energy transferred per unit time. The kinetic energy of an object is equal to the amount of work that is required to accelerate the object from rest to a certain velocity.
I know that we can work by exerting power. The power comes and get from energy so they are connected to each other.	I want to know how energy are get into power.	Most power plants use coal, but some use natural gas, water or even wind. The current is sent through transformers to increase the voltage to push the power long distances.

After all the groups have presented, they drafted questions that they have to investigate through experimentation. Table 2 summarizes the experimental set-up of three groups.

Table 2.

Experimental Set-ups by Selected Groups

Group	*Experimental set-up*
Group A	The inclined plane is set up with different heights of 1.27 m, .203 m and .305 m and a length of 1 m. With the aid of spring balance the cart measures 2.5 N. This is to observe if the height will affect the power, kinetic energy and speed of the cart at the end of the experiment.
Group B	We put the can in a plain. We measure the range of the can from the hitter and we got exact 2.5m, then we measure the weight of a slipper using spring balance and we got .11 kg and we try to hit the can to measure the time using a timer. We will use a formula to find the final velocity of the slipper.
Group C	We have shot two arrows with different masses and different forces using the bow for us to have better understanding about the concepts . We took the force using the spring balance, distance and time (when it reaches the ground) . We did this to answer the relationship of work and power. In order to solve work and power, we use the formula W=Fd and P=W/t

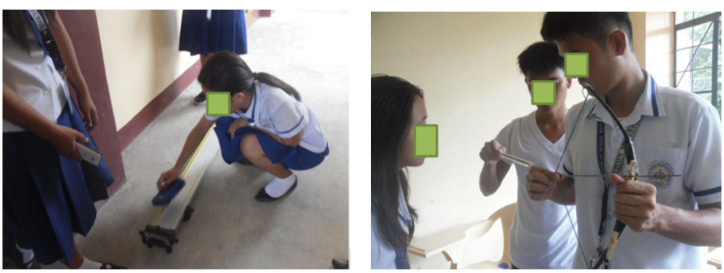
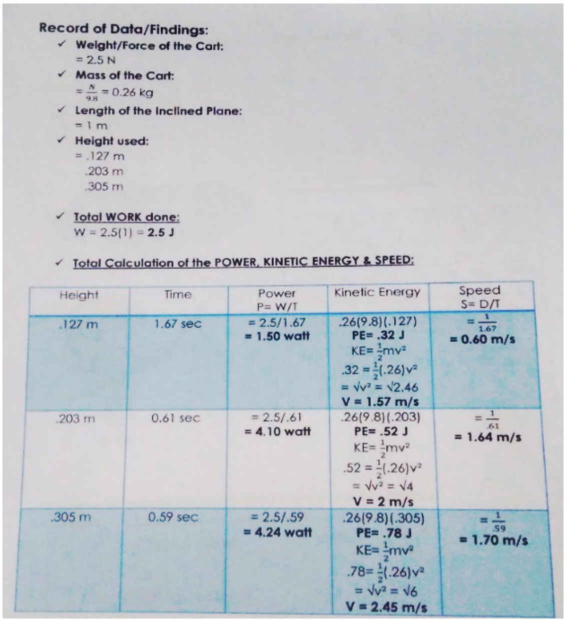


Figure 4. Experimental Set-ups by Selected Students.

Students designed their experimental procedures and decided on the materials. Some groups used rubber bands, improvised bow and arrow, dynamic carts, and inclined plane. Their curiosity sparked the investigation. During the investigation, the students had opportunity to grasp the concept, manipulated variables, observed what happens when variables are controlled, and observed how the actual set-up works.



Record of Data/Findings:

- ✓ **Weight/Force of the Cart:**
  = 2.5 N
- ✓ **Mass of the Cart:**
  $= \frac{N}{9.8} = 0.26$ kg
- ✓ **Length of the Inclined Plane:**
  = 1 m
- ✓ **Height used:**
  = .127 m
  .203 m
  .305 m
- ✓ **Total WORK done:**
  W = 2.5(1) = **2.5 J**
- ✓ **Total Calculation of the POWER, KINETIC ENERGY & SPEED:**

Height	Time	Power P= W/T	Kinetic Energy	Speed S= D/T
.127 m	1.67 sec	= 2.5/1.67 **= 1.50 watt**	.26(9.8)(.127) **PE= .32 J** $KE= \frac{1}{2}mv^2$ $.32 = \frac{1}{2}(.26)v^2$ $= \sqrt{v^2} = \sqrt{2.46}$ **V = 1.57 m/s**	$= \frac{1}{1.67}$ **= 0.60 m/s**
.203 m	0.61 sec	= 2.5/.61 **= 4.10 watt**	.26(9.8)(.203) **PE= .52 J** $KE= \frac{1}{2}mv^2$ $.52 = \frac{1}{2}(.26)v^2$ $= \sqrt{v^2} = \sqrt{4}$ **V = 2 m/s**	$= \frac{1}{.61}$ **= 1.64 m/s**
.305 m	0.59 sec	= 2.5/.59 **= 4.24 watt**	.26(9.8)(.305) **PE= .78 J** $KE= \frac{1}{2}mv^2$ $.78= \frac{1}{2}(.26)v^2$ $= \sqrt{v^2} = \sqrt{6}$ **V = 2.45 m/s**	$= \frac{1}{.59}$ **= 1.70 m/s**

Figure 5. Sample Experiment Results of Students.

Figure 5 shows that students gained understanding on how to do calculations involved in their experiments. Their prior knowledge, research and their presentations helped them in the process. Students presented their experimental design, findings, and conclusions to class, which I have validated. In the aspect of feedback mechanism, I assessed the students' performances from the presentation of research, completion of investigations and presentation of findings and conclusions.

Difficulties Encountered by Students during the Implementation of OILMP

To describe the difficulties encountered by the students during the implementation of OILMP, I analyzed the following transcripts:

Table 3.

Difficulties encountered by students during the implementation of OILMP

My Questions	Students' Responses	Construct/ Theme
Was it difficult for you to draft the questions and design for investigations? What are the other sources of your difficulties?	*Nahirapan po kasi hindi namin alam yung process na dapat iundergo para makuha naming yung accurate na sagot dun sa mga questions na binigay naming (Difficult, because we do not know the different* processes to perform, for us to answer our questions accurately)	Not having enough knowledge of the processes
	Marami kaming process na pinagdaanan Ma'am kaya hindi po sya madali (We had to undergo different processes, that's why it was not easy.)	Complex processes involved in open inquiry learning
	"*sa computation and measurement nahihirapan* (I had difficulty in computation and measurement)	Difficulty in calculations and measurements

Students had difficulties in the open inquiry learning because they did not have enough knowledge and had to undergo complex processes and calculations during the implementation. These students had no prior experience on open inquiry learning.

Scaffolds provided by the OILMP

Table 4.

Scaffolds provided by OILMP

My Questions	Students' Responses	Construct/Theme
Did you learn about work, power and energy by using this approach in learning? Along the lesson, which part helped you learn?	*Mas naging madali intindihin yung rules at saka yung laws ng physics kasi kami yung nagdidiscover hindi kami napepressure kung ano binigay samin."* (It was easier for us to understand the laws of physics because we were the one who discover and we were not pressured on whatwever information was provided to us).	Motivation
	Nung una po mahirap, kasi hindi pa po napag-aralan, kami po yung nag aral pero dahil dun sa questions dun nabubuo aming ideas, dun din po parang exciting po sya gawin kasi dun po naming makikita na natutunan po naming yung topic. (At first, it was difficult , because we did not discuss the topics yet, we were the one who studied the topics but because of our questions, we were able to develop ideas, it was exciting to answer the questions because through that we will be able to know if we learned something about the topic.)	
	Kasi may sinusundan ka pong questions, kaya may guide ka na (We already have our questions, that's why we already have a guide)	Questions
	Teamwork, dahil yung lahat ng mga katanungan ng mga kgrupo mapagsasamasama (Teamwork, because all the questions of the members were combined.)	Teamwork
	Madali kasi nakapagbrainstorm, naidentify yung mga variables na gagamitin (It was easy because we had brainstorming , we were able to identify the variables to be manipulated)	Brainstorming/ Communication
	I guess it was easy for me because I can use internet to browse it and I will find my answer on my own."	Internet resources

Was it easy for you to design your experimental set-up , why? Did you learn from your investigations?	*Hindi naging mahirap at madali lang humanap ng materials* (It was not difficult because it was easy to look for the needed materials).	Availability of Materials
	Pinakanatuto po kami sa pagcoconduct po ng research kasi sa experiment po naming Ma'am isang experiment lang po, hindi katulad nung sa research na marami po kaming nakitang examples (we have learned most through research because in the experiment, we only had one experiment, unlike when we did the research, we were able to see more examples.	Research
	Mas maganda dahil hands -on , mas tumatak sa isipan nagkaroon kami ng first hand basis dun sa gagawin naming Ma'am kasi hindi lang kami nakikinig, nakikita pa namin at naeexperience yung mismong subject (It was better because it was hands on, there was more retention of ideas, we had our first hand basis in the activity, we did not only listen, we were able to see and experience the subject itself)	Hands-on experimentations
	With the help of the teacher, we identified what we are about to present."	Teacher's assistance

Based on the abovementioned transcripts, the OILMP elicited students' motivation. According to some of the students, they were excited in learning the concepts on their own. Therefore, students were intrinsically motivated to list the questions, do research and conduct investigations. Teamwork scaffolded students' learning processes. Through collaboration, they brainstorm or shared their ideas with their groupmates to come up with the experimental designs. Aside from communication within the group members, students also learned through communication among other groups. Reporting their research and findings can help them learn from one another. Therefore, it should be noted that in conducting open inquiry, students should be given a chance to report their research and their findings. Another strength of the OILMP is that it provided the students with hands-on experience during the research and experimentation. Students did not experience difficulties in performing the experiments because they planned for the materials used and planned the procedures of the investigation process. My assistance, as their teacher also provided scaffold in the learning process. I facilitated the learning process by assisting and motivating the students and by validating the information they present as well. Teachers should also assess the students throughout the open inquiry process and should immediately provide feedback. Information available online also anchored the learning process. However, in the process, students should evaluate the information they retrieved from the internet. Teachers had to assist students in limiting the context of their investigations within the topic covered in class.

Discussion

Open Inquiry Learning Model in Physics

Majority of literatures make use of open inquiry approach in the investigation stage. However, with the use of OILMP, I aspire to engage the learners in the actual discovery of the concepts before the investigation. Given the circumstances, the students are tasked to complete 'What I know, What I want to know and What I learned' chart so that I am able to assess their prior knowledge about the topic. Correspondingly, students developed their knowledge based on their prior knowledge and observations (Zion, 2012). I resolved to give my students autonomy in identifying what they want to learn about the topic as long as the context was stated and specified to them. This strategy can give the students sense of ownership in the learning process as well. They first answered their inquiries by conducting research using resources or references available to them. Afterwards, to check their conception about the topic and to verify if the researches are within the context, they were required to present their research. During the presentation, I have identified and analyzed their misconceptions, and those must be addressed immediately. On the other hand, students exposed to open inquiry are responsible in determining the purpose of their investigation, can plan and conduct experiments, interpret data from the experiments and use results to justify the conclusions (Teig et al., 2018). Hence, the model should reflect these tasks of the students. In the model, the roles of the students like asking, planning and investigating were incorporated. These roles may provide them with first-hand experience to understand and appreciate science concepts. Then, students were asked to draft new questions which can be answered through experimentation. After finalizing their questions, they also planned for the experimental design and performed their investigations. Reporting of results and conclusions were included in OILMP because as stated by Pedaste et al. (2015), discussion is always involved in every phase of inquiry approach, where students share their results and conclusions to their groupmates, classmates and teacher. Connectedly, teachers in open inquiry act as facilitators. In the KWL stage, teachers may elicit questions from the students. Along the process, teachers should motivate students because negative attitudes of students towards Physics hinder the conduct of inquiry work (Zezekwa, 2011). Besides, as specified by Mcnew-Birren and vand de Kieboom (2017) in the process of facilitating student engagement, teachers often utilize questioning to guide students through scientific inquiry. In addition, according to Pedaste et al. (2015), discussion phase is present at any point of inquiry which enable clarification of conceptions of students. During this phase, teachers had to validate and summarize information to avoid misconceptions. Since assessment is vital in the learning process, another role of teachers is to assess the students in open inquiry learning model, through different forms such as written examinations, performance tasks, and self-assessments. Constructivism adopts collaborative work (Taneri, 2010); therefore, in doing an open inquiry learning approach, students should form small groups as this can maximize the involvement of each student in the discussion.

Difficulties Encountered by Students in OILMP

My conduct of open inquiry brought some difficulties and challenges on the part of the students. Not having enough knowledge on the processes they had to do is one of the difficulties they experienced. These students were used to 'cook-book' type experiments, where all the processes are dictated to them, a shift in the learning approach caused them difficulty. Additionally, in OILMP, they had to face complex processes from identifying the problems to be solved to discovering how variables can be predicted using equations in work, power and energy. They also had difficulty in calculations and measurements because they were used to lecture methods in discussing concepts and sample problems. This finding agrees with Arslan Buyruk (2014), where pre-service teachers applied an open inquiry approach, they had difficulty because it was their first time to meet with an inquiry-based laboratory set-up. To address the concern of students, there should be more exposure to this learning approach. As students get exposed to this learning pedagogy, the difficulties they experience can be eliminated. Thus, it is indeed necessary to conduct an orientation before this model is implemented to the classroom.

Scaffolds Provided by OILMP

The open inquiry approach involves complex processes that may even lead to frustration of students. On the contrary, it was found out that it provides scaffolds for students' learning. These scaffolds are motivation, questions, teamwork, brainstorming or communication, internet resources, availability of materials, research, hands on experimentations, and teacher's assistance. In OILMP, the teacher motivates the students to learn and finish the tasks. Letting the students decide what to investigate already aroused their interest towards the subject. According to Sadeh and Zion (2012), students express more motivation and interest when they choose the subject they like and when they collect and analyze their own data. Starting an open inquiry learning approach might be difficult because students and teachers have no idea where to start. As such, in OILMP, the questions in KWL served as students' outline for discovery. Their list of questions gave them focus on what to investigate. Similarly, inquiry based learning has the learners' questions, ideas and reflection at the center of the learners' learning experiences (Alamedine & Ahwal, 2016). Moreover, teamwork and collaboration also have scaffolded students' learning process. They brainstorm and share their ideas with their groupmates. Such processes highlight inquiry approach as collaborative in nature, where students worked in teams, brainstorm, share ideas in order to meet one goal (Alamedine & Ahwal, 2016). Conduct of research and online resources have played a major role in the OILMP for the reason that students have seen more examples and applications through online resources. As stated by Unlu (2015), web-based inquiry can improve science process skills of students, and technology can help students visualize the lesson, especially in the case of failed experimentations, they will still be able to answer their inquiries through online resources. Along with it, hands-on investigations also provided students with evidence-based explanations (Teig et al., 2018; Weiland, 2012). While according to Unlu (2015), insufficient materials for data-gathering impedes the implementation of inquiry in Physics classrooms. This concern was addressed by OILMP since the students decided on what materials were used in their investigation. Teacher assistance, information validation and processes implemented on addressing misconceptions also aided learners to accomplish their tasks in open inquiry. These scaffolds are very crucial in an open inquiry model, to avoid students developing incorrect information (Keselman, 2003, as cited in Arslan Buyruk, 2014).

Implications of the Study and Self-reflection

Many teachers are hesitant of conducting open inquiry in classrooms, some of the reasons are the skills of students and the resources available, but in this study, I learned that students can easily adopt to the implementation of the new learning approach. Proper orientation is needed so that they can prepare themselves for the different stages that they have to undergo during the implementation. Open inquiry approach can also be used in establishing the concepts with the students. It is necessary to allow students to use available resources, books, online resources where they get information about the concepts. However, teachers had to validate the information that students are presenting to make sure that it is correct and within the context of the topic. Another problem in conducting open inquiry approach is the lack of laboratory equipment in schools. But as can be seen in this research, students were resourceful that they designed their experiments so that the materials they need are readily available. Another problem is the time constraints, indeed implementation of OILMP took around four weeks. However, students had more chance on learning and conducting investigations on their own. There are so many online resources where students can get information and learn concepts, but are we giving them enough opportunities to develop their 21st century skills? It is time to review our curriculum and look into how we ensure that students develop the skills they need. Assessment and feedback system should also be done all throughout the open inquiry processes, to ensure that students are learning from different stages. To maximize the benefits of open inquiry learning approach, this should be applied continuously in the classroom setting. The following figure shows the improved OILMP as a product of investigations and constant reflection. For the roles of teachers, I added orient, ask and provide feedback. For the students who will be exposed to open inquiry for the first time, an orientation about the learning approach and the tasks they had to complete is necessary. During the discussions, teachers should constantly ask questions to validate the information presented by the students. They should also provide constant feedback for students to validate their conceptions.

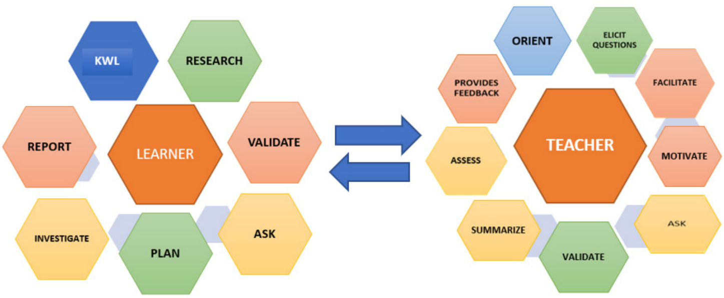


Figure 6. Modified Open Inquiry Learning Model in Physics.

Conclusions, Implications and Future Directions

Open inquiry learning approach has positive effects on Science education, however, despite the efforts of the Department of Education, there is still a gap in the effective implementation of inquiry-based teaching in the Philippine classroom (Gutierez, 2015). One of the reasons for this gap is the absence of a clear model of open inquiry learning. Hence, this action research aimed to develop and evaluate OILMP to help Physics teachers concretize the approach in the Philippine physics classrooms.

The developed OILMP describes the roles of teachers and students in inquiry learning. In this learning model, learners are tasked to complete KWL chart, conduct research, validate information they retrieved, ask questions, plan for investigations, investigate, and report their research and experiment findings. Teachers play a vital role in the learning process. Teachers should orient the students of the inquiry approach. They should elicit questions when students could not decide on what they want to investigate. Teachers are tasked to facilitate the learning process and motivate the students to learn. During presentations, the teacher should immediately address any misconception. It is very important for teachers to summarize students' learning. Assessment should also encompass concept attainment, performance in research, experimentation, and presentation. Immediate feedback should also be given to the students.

Open inquiry brought some difficulties to the students, they had to face complex processes, and calculations. Another cause of difficulty is the absence of experience with open inquiry learning prior to the implementation of the study.

Although students experienced difficulties, the OILMP provided scaffolds for students' learning. The questioning stage gave students the motivation to learn more and do investigation. It is evident that they are intrinsically motivated throughout the learning process since they have decided on what they wanted to learn. The research provided them chance to learn on their own. At this stage, they evaluated the validity of the content from the reference materials. Online resources provided valuable support in the implementation of this model, as it may assist students to having a meaningful learning experience.

The OILMP presented in this paper could serve as a guide for teachers who attempt to conduct open inquiry in the classroom. More exposure to open inquiry learning model can eliminate the difficulties faced by the students. A gradual shift from guided inquiry to open inquiry learning is also suggested. This model may provide significance to the teaching and learning process of Science, geared towards simulating the real nature of Science in the classroom. The findings can be translated into changes in the conduct of an open inquiry approach, as it provides a detailed process of what students and teachers should do. This model can also be adapted in professional development programs and teacher trainings.

Some limitations were identified along the course of the investigation. The effectiveness of the learning model in terms of concept or skill attainment was not covered in the study. Future studies could use this model and evaluate its effects on concept and skill development. Expanding data gathering and analyses over a longer period for more encompassing outcomes is also suggested.

To validate the OILMP further, a teacher training introducing the model may be conducted. A longitudinal study on the effects of OILMP to the actual teaching practices or pedagogies may also be investigated.

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