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An Evaluation of the Effect of the Improvised Experiments on Student-teachers' Conception of Static Electricity

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Abstract

This study is investigating the student-teachers' conception of static electricity in Rwandan teacher training colleges. The study used a pre- and post-intervention design, where two groups of students were randomly assigned in two groups. Along a period of four weeks, one group was taught using the traditional method (TRAD) while another using improvised experiment (IME) method. The student-teachers were given a test before teaching while after teaching the same test was administered to both groups. The study was not interested in testing student-teachers' achievement rather the conception of static electricity. The test was composed of six item questions and their answers were coded as "out of the topic, unrelated information and opposite answers". After performing pre-test, student-teachers showed confusions related to non-mastery of content and alternative conceptions related to static electricity and magnetism. Though about 27 per cent and 17 per cent of student-teachers in TRAD and IME respectively, reduced the gaps in their confusion after getting teaching intervention, however, there was found to be no statistically significant difference (p>.05 at df=10) in all of the item questions between these teaching methods in favour of IME. Four item questions showed an improvement while student-teachers developed more conceptual confusions in other two item questions. Not only examining student-teachers' conception in static electricity but also teachers were recommended to be aware of students' ideas, opinions and confusions prior to their lesson planning, teaching materials preparation, as well as teaching implementation.

Keywords: Conceptions, Static electricity, Improvised experiments, Student-teachers

Introduction

Rwandan mission of poverty reduction and enhancing the well-being of the population through improving skill levels and alleviating economy is assured by equitable access to quality education, promotion of science and technology, critical thinking, and positive values (MINEDUC, 2013). In this regard, teacher training colleges are taken care since they are the ones offering certificates for teaching primary level. In fact, in Rwanda, after completing an ordinary level (grade 7-9), students have three options to upgrade to the advanced level. These are general schools (GS) focussing on science and mathematics, languages and literature, and social sciences and humanities; primary teacher training colleges (TTCs) focussing on training primary teachers, and technical vocational education and training (TVET) focussing on workforce development. Generally, science is one of the important courses that will help students to cope with the problems they encounter in daily life and understand nature (Benzer, Bayrak, Eren, & Gürdal, 2014). Specifically, Physics teaching in Rwanda is taught with challenges of lacking enough and adequate laboratory activities as well as lack of teachers' experimental kills (Ndihokubwayo, 2017), therefore, the major decision should be taken into consideration to teach physics in an effective way. Consequently, learning and teaching method for better science lesson should focus not only on the teachers but also on the student-teachers, this research will target the teacher training colleges in Rwanda as a source of basic and delivering knowledge and skills in order to recommend future primary teachers to conceive the modern classroom and learner-centred as well as relating science to the real world.

Actually, the basic issues in learning science in general and physics, in particular, should start from the fundamental knowledge deliverers—student-teachers—since the core aim of education is to improve their understanding of scientific concepts. This should be channelled through active learning. According to Tarhan and Sesen (2010), during active learning, the participation of students is needed in order to support them to be more expressive in the learning process. By conception of static electricity, we mean alternative conceptions—like the misunderstanding between electrostatics and magnetism—or misconceptions, confusions rooted from non-mastering of the concepts, gaps in the students' understanding, struggle with language and terminologies of a certain word or graphical interpretation, and inaccuracy in remembering concepts, formula or laws. Apart from the lack of basic understanding and confusion, alternative conception in this study may also mean the student explanations which are scientifically inconsistent with the knowledge. For instance, if teachers want to get the success of their students, they are advised to pay attention to how they learn and they must teach them physics lesson as a scientific problem (Daniela et al. 2015).

Therefore, doing experiment may improve learners' understanding of information and helps them to develop problem-solving, analytical and critical thinking skills in the active learning environment as well as positive attitudes towards science. Despite the experiment in general, improvised experiment role-plays at enhancing a learner-centred teaching approach. For instance, Bhukuvhani, Kusure, Munodawafa, and Sana (2010) believe that improvised experiments are the pedagogical intervention strategies enabling teachers to make and use locally available materials to substitute conventional equipment unavailability.
Several researchers have pointed out some physics alternative conceptions. For instance, electrostatic induction was revealed as a difficult concept to learn (Akdeniz, Bektaú, and Yi÷it, 2000), and most of the students showed difficulties in learning the concept of

electricity (Çığrık & Ergül, 2009), however, the study of Başer and Geban (2007) showed that learning activities based on conceptual change conditions effectively caused a better acquisition of conceptual change of static electricity concepts than the traditional instruction. While investigating into students' understanding of the transfer of charge between two charged conductors (Guruswamy, Somersddag, & Hussey, 1997), it was found that a considerable number of students from the eighth graders in physics course were unable to predict the transfer of charge correctly from one conductor to another. In a study designed to determine the difficulties in understanding the interactions of electric charges with magnetic fields, among the reasons given by physics teachers were that magnetic force situations are three dimensional, the right-hand rule is an unusual procedure which is often misunderstood by the students (Maloney, 1985). While determining the university students' conceptions about some electricity concepts, the students were asked to write their reasoning in the electricity concept test, it was found that students showed common misunderstandings (Bilal & Erol, 2009). In an exploratory study about understanding of basic concepts of electric and magnetic fields revealed some students' concept confusions in source of current, electric field, and magnetic field; the results also showed the students' alternative understanding in the effect and direction of electric and magnetic fields and forces on materials (Hekkenberg, Lemmer, & Dekkers, 2015).

In a study of how students construct knowledge about electricity and magnetism by dawing upon aspects of their experiences during the course of a school visit, it was found that there is a strong relationship between learning from school, home, and in informal learning situations, therefore recommending teachers to use science museums and similar centres (Anderson, Dierking, Lucas, & Ginns, 2000).According to constructivism, learning happens in constructing the knowledge in the mind of the learners; therefore, determination of students' alternative conceptions is very important in terms of choosing the right teaching methodologies (Seçken, 2010). The author continues to say that the conceptual misunderstanding develops when students are taught rote concepts and not let them think and overcome the non-scientific beliefs themselves. According to Redish (1994) and Daniela et al. (2015), Physics as a difficult discipline for many students requires to use a variety of modalities and frame into various interpretations and different multiple representations. Consequently, most curricula now emphasize on understanding rather than knowledge and processes rather than content because these approaches put great emphasis on learning through discovery, provision of science education in experimentation and practical work (Angus & Keith, 1992). Therefore, one reason to identify student wrong conceptions and remedy them is to empower and increase meaningful learning and contribute to students' academic success (Aydin & Balim, 2009). Since the student-teachers from TTCs were found to poorly perform in physics in general and in static electricity in particular (Ndihokubwayo, Uwamahoro, & Ndayambaje, 2018). Therefore, this study will reveal possible student-teachers' different and common conceptions rising on static electricity unit. The present study tends to evaluate the effect of improvised experiments intervention on student-teachers' conceptions in static electricity unit. Therefore, the research question related to this objective is: To what extent the IME intervention overcome the confusions that student-teachers have in static electricity unit? The study will add to the existing literature on the analysis of student-teachers' low conceptions and remedy them with an IME method. It will be of immeasurable value to educators, teachers, curriculum designers, policymakers as well as those involve with teaching personnel training. Student-teachers will also have more opportunity to fill the conceptual gap and complete their conceptions.

Research Methodology

This research focused on year 1 students (grade 10 or senior 4 of TTCs) as our target group since static electricity which belongs to the chapter of electricity was taught in this grade (Ndihokubwayo, 2016 pp128) during the year 2015. In this study, conceptual understanding open questions (Ndihokubwayo et al., 2018) prepared by the researchers were administered to collect data in order to reveal the student-teachers' conception of static electricity. The data were described qualitatively as well as quantitatively. This is to say, the presentation of data was presented in tables in the form of texts of different conceptions in static electricity with the correspondents' number of student-teachers. This research is a true experiment. It used the randomised pre-test and post-test control group design (Fraenkel, Wallen, & Hyun, 2012) in a way that two classrooms of 96 students were mixed and randomly selected from counting 1 and 2 so that students with the same number were assigned to one group. Let say students who counted 1 they have an odd number and joined traditional teaching group (TRAD) while those who counted 2 they have even number and assigned to improvised experiments group (IME). The objective of the testing the contribution of improvised experiments on scientific understanding has been also measured by pre-test and post-test to check the extent that student-teachers fill their conceptual gaps in static electricity after an IME intervention.

Prior to teaching intervention, a pre-test was administered to both classrooms of 48 student-teachers in TRAD and 48 student-teachers in IME in order to disclose basic different conceptions they might have. After pre-test, the corresponding researcher taught both classrooms during a period of four weeks. TRAD classroom (control group), student-teachers were taught using chalk and blackboard while IME classroom (considered as the treatment group), student-teachers were taught using chalk, blackboard, drawing, and electrostatics-related experiments. In those four weeks of intervention, a session of four lessons for each group was covered as follow; Electrification by friction, contact (conduction) and induction; Electric intensity and lines of force: (i) Isolated charges (ii) unlike charges (iii) like charges; Electrostatic potential; and Thunderstorm and lightning phenomenon. The lesson plans structure in both TRAD and IME groups are presented in Table 1.

Table 1 Lesson plan in both TRAD and IME groups

Lesson plan sections	TRAD	IME
Introduction	The researcher presented a problem by drawing an object on the blackboard to stimulate the student-teachers interests;	The researcher presented a problem by showing a real object to students to stimulate the student-teachers interests;
Lesson development	Videos such as the lighting phenomenon and different ways of electrostatic charging were watched There were no experiments apparatuses created	Videos such as the lighting phenomenon and different ways of electrostatic charging were watched Student-teachers were provided with locally available materials, then with the guidance

	There were no experiments done rather Student-teachers used discussed in groups using textbooks The researcher explained and taught the content using blackboard and chalk	of researcher, they created experiment apparatuses Experiments were done in groups The researcher explained and taught the content using blackboard and chalk
Conclusion	Student-teachers were given the opportunity to present their findings from their readings Researcher provided a summary of the lesson.	Student-teachers were given the opportunity to present their findings from their experimentation Researcher provided a summary of the lesson.

In IME group, several experiments such as Pencil spin and Ping-Pong ball, Straw and balloon that can bend water, Cans can walk, Balloons can stick on the wall, Electroscope using plastic bottle and wires, Plastic cup capacitor to provide amount of charges and volts, and Van de Graff generator to explain thunderstorm phenomena were done. Finally, with same student-teachers performed a post-test, the conceptions have been also measured to check the extent to which different conceptions have been completed. The same test was administered in pre- and post-test. This comprised by item questions related to the understanding and analysis of static electricity, the concept of charges, and the application of static electricity. The questions were validated by Ph.D. classmates from IDEC[1]/Hiroshima University. By the sake of reliability, after removing highly lowly performed items, 6 item questions have served the test of this study.

Data Analysis and Findings

Each item question has been analysed independently and its findings are displayed in Table 2. The first column presents grouping criteria, while the second column shows some examples of common conceptions. The numbers under pre/post tests indicate student-teachers in a certain criterion over 48 student-teachers sat for both tests. Apart from several groups such as “Nothing is written” and “Correct answer” which were not the interest of this study, the common grouping criteria of different conceptions considered herein

[1] IDEC: Graduate school for International Development and Cooperation

were (a) Out of the topic, (b) Unclear information, and (c) Opposite answer. These “out of the topic” or “unrelated information” are caused by the gaps in the student’s understanding, and “unclear information” put forward struggle with language and terminology while “opposite answers” take a root from an inaccuracy in remembering the concept, formula or a law.

Table 2 Item questions with common conceptions

Grouping Criteria	Example of common conceptions	TRAD		IME	
		Pre	Post	Pre	Post
First item question: Law of electrostatics					
A-Out of the topic	*$F=KQ_1Q_2/r^2$ (Coulombs’ law) *North and south poles attract each other, south and south or north and north poles repel each other *Heat can pass through 3 ways: conduction, convection, and radiation	8	2	8	3
B- Unclear information	*-Negative charge -Positive charge *Unlike charge gives light, like charge does not give light	9	6	18	16
C- Opposite answer	Same charges make attraction and opposite charges make repulsion	1	1	0	1
Second item question: Definition of static electricity					
A-Out of the topic	It is the capacity of heat and magnet	3	1	2	1
B-Unclear information	*Study of electricity and how current works *The energy that produce light, that helps to see	21	13	29	21
C-Opposite answer	Study of charge in motion	10	8	9	8
Third item question: How to test different charges					
A-Out of the topic	Magnetism description *(See Figure 3a)*	3	3	4	0
B-Unrelated information	Cells description *(See Figure 3b)*	21	11	21	9
Fourth item question: Interpretation of different electroscope graphs					
B-Unrelated information	*This figure is a discharge then will change gold leaf to be diverging *This situation is gold leaf electroscope	20	26	17	25
Fifth item question: Use and application of static electricity					
B-Unrelated information	*Static electricity is used in the house, school *Torch *Pulley …	39	10	30	14
Sixth item question: Proper distribution of charges on the sphere					
B-Unrelated information	Selection of all letters (A, B, C, D, and E	5	3	4	2
	Selection of the only E	10	17	8	10
	A mixture of true and false letters (e.g. A, D, and B, C, E)	21	20	14	25
C-Opposite answer	No any true letter (e.g. B, C, and E)	3	3	5	4

First item question

From Table 2, it is shown that there was an enormous change in group A (under the first item question about the law of electrostatics). After the intervention, 6 out of 8 and 5 out of 8 student-teachers move from pre-test to post-test in TRAD and IME groups respectively. So, this means that 6 and 5 student-teachers from TRAD and IME respectively are no longer providing ‘out of the topic answers’ after the intervention. The common conceptions in this statement of a law item are that student-teachers confuse electrostatic law with other laws like Coulomb’s law and magnetism in pre-test (example see group A under the first item question), however, this confusion is reduced to 75.00% and 62.50% in TRAD and IME respectively after the post-test.

Second item question

The second item question was asking the definition of static electricity. Most of the common conceptions lay between group B of unclear definition and group C of opposite answer where most of the student-teachers are not able to define static electricity where they provided unclear information like “Study of electricity and how current works”. For instance, after the intervention, 8 out of 21 and 8 out of 29 student-teachers move from pre-test to post-test in TRAD and IME respectively (see group B under the second item question). So, this means that 8 student-teachers are no longer providing “unclear definition” after the intervention. Not only describing unclear definition but also instead of “study of electric charges at rest”, student-teachers misunderstand and give opposite definition “study of charges in motion” (see group C under the second item question in Table 2) in both tests. However, this unclear definition is reduced to 38.09% and 27.58% in TRAD and IME respectively after the post-test.

Third item question

The third item question was asking student-teachers using drawings to test different charges. It shows that they described magnetism poles instead of electric charges (see group A under the third item question in Table 2 and Figure 1), however, this alternative conception was reduced at 100% in the post-test in IME while nothing changed in TRAD.

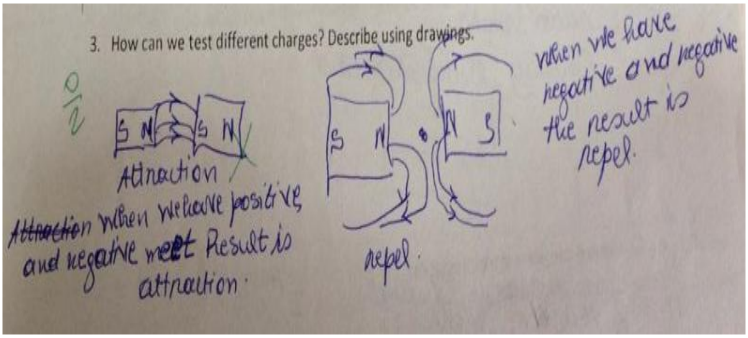

Figure 1 Alternative conception of testing different charges

Additionally, confusion arises where student-teachers mention unrelated information, (see group B under the third item question, Table 2 and Figure 2), however, this confusion is reduced to 47.61% and 57.14% in TRAD and IME respectively after the post-test. Additionally, without describing, some student-teachers think that only graphs are enough (struggle with language and terminology).

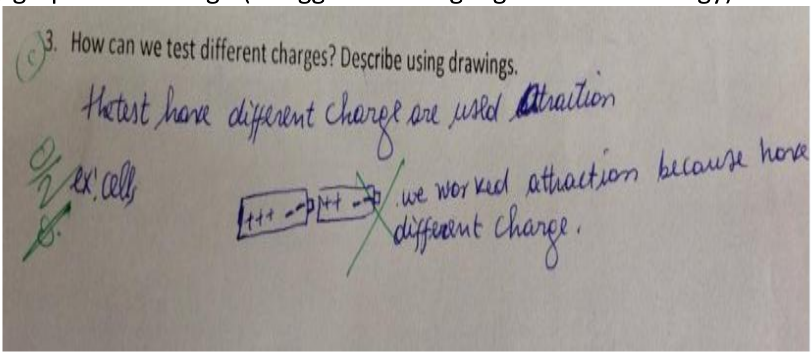

Figure 2 A gaps in the student's understanding, on testing different charges

Fourth item question

The fourth item question was about the interpretation of different electroscope graphs. Unrelated and insufficient information noticed a remarkable change in group B (under the fourth item question, Table 2). Unfortunately, confusions and gaps in the student's understanding increased after teaching intervention at a rate of 23.07% and 32.00% of student-teachers in TRAD and IME respectively after the post-test. This means that student-teachers got more confused as they get IME intervention. Additionally, most of the answers are incomplete or not relevant, insufficient and unclear to question in post-test than pre-test (Figure 3).

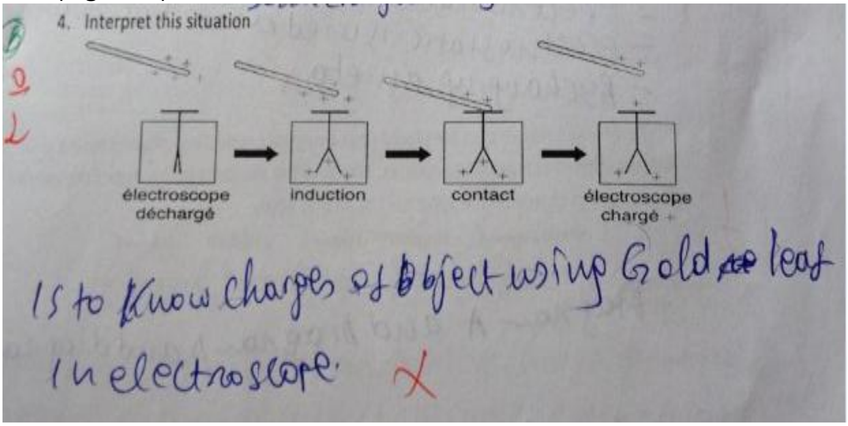

Figure 3 A gaps in the student's understanding on Interpretation of electroscope

Fifth item question

The fifth item question was about the use and application of static electricity (examples that apply static electricity). An enormous change in group B under the fifth item question where most of the student-teachers wrote answers that do not make sense, they just provided insufficient information like "static electricity is used in the in the house, school, …" (see group B in Table 2 under the fifth item question). Twenty-nine out of 39 and 16 out of 30 student-teachers from TRAD and IME respectively move from pre-test to post-test. So, this means that 29 and 16 student-teachers from TRAD and IME respectively are no longer providing answers that do not make sense or insufficient information after the IME intervention. Therefore, this confusion is reduced to 74.35% and 53.33% in TRAD and IME respectively after the post-test.

Sixth item question

The sixth item question asked to list all images that are right in terms of charge distribution. Apart from choosing several answers, student-teachers misunderstood charges distribution. Diagram E shows entire positive distribution and this can never happen, student-teachers confuse neutral charges with blank space, this was counted as a common misunderstanding (an example of a mixed answer including letter E, see group B in Table 2 and Figure 4). The selection of the letter E as the answer was higher than other letters and their mixture. In the student-teachers' answers, it counted 20.83% and 35.41% in pre- and post-test respectively of TRAD while 16.00% and 20.83% were counted in pre- and post-test respectively in IME. Unfortunately, confusions and inaccuracy in remembering concepts have been increased after teaching intervention at a rate of 41.17% and 20.00% in TRAD and IME respectively after the post-test. This means that student-teachers got more confused as they get intervention and answered the letter E.

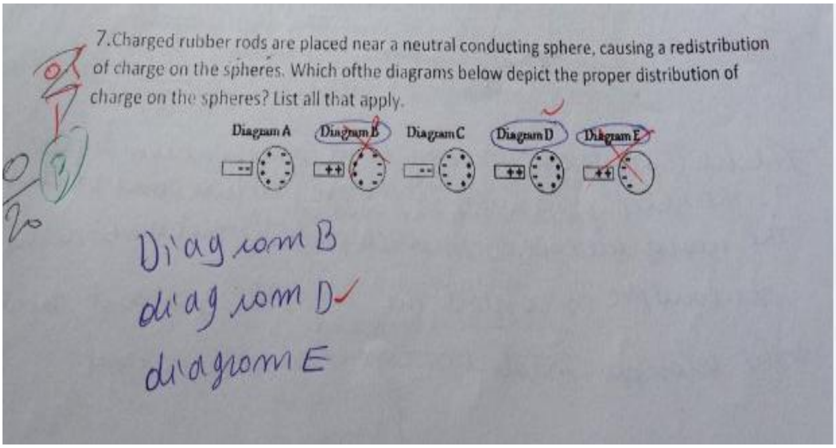

Figure 4 Inaccuracy in remembering concept on the proper distribution of charges on the sphere (source: www.physicsclassroom.com)

To sum up the above results, the overall observation is summarized in Table 3. The student-teachers before-and-after intervention ratios were 29/21 and 28/23 from TRAD and IME respectively in terms of conceptions of static electricity. This means that on average, 8 out of 29 and 5 out of 28 student-teachers from TRAD and IME respectively overcame and completed their low conceptions after performing the post-test. Table 3 shows a number of student-teachers in grouping criteria of common conceptions from pre- and post-test as well as the difference between both tests.

The overall mean scores of all item questions in TRAD and IME methods were found 27 and 14 per cent of student-teachers respectively in terms of filling their low understanding, however, there was no statistically significant difference (p>.05 at df=10) between these teaching methods. Therefore, the IME did not make a significant difference in students' understanding of static electricity. This means that the TRAD method overcame low conceptions at a rate of 27 while IME completed student-teachers' conceptions at a rate of 14.

Table 3 Average number of student-teachers with common conceptions

Item	Grouping criteria	TRAD		IME		Pre-Post (D)		D/pre*%	
		Pre	Post	Pre	Post	TRAD	IEM	TRAD	IEM
1	A, B, C	18	9	26	20	9	6	50	23
2	A, B, C	34	22	40	30	12	10	35	25
3	A, B	24	14	25	9	10	16	42	64
4	B	20	26	17	25	-6	-8	-30	-47
5	B	39	10	30	14	29	16	74	53
6	B, C	39	43	31	41	-4	-10	-10	-32
Mean		29	21	28	23	8	5	27	14

Discussion of Findings

The present study aimed at overcoming low understanding and completing common conceptions of student-teachers in static electricity using IME. In this study, the first item question aiming at determining the alternative conceptions of student-teachers about static electricity which is constituted by stating two laws of electrostatics, the inaccuracy in remembering concept, formula or a law found were Coulomb's law and the magnetism's law. The misconceptions between static electricity and magnetism were also realised. This may be caused by non-mastery of content or student-teachers are not able to differentiate these laws. Not only the present study but also other studies have provided results on student conceptions. For instance, Sözen and Bolat (2011) using the data from the analysis of quantitative and qualitative questions they found that student-teachers have different conceptions related to sound transmission. Additionally, in the study of Kartal, Öztürk, and Yalvaç

(2011), 75% of student-teachers have chosen incorrect answers in heat and temperature test as a consequence of heat flow.
Taking a look at the second item question about static electricity definition, it was difficult for most of the student-teachers to reduce inaccuracy in remembering the concept of giving opposite definition "study of charges in motion" in the post-test. Opposite answer may be caused by making mistake or the struggle with language and terminology.

Generally, most of the researches have exposed student-teachers that they do not understand the abstract concepts of heat, light, electricity, magnetism which encounter in physics (eg. see Welzel, 1998 and Küçük et al., 2005). For instance, when the different conceptions in third item question—using graphs in order to test different charges—were analysed; it was seen that enormous reduction—16 out of 25 student-teachers are no longer showing the confusions (Table 3)—appeared; however, an alternative conception between static electricity and magnetism was again realised. For instance, student-teachers still have confusion in describing magnetism poles even after IME intervention. This may be caused by non-mastery of content. Nine student-teachers still fail to provide related information even after post-test (Figure 2). This is caused by the fact that they use frequent examples in their homes like cell batteries where they see drawn symbols of positive (+) and negative (–) charges.

The content may also be new to student-teachers and the teaching time was not enough to digest the necessary and important concepts. In addition, this is also well explained by Küçük, Çepni, and Gökdere (2005) that the most of the alternative conceptions take the source from students' daily life experiences and different cultures they live in (Harrison, Grayson, & Treagust, 1999). As a result of analysis of drawings and multiple choice questions, not only this study but also (Sözen & Bolat, 2011) found that student-teachers do not notice that sound is heard by reflection and the particles in the medium transfer energy by vibrating while the sound is being transmitted they just thought that matter moves in the direction of the sound transmitted.

In the fourth item question about electroscope interpretation, the increase of 8 student-teachers with gaps in their understanding in the post-test has appeared. This made student-teachers to give more incomplete or irrelevant answers even after studying, these seem as "the figure is a discharge then will change gold leaf to be diverging" or "this situation is gold leaf electroscope". This might be caused by the difficulty of the item which does not fit their cognitive level. It may also be caused by the fact that after the intervention of lesson, a new content to student-teachers was introduced since this concept needs a lot of time to conceptualize. Another reason may be that they are not used to this kind of question of "interpretation". Moreover, this is in contrast with an improvised experiment teaching method that it implies student-teachers understand better when they are engaged in hands-on activities. For instance, according to Bhukuvhani, Kusure, Munodawafa, and Sana (2010), during the improvised experiment, scientific concepts are learned and internalized easily by the learners rather than proceeding with chalk-chalkboard and teacher-talk.

"Where can we use static electricity? Give other examples that apply static electricity" (the fifth item question). Improvement due to IME has been shown by 16 student-teachers in post-test, however, 14 of them couldn't escape writing unrelated conceptions like "static electricity is used in the school" in the post-test. This is because the learning style of the traditional method where they are used to learn, it is just only the concepts and no discussion of the role of what they learn in school and no hands-on activities to see really how to apply those concepts. Additionally, the gaps in the student's understanding together with struggle with language and terminology would have been a core root of this performance. Seemingly, using open-ended concept test to identify the 5th and 6th-grade student-teachers' alternative conceptions on light and the speed of light subject, the study points out that learners have different conceptions about some basic concepts on the light (Aydin, Güliz, & Balim, 2009).

The last item question which was asked to list all images that show proper charge distribution has displayed various conceptions and confusion of misunderstanding charges distribution among the student-teachers. For instance, diagram E (Figure 4) shows the entire negative distribution and about 10 student-teachers still confuse neutral charges with blank space; selecting all letters while others mix the correct and wrong letters even after getting studied. Explanatory, diagram E shows the metal sphere with an overall positive charge. The diagrams B and C show the charge on the rubber rod attracting the like charge on the sphere. But since like charges repel, this could never happen. Since charged rubber rods are placed near a neutral conducting sphere, diagrams A and D properly show the charge distribution with the charge on the rod attracting the opposite type of charge which is present on the sphere.

Conclusion and Recommendations

The average mean of student-teachers before and after interventions was found to be 29 and 21 in TRAD and, 28 and 23 in IME in terms of common conceptions adjustment. This is to say that both interventions played a role in terms of helping student-teachers lowering misconceptions as well as completing or filling the gaps in their understanding. From the results, one can see well that after getting intervention, student-teachers try to provide accurate instead of unrelated information, however, the fourth and sixth item questions asking the interpretation of different electroscope graphs and selection of the proper distribution of charges on the sphere respectively showed an enormous increase of confusions. Therefore, despite the low outperformance of IME, we highly recommend Rwandan teachers to cross-check prior knowledge of their learners before going further in teaching so that they would go smoothly and aware of possible ideas, opinions and confusions they might have. More future studies are needed to know why student-teachers get confused even after learning. These studies should accommodate control groups alongside other various interventions and would be designed in a way that more item questions are given and intervention is taken over a long period of time, and students should be interviewed to check not only performance of treatment but also appreciation of it since though there was no great improvement in IME along TRAD, however, the experiments done might have leave skills among students.

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