



ON USING VARIOUS MATHEMATICS INSTRUCTIONS VERSUS TRADITIONAL INSTRUCTION: AN ACTION RESEARCH

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Abstract

In this research, I provide an overview of potentially selected interactive mathematical instructions that help learners-educators identifying the most effective practices for teaching a course on differential equations. Based on my practical experience, positive and negative aspects of the used techniques are discussed. Immediate reactions on the disadvantages of the implementation of these different instructions have been successfully demonstrated throughout the practices. I conduct a survey in form of a questionnaire asking the learners about their opinions in this experience from which conclusion and recommendation are drawn and proposed to use in the process of teaching and learning next semesters.

Keywords: Interactive Mathematical Instructions, Teaching Differential Equations, Traditional Approach versus Different Mathematical Instructions.

Abstrak

Penelitian ini memberikan gambaran tentang pembelajaran matematika yang interaktif untuk membantu pembelajar dan pendidik dalam mengidentifikasi pembelajaran yang paling efektif untuk mengajarkan persamaan diferensial. Aspek positif dan negatif dari berbagai proses pembelajaran akan dijelaskan dalam penelitian ini. Seluruh respon siswa selama proses pembelajaran telah berhasil didokumentasikan. Kesimpulan dan rekomendasi untuk kegiatan pembelajaran di semester berikutnya, didasarkan pada hasil survei terkait pendapat peserta didik selama proses pembelajaran yang telah diimplementasikan.

Kata kunci: Pembelajaran Matematika Interaktif, Pengajaran Persamaan Diferensial, Pendekatan Tradisional versus Pembelajaran Matematika yang Berbeda.

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Throughout my teaching experience in higher institutions which goes back to more than 15 years, I have the opportunity to teach undergraduate and graduate mathematical courses of different disciplines. Currently, I am working as a professor of applied mathematics in Department of Mathematics and General Sciences at Prince Sultan University (PSU). The duty at PSU is typically divided to teaching, research and services. My teaching responsibility which is the main concern here is the most visible: learning the material, keeping up to date with current advances in both teaching and research, choosing an appropriate textbook, preparing lectures, supervising students and grading. Based on my practical experience, I have come to a perception that teaching and learning mathematics is the most challenging amongst other disciplines (Ale, 1981; Widjaja, 2013; Edo, Hartono, & Putri, 2013; Sarma & Ahmed, 2013; Truxaw & Rojas, 2014). Indeed, the development of an effective mathematics classroom environment is not easy task and it requires continuous and simultaneous renewal of academic curriculum, types of instructions and assessments. I believe that my main

responsibility as a facilitator is to make math simple, straightforward, plausible, interesting and relevant. Mathematical communication, problem solving, reasoning, connections and representations do not go beyond the mathematical contents themselves (Anthony & Walshaw, 2009; Hannah 2013).

The Faculty of Engineering at PSU was established a few years ago. At that time, I was invited to develop a new course for Engineering Departments. This course is called Differential Equations which we refer to as Math 225. A primary purpose of this course is to study basic concepts and structures and to provide knowledge of solving techniques that underlie mathematical fundamentals. The learners' cohort of Math 225 has good pre-university education. Often, they are talent, intellectually gifted and demonstrate high academic performance. I have the chance to teach and coordinate this course since the year 2013. Based on its nature, the contents of this course involve many conceptual and theoretical aspects (Zill, 2013). During lecturing of this course and due to large amount of delivered tough and abstract materials, I discovered that it is a monotonous course which contains tedious and repetitive things. Receiving cordial feedback from learners, it was obvious that they feel bored in the class. "I feel upset when you start writing on the board" a student said. In addition to this and despite of their high performance, learners' grades at the end of each semester were not satisfactory. For instance and upon analyzing certain statistical data, I have noticed that the rate of failure in this course in fall semester 2015-2016 was high; see Table 1.

Table 1. Percentage of passing and failing students in Math225 in AY 2015—2016.

Course/Term	Number of Students	Number of Pass	Number of Fail	Percentage of Pass	Percentage of Fail
Math225 Fall 2015-16	28	16	12	57%	43%

Taking into consideration the students' real high performance, 43% is considered high failure percentage. Therefore, it could be suspected that there might be some problems in mathematics instruction which, I think, it has created the above unfavorable condition. I thought it is necessary to study the problems stems from types of instructions to get a better picture of the situation and to identify the means to improve the teaching and learning process. After conducting constructive discussions with my students and colleagues, I have come to a realization that the standard and traditional way of instruction used in this course could be the main reason behind this deficiency.

The current research is devoted to introduce a systematical study in a form of action research on potentially selected dynamic and interactive types of instructions that may help learners--educators identifying the most effective practices for teaching mathematical courses. Unlike previously considered study (Ferguson, 2006; Gamble, 2011; Loveland, 2014), I will carry out this experience by employing different types of instructions throughout the lectures of Math 225 instead of only using the traditional approach. Comparison between the new and old techniques is conducted for the sake of

deciding on which method works better. By filling in a questionnaire, the students' opinions will be considered and students will be able to answer relevant questions and add useful comments from which I will try to provide an optimal exposition that helps in enhancing and developing students' performance.

The discipline of mathematics is considered to be one of the most difficult scientific subjects for dissimilar learners and educators (Ale, 1981). One of the main reasons behind this drawback is that math curriculum often builds on information learned in previous years. If a student does not have the required prerequisite knowledge, then the teacher is left with the hard choice of either remediation or proceeding ahead and covering subjects the student might not understand. Students may also fall below their expected level of achievements because they do not like or understand mathematics. "Math contents are cold, tough and abstract" a student said. Other student said: "Mathematics is too often taught as a distant science with an endless list of formulas and seemingly no connection between topics".

Before proceeding to the main point of this section, I will expose on of the the latest analysis which reflects students' opinion about mathematics. Indeed, data have been collected using sample of selected learners of mathematics in a sample university (Sarma & Ahmed, 2013; Prahmana & Kusumah, 2016). The so collected data have been analyzed subject to the complexity and difficulty of areas in teaching and learning mathematics. Figure 1 demonstrates the percentage of responses against mathematics as difficult, average and not difficult to learn.

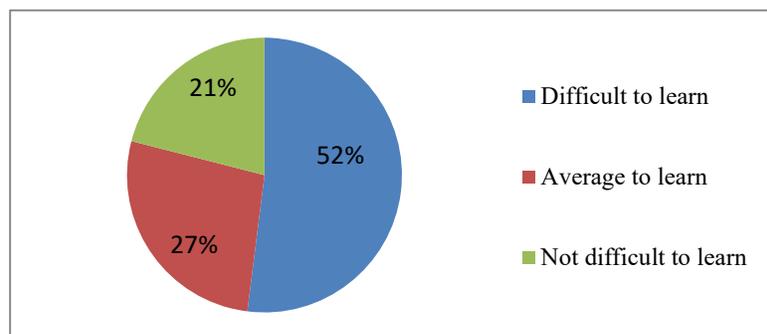


Figure 1. Responses for mathematics as difficult subjects

The outcome of this data tells that learners' prejudgment about the difficulty of mathematics is itself a challenge for both learners and educators. I am concerned here with the reason which justifies students' failure with the fact that mathematics is an abstract, monotonous and boring course that involves many conceptual and theoretical materials!

In the fall semester of the academic year 2015-1016, I taught Math 225 to students of Communications and Networks Engineering and Engineering Management. Most of the students in both departments got PSU scholarship for high academic performance. In particular, they had

exceptional ability to deal with mathematics problems. My class was dominated by traditional teaching methods which are based on direct instruction where students are shown one standard method. No other activities such as employing student-centered group or whole-class discussions were achieved during the whole semester. At the end of the semester and when looking at the final results, I was shocked by the students' grades. Although they were of high performance, their final grades were not properly accepted. Upon conducting a quick face to face debate with the students I realized that the way of instruction in the class could be the reason behind this. Deeply investigating the problem, I apprehended that the traditional methods of math instruction have many disadvantageous. In particular, they do not allow for much questioning, investigating or individual development of understanding. Traditional math works in short term but students who cannot remember what the teacher did on a certain step or do not understand why the teacher used a particular procedure will naturally be forgotten.

I started intervening by conducting fruitful discussions with department head and colleagues. They all agreed that the contents of this course involve many abstract concepts that could be tedious and repetitive for the students. Moreover, the traditional instruction that used in class could also be influential reason for this interference. The comments I received from my students and colleagues give me indications that the way of instruction in this course needs a modification. I started redesigning the curriculum of this course to consider it in spring semester of the academic year 2014-2015. A colleague of mine, Dr. Baha Abdallah who is an assistant professor in the same department is willing to help in performing this modification. He will visit the class, observe the application of the technique and build up constructive critics that might be of great benefits on the achievement of the activity goals. The new strategy is based on incorporating different types of instructions during lecturing in Math 225 class. Indeed, I divide these new instructions techniques into four types:

- i) I will lecture by using the traditional mathematics instruction,
- ii) I will lecture by using power point presentations,
- iii) Student-group will lecture,
- iv) I will utilize the flipped classroom in the lectures.

Each type of instruction will be used in lecturing the contents of Math 225 depending on the subjects' nature. Indeed, I will use the traditional instruction in quite theoretical subjects. However, I will employ the second method in topics involving graphs, figures and simulations. The subjects that contain applied materials without going deeply into the proofs will be lectured by the students. On the other hand, I will utilize the flipped classroom technique on easily justifiable and understandable subjects.

METHOD

In this section, I will introduce each method, discuss how it works and talk about its positive and negative aspects.

Traditional Mathematics Instruction

In this technique, the usual old fashioned mathematics instruction is used in the lecture. As usual, I stand at the front of the classroom near the chalkboard and the students are sitting in straight rows looking with a textbook open on the desk and paper and pencil ready to take notes. In 50-minute math class, I start by recalling what we did in the previous lecture and highlighting helpful materials for the first 10 minutes, followed by a comprehensive presentation of the new topic for 25 minutes. The students are then asked to begin practicing the new contents by answering and completing multiple problems for the last 15 minutes until class time is finished. This is a typical traditional instruction that involves no other activities in the class. Using this way of instruction, I spend three weeks delivering Chapter 2 and Chapter 3 of Math 225.

Upon conducting a debate with the students, we agreed that this method is efficiently applicable for the topics that need more detailed explanation on the board. It gives the instructor the chance to expose students to not readily available material, allows the instructor to precisely determine the direction of the presentation and facilitates large-class communication. However, it is monotonous and does not involve interactive activities that might attract the attention of learners. It places students in a passive rather than an active role and encourages one-way communication of delivering topics.

Lecturing by Using Power Point Presentations

In this activity, I prepare lectures using power point presentations. After establishing a contact with the textbook publisher of this course, I get an access code to WileyPlus utility which is an online environment for effective teaching and learning. This utility was helpful and enabled me to download plenty of power point materials. Over two weeks of the curriculum, this way of instruction was used to deliver lectures on chapter 1 and chapter 4 of Math 225. The materials of these two chapters involve studying the behavior of the solutions at infinity which requires sketching graphs for the solutions. As it is not easy to achieve this drawing mission on chalkboard, the use of power point presentation was effective tool to illustrate the materials and thus overcome this problem.

We discussed the efficiency of this method with learners who shared the positive and negative points of this method. Indeed, power point is easy for me to update and save my time and energy. It's neat and clean and it allows portability of materials. It also provides a platform for incorporating a variety of different kinds of multi-media file-types: images, video, audio and animations (Saadati, Tarmizi, & Ayub, 2014). However, there are also drawbacks to using power point as a teaching tool. Incorrect use of power point technique can discourage interaction between students. A student criticized this way of instruction because of big amount of slides I present and because I forced the students to move through the materials quickly. This can sometimes discourages students and leads

them to stop following the lecture. One more complaint from the student side was on the point that using the smart board to present the materials does not allow students to take notes during the lecture.

Lectures Presented by Students

Using this way of instruction, I divided the class into 5 groups of 5 students each. I assigned one section for each group and asked them to prepare themselves to lecture chapter 5 over five contact hours. The 50-minute lecture for each group was divided in such a way that each student will participate by delivering 10 minutes of the section contents. His contribution could be either by presenting theoretical concepts of the subject or solving problems. I gave them the freedom to choose either way.

It was very nice activity as it gave the students a chance to present their knowledge of the subject through the way they prefer. Some groups used the web based materials and presented the lecture using power point or videos. Others, however, used the traditional instruction technique. This method increased the motivation, encouraged group work discussion and established self-confidence among learners. On the other hand, when I asked the students about their opinion in this activity, the majority confirmed that it was effective only for the students who were in charge. In other words, only the 5 students of group 1 who delivered section 1 understood the materials well, whereas, the other students did not.

Utilizing Flipped Classroom in the Lecture

In this technique, short-video lectures and power point presentations on relevant subjects are given to the students who watched and read the materials at home before the class session. In the class, however, time is devoted to exercises and discussions. I asked the student to do this on chapter 6 of Math 225 over one week of the curriculum. The process of this activity starts by stating the main formulas and theorems on the chalkboard, writing problems and then asking the students to solve them.

The advantages of this type are controlling the students well, promoting student-centered learning and collaboration and providing easily accessible materials. The disadvantages, however, could be the necessity for students to have access to a computer and internet in order to view the lectures. This is particularly hard for students who already have limited access to such resources. Flipped classrooms are dependent on students' participation since one must trust students to watch the lectures at home. Unfortunately, there is no way to guarantee that the students will be obliged or cooperated in this regard; for further details see the thesis (Diab & Abdel, 2016).

RESULTS AND DISCUSSION

This section is devoted to deliver how I reacted on the application of each type of instruction. I have to ensure that my intervention was based on the comments I got from the learners during the

implementation of each activity. In addition, I will construct a survey to ask the students about their opinions in this experience and which type of instruction they prefer. This will enable me to draw a conclusion and thus propose a recommendation for the next years.

Reflections

Here are my reactions on the problems raised by the learners during the application of activities. I could deal with some problems, but could not proceed with others.

Reflection on type 1: The first reflection was on the use of the traditional mathematics instruction which I used to employ in my lectures. Indeed, the decision of conducting different types of instructions for the course Math 225 came as a reaction after the feedback I got from learners regarding the nature of the contents of Math 225. Moreover, the bad grades of the students played an important role in looking for alternative ways of instructions.

Reflection on type 2: On implementing the power point way of instruction, I got a criticism from the students that delivering materials was quick so there was no chance for them to follow up, the process itself was overloaded with big amount of documents and they were not able to write their own notes. Taking these comments in consideration, I was forced to go slowly through the details during the lecture to ensure that everybody in the class understand well. This gave the students more time to think and decide. Also, I decided to send the contents of the subject to students' e-mails prior the lecture session. They were asked to copy these contents before they come to next class. This gave them a chance to take notes on ready-copied materials.

Reflection on type 3: The third way of instruction which allows the students to conduct the lecture was the most criticized method through this research. The drawback of this method which I got from learners was that not everyone in the class was involved in this technique except those who were in charge. As an example, only the members of group 1 who delivered section 1 of chapter 5 understood the contents of this section. The rest of students were not really involved. I tried to think how I can help the students but found no solution. One more thing I could not avoid during the implementation of this activity was the failure of students in charge to give convincible answers to some theoretical questions raised by other students. I found that I have to interfere many times in order to cover this gap.

Reflection on type 4: At the first day of this activity, I realized that the students were not so interested. Indeed, some students came to class without looking at the given materials. This caused a trouble for them as they were not able to follow the subject while others were completely involved in the experience. To overcome the drawback of this technique and to force the students to be fully engaged, I decided to apply an immediate evaluation to the students by giving them extra points on what they achieve during this activity. This idea increased and encouraged the engagement of the students in the lectures followed. In addition, I decided to post the name of the first student who provided the correct answers on the chalkboard. I asked him to get a photo of his answers and to send them to the group through WattsApp application. By doing so, I urged the students who were not able

to follow up to get involved in the process.

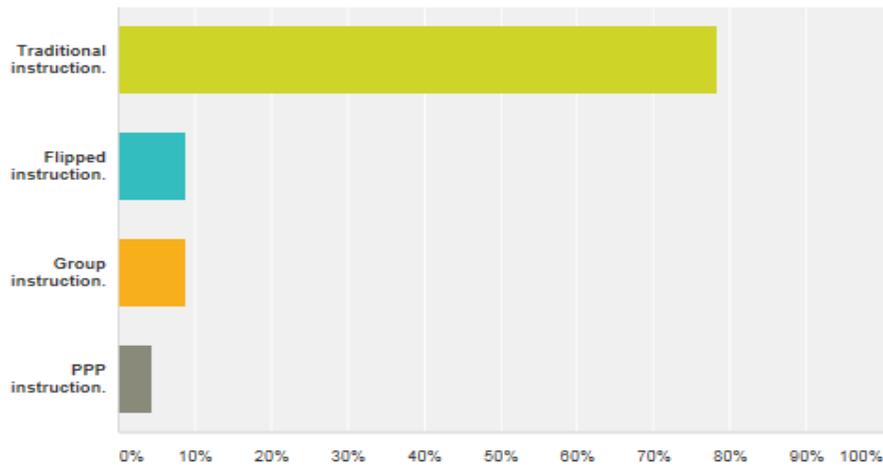
A Survey

For the sake of identifying the most effective practices for teaching Math 225, I constructed a survey in form of a questionnaire among the learners. The first question shows the high GPA of the students. The rest of the questions, however, focus on the best type of instruction that fits the learners.

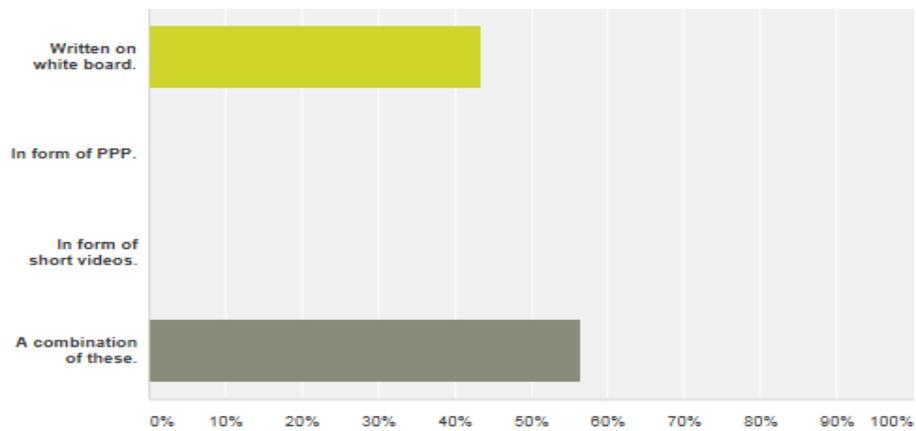
1. What is your GPA?

Answer Choices	Responses	
3.6 - 4.0	41.67%	10
3.1 - 3.5	33.33%	8
2.6 - 3.0	4.17%	1
2.1 - 2.5	20.83%	5
2.0 or below	0.00%	0
Total		24

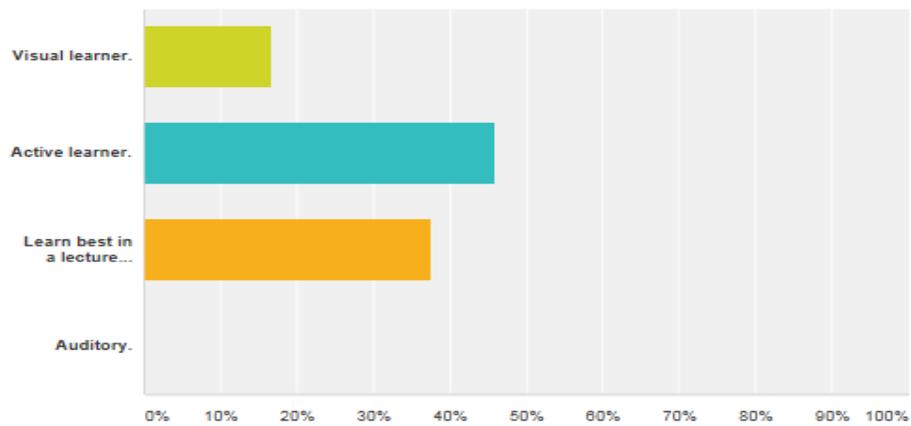
2. Which type of instructions would suit you best?



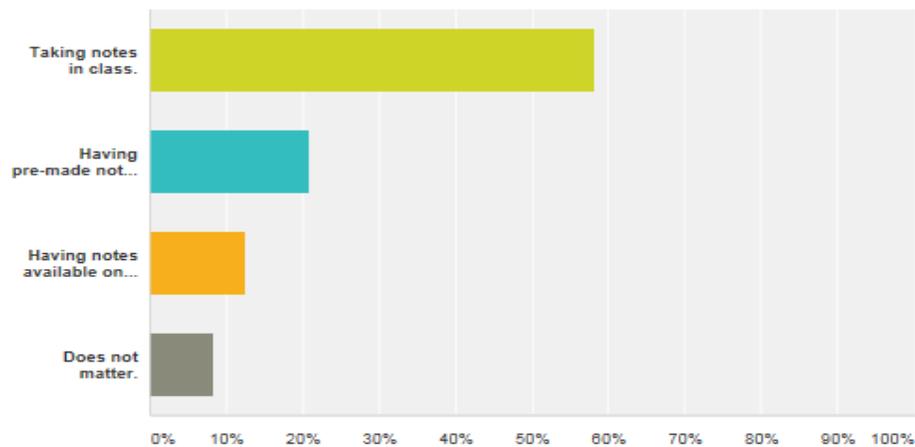
3. How would you like lectures to be presented to you?



4. How would you describe your learning style?



5. What form of note-taking do you prefer?



By analyzing the data captured from the above questions, it is clear that the learners voted for the use of combination type of instructions. In addition, I asked the students to answer a question

regarding their opinions in the types of instructions we have employed throughout this course. Here are some responses:

First of all thank you for all what are you doing for us regarding the different types of mathematics instructions:

1. Traditional type: It's a regular way for teaching, most of teachers use it, and it's good.
2. Power point techniques: it's a nice way but there was a lot of difficulty for me to understand and solve homework, I do every think with myself.
3. Flipped classroom method: I like this way very much, it's a new way, and I prefer it more than the power point technique.

Finally in my opinion, I see that traditional type is the best way because we will take the information directly from you and we can study it easily.

Since we have started the academic semester, we have used different learning techniques or styles. Each of them has pros and cons. starting with the traditional technique, I think it's the best among all of them, but still it's a time consuming method especially for theoretical concepts, however, we can deal this by using PPP during lectures. As for the flipped class method, I think it is not as good as traditional method but still better than "student-groups" method, because in such a method we can miss some point from your lecture which may be important. For instance, if we took traditional method in consideration, by the time you are lecturing and solving examples, there may be a key point which makes me understand the whole lesson without being paused. As for the "students-group" method I think it's the least effective method, however, we have saved time for chapter 5 during class time, but still I spent more time at home for solving the homework and reading the lesson. In this method I didn't receive the desired knowledge compared with other methods. To sum up, the methods are ranked as follow traditional method, flipped class method, "students-group" method.

First, "FLIPPED CLASS": The best advantage that we try to solve with our hands in each section which make us know where is our problem specifically and when I'll look at my solution later, I'll understand my steps better than copying from board. The problem is that spending time on videos, slides or book takes long time and maybe after that we still don't understand. but when you teach us the concept and theory you shortcut a lot of time. I think that the problem in the last week come because of the quantity (whole Ch.6) was big while it was good in Euler equation because it was just a section.

Second: "The GROUPS": I'm different than others in this point because I saw that it was very good. The movement was good for us. I liked students' way of solving because they go much slower and explain each primary step. I know that we must know that primary steps but sometimes we missed a small step that makes the whole section losses and students remind us. Also when you ask them your questions we came up with the full useful of the class.

In my opinion, we can do a mix. Traditional way then small example, then you give us an example to solve and give who solve right any mark as a "BOUNCE" then you solve it on the board. I know that this will let us take just 3 or 4 examples in the class but we'll understand the lesson by 85%.

I would like to let you know that I like to have new styles in teaching!. But the idea is the students learn the contents of the chapter just one or two day before they give the lecture, and you as a teacher who has a great experience know where the students may not understand, Unlike our friends, so you know the way to teach and give the content in an interesting way which make the class very interactive.

Traditional type is the best type to study because you make the materials in this type easier than another types but the problem is we don't study in our home enough .For the flipped classroom method it's harder than the traditional type but the advantage in the flipped classroom we study in our home because we know you will ask us about the material and you give us bonus if we can solving the problems. For me I think the best way is to make the traditional way and the flipped classroom in the same time. You will send the material with sari before we take it in class and in the next day in the first 10 m you will ask us about some problems and you give who solving the problems bonus like what we do in the last week .After that we will have 40 m to the traditional type. In this we you can make materials easy and also you can know who is studying in his home.

The answers of the students were fluctuating. However, one thing is common--traditional instruction is the preferred type. The students ensure that they would like to take Math 225 by using the traditional approach along with the incorporation of certain web-based utilities which will depend on subject's nature (Stone & Perumean-Chaney, 2011). This will make the contents of Math 225 more interesting and fascinating.

CONCLUSION

This research focused on examining the effectiveness of applying different mathematics instructions versus the traditional instructional approach in the lectures of Math 225. I chose this course because I have discovered in the last semesters that its contents involve abstract materials that could be the reason behind the bad grades of the learners. The process of this research started with the observation of the problem, the plan of the intervention, the application of the plan in the classroom, the handle of the disadvantages and then ended at the arrival to an optimal type of instruction. With the help of the feedback of the students and the peer reviewer, I have reached to the conclusion that the use of combinatory type of instructions could be the best instruction type that may help in enhancing the students' performance. I recommend applying the new suggested technique for Math 225 next semesters. I believe that, in parallel with the traditional approach, the incorporation of different type of instructions such as the use of web based materials as well as the implementation of the flipped classroom will help in avoiding all disadvantages of the traditional way of instruction, make the lectures more pleasing and joyful and attract the attention of the leaners.

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