An Interactive Approach Of Teaching And Learning Prerequisite Mathematics Course And Core Antenna Design Course During COVID- 19 Pandemic

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The emergence of COVID-19 has brought up some concerns and changes in the approaches to the teaching and learning of some engineering related modules, particularly in South Africa. Therefore, the teaching of an electronics engineering course demands a balanced interactive approach, as requested by the curriculum. On this note, this paper reports the common approaches of teaching and learning mathematical modelling in antenna theory and design. It also discusses the impact of interactive learning in modelling some mathematical skills in engineering education. It emphasizes the form of interaction that exists among students and lecturer, lecturer and students, and the whole class with the lecturer. The paper therefore reports the strategies of teaching and learning of mathematical modelling in antenna theory and design, using the interactive methods, as suggested by the university during COVID-19 period. In view of this, the paper confirms that the adoption of an interactive teaching and learning method helps to increase students' understanding when learning Antenna Theory and Design (ATD). In achieving the goal of the study, a qualitative style of data collection was adopted, coupled with a thematic approach of discussion of the study. This gives room for the appropriate approach of teaching and learning, of mathematical modelling, in antenna theory and design courses, during COVID-19 era in a university in South Africa.

Key words: *COVID-19, Interaction, Engineering, Prerequisite Mathematics, Learning, Teaching*

DOI : 10.5281/zenodo.18351859

Introduction

The sudden emergence of COVID-19 pandemic has caused a distortion to the free running of some high schools and higher institutions of learning around the world. This has resulted in less understanding of the actual approach to be adopted when teaching some practical link courses, such as prerequisite mathematics and engineering mathematics in a practical way (Adedoyin&Soykan, 2023; Vanourek, 2020). This situation has caused the inability of some students to graduate, as stipulated, because of their little knowledge of the approaches to adopt when interacting in a practical way, as stipulated by Curriculum and Assessment Policy (CAPS) curriculum and Department of Higher Education and Training (DHET) syllabuses. These are approved by the school of engineering in universities within the country. It is generally believed that several learning approaches have been proved and tested, while some were designed for the situations on ground. In view of this, Vorhölter, Kaiser and Ferri (2014), present four categories of learning, which were common among engineering academics and students, when teaching and learning mathematical concepts that are related to an antenna theory and design. The approaches of teaching and learning mathematics concepts include first, the formative learning approach. This is the approach of modelling mathematical concepts, which center on learners' ability during the process of creative and explorative learning. It uses their competence in and knowledge of modelling their ideas while learning. This is possible from their confidence in their ability to do mathematical modelling (Lingefjärd, 2000; Redish& Smith 2008). The formative learning style, therefore, reports that the competence of mathematical modelling, among engineering experts, depends wholly on their competence as students, or teaching experts.

The second category, as suggested by Vorhölter and his co-researchers, is the critical competence learning, which emphasizes on the students' learning style. The style is the actual mathematical knowledge acquired for a particular

situation, along with the common style demanded by the industry (Vorhölter et al., 2014). This learning style exposes engineering experts to mathematical modelling, in line with industrial demands that would increase their design. Therefore, collaboration between industrial experts and academics remains important. The truth of the matter, however, is that, presently, such collaboration, in the design process, is seldom found at South African universities, despite the challenges encountered during COVID-19.

The third learning, known as the utility learning approach, is a learning style that helps the experts to unfold a mathematical theory in an interdisciplinary manner, which may be advantageous to both public and private organisations (Lingefjärd, 2000; Redish& Smith, 2008; Vorhölter et al., 2014). It is a well-planned logical form of mathematics modelling adopted when teaching and learning engineering design, in a mathematics related course such as an antenna technology. Lastly is the pictorial representation of mathematical concepts, which is another category of learning that aims to provide students with a rich multi-facetted picture of mathematics, as a science that is an integral part of society and culture (Ärlebäck, 2009).

The fact remains that COVID-19 pandemic has disapproved the efficiency of the above-mentioned teaching approaches just because the COVID-19 outbreak found some higher institutions of learning, around the world, unprepared. This was because of a sudden shift to online means of instruction without adequate preparation (Bower, Lai, Van Bergen, Hobson & Stephens, 2023). However, in as much as mathematics is regarded as a useful tool, among electronics engineering students and academics, when making reasonable decisions, the full endorsement of mathematical modelling would facilitate the production of electronics related devices. Along similar lines, Gallegos (2009) and Blomhøj et al., (2009) also reported that the presentation of mathematics, in a real-life situation, indicates appropriate professional use of mathematics, as applied in an engineering context. However, teaching the modelling of mathematics, using online platforms, among the engineering students, was found to be a bit difficult due to some practical applications involved. On this ground, in as much as electronics engineering students adopt mathematics concepts, for everyday decision making, the use of an online interactive approach of modelling mathematics should be well investigated, when teaching and learning an engineering related mathematics course. From this background, this study investigates the interactive approach of teaching and learning a prerequisite mathematics course and a core antenna design course during COVID-19 era. This study was guided with the research question stated below:

- To what extent do engineering academics and final year engineering students interact, using mathematical modelling in prerequisite mathematics, and a practical antenna design course in the way they do?

Actualizing the goal of the study involves checking up with some factors that limit interaction among the students and their lecturers, when teaching and learning mathematical modelling in antenna theory and design. This is addressed in the section below.

Teaching and learning of mathematics modelling in COVID-19 era

In South Africa, the digital transformation in universities and other higher institutions of learning has been a topical issue that different education stakeholders are concerned about, when teaching and learning mathematics related courses, during COVID-19 era (Adedoyin&Soykan, 2023). However, several studies have reported the different approaches adopted when teaching mathematics among high school and university students during the COVID-19 pandemic era. These include personalization approach, authenticity approach, and collaborative approach. Also included are conversation and data sharing among students to lecturer; students to students; task to students, and lecturer to task (Yates, Starkey, Egerton &Flueggen, 2021; Bower, Lai, Bergen, Hobson & Stephens, 2023). Yan and others reported that the spread of the pandemic all over the world has disrupted many schools. There is, therefore, the need for an appropriate approach that can help learners, from different departments in the school of engineering. Their study failed to consider the impossibility of teaching and learning some mathematical courses by using online tools (Yan et al., 2021). The study concentrated on home-based curriculum, which does not resolve the process of interaction among the students and their lecturers.

In order to understand and improve the teaching strategies, needed to teach mathematical concepts during COVID-19, the use of technology, that could facilitate collaborative learning, cannot be toyed with, among engineering students and academics (Bower et al., 2023). For instance, the interaction among students using web-conferencing such as Zoom, Team, Google Meet, and other learning management tools, such as Google Docs, remains important (Span 2023; Yan 2021). However, recent evidence, that are common to the process of teaching and learning mathematics, using valuable technology for university and college students, at their various homes and schools, is still scarce, due to the complex nature of engineering mathematics (Yates et al.,2021). On this ground, these researchers argued that having a better understanding fn the impact of parents and guardians, in guiding and teaching their children, remains important but not enough (Yates et al. 2021). All these could be attained by considering the space and environment to operate, when teaching and learning mathematics, in an interactive learning environment, using online teaching and learning tools, during COVID-19 home learning.

Furthermore, Span suggests that the major things that should be considered, when using technology in teaching and learning mathematics during COVID-19 era, is the lecturer's competence in using some online platforms such as MOODLE, Team, Zoom, among many others, for the purpose of easy application to teaching and learning. He emphasized that every lecturer must have a way of crafting virtual lecture rooms to meet up with teaching and learning demands (Span, 2023). Adedoyin andSoykan (2023) reported that students and instructors with low digital

competence are liable to lag behind in online learning. Bate argued, however, that the use of institution-supported tools or video-conferencing systems such as Team, ZOOM and other Web initiated tools, from desktop and mobile tools, may go a long way in assisting an interactive teaching. The truth of the matter is that it could resolve the aspect of interactive teaching and learning when teaching mathematical concepts (Bates, 2020). Similarly, Moore (2007) also explained that an interactive approach of learning, among open distance learners and academics, learners to content, and learner to learner, is possible in teaching some courses that do not have some practical related aspects. On this ground, the situation created by COVID-19, which has been nick-named 'emergency remote teaching', does not resolve the teaching of mathematics modelling in engineering contexts (Hodges et al., 2020). Therefore, creating a reliable teaching and learning approach, for modelling mathematics concepts, in a future pandemic related situation, remains important, to avoid the use of 'emergency teaching style', which may not be appropriate in teaching mathematics courses.

Conceptual framework

Possessing a suitable framework, as a guide for an engineering related empirical study, is very important. In view of this, the researchers adopted some conceptual models that are related to interactive teaching of mathematical concepts as suggested. As a result of this, some empirical studies have taken different learning approaches, to investigate the role of interactive learning in the teaching and learning of mathematical modelling, in engineering related courses, especially in antenna design courses (Fasinu, Govender& Kumar, 2023; Fasinu, 2021; Kaiser, Blömeke, König, Busse, Döhrmann&Hoth, 2017). Therefore, when teaching mathematics in an engineering context, the first approach is to conceptualize the appropriate learning approach, which is quite relevant. On this note, the accurate of judgmental learning model was adopted, which is the model that determines the comparison of teachers' predictions to student learning style. This model centers on the achievement of the actual performance on the main objective, and the interaction of the lecturer to students (Kaiser et al., 2017). The second teaching style is the situational learning model, which allows the process of teaching and learning based on the situation surrounding the process of teaching mathematics. This involves students' understanding of the mathematics content involved, students to lecturer, and students to students' interaction, among many others. This style of learning has been called situation-based diagnostic interactive learning, which could be translated using online tools (Hoth, Döhrmann, Kaiser, Busse, König&Blömeke, 2016). This approach of learning focuses on the diagnostic competence needed in learning situations, in which students make errors in the context of mathematics. The errors students make, when learning, are turned into a practical mathematical reasoning, through a careful online teaching (Larrain& Kaiser, 2022). An integrative model gives room for the blending of other models, using an online platform for mathematical modelling. All these learning styles provide adequate approaches of teaching and learning mathematical modelling in engineering education. Therefore, one could argue that a situational-based judgmental interactive model (S-JIM) remains the possible theory for learning engineering mathematics and prerequisite mathematics.

Methodology

In collecting the available data proposed by the researchers, data from electronics engineering academics, teaching prerequisite mathematics, and core antenna theory and design, were explored. Data were also collected from the students learning the course in a university in South Africa. On this note, four engineering academics and nine electronics engineering students were interviewed. An open-ended survey questionnaire was adopted as a tool of collecting our data and an interview guide. Furthermore, an observation session was also adopted, using the university's, online teaching tool as recommended by the university authority. Therefore, qualitative approach of data collection was explored.

Results and Discussion

This section provides data in response to the research question stated earlier. To achieve this, data were collected from the responses of engineering academics teaching either the prerequisite mathematics or antenna theory and design courses. The views of the academics and students that teach or take the prerequisite mathematics are also reported. The data arose from the interviews, open ended survey questionnaire and the researchers' observation notes. The final reports of the views of the participants are hereby presented in three categories and subcategories, as indicated below.

Extent of interaction among academics and students teaching and learning prerequisite mathematics

This section of the data presents and reports the views of the participants, regarding the nature and extent of the interaction among lecturer-student, studentsto lecturer, students to task, among many others, when teaching or learning the prerequisite mathematics course. The extracts from the responses of the participants, and the researchers' observations during the process of data collection are reported. The data gathered from the participants' responses, using the survey questionnaire and the interview guide, among the electronics engineering academics, teaching the prerequisite mathematics courses, as well as the researchers' notes, during onsite observations, show that there are some interactions that exist between the students and the lecturers. The summary of the responses, captured, is reported below using a research question captured: *To what extent do engineering academics and final year*

engineering students interact using Mathematical Modelling in an Antenna theory and Design in the way they do? The responses of the participants are reported below:

Lecturer-student interaction in prerequisite mathematics lectures: nature of the interaction

In as much as the aim of this section was to know the level at which the engineering academics interacted with the engineering students when teaching and learning prerequisite mathematics, the researcher asked the participants in the interviews whether there had been any form of lecturer-student interaction during the prerequisite mathematics course. Participant AC1 reported:

> ***"****Yeah! We can't do without that [interaction] in mathematics, we will need that."*

He further re-emphasised this:

> *"Yes, [I] seldom adopt teamwork"* Similarly, the Researcher (R) observed that: *"Interactive teaching is part of the approach of teaching suggested by the university among many others."*

When asked whether students do interact with their lecturers, an undergraduate student (UG5) confirmed that:

> *"Yes."*

Similarly, UG1 responded:

> *"I do interact with my lecturer."*

And UG3 also said:

> *"Yes, they do interact."*

From the responses stated above, one could argue that interactive teaching is part of the teaching method approved by the university as a tool for learning. Therefore, the role of interactive teaching cannot be overemphasised, when teaching a prerequisite mathematics related course. Among the academics, AC1 confirmed that the absence of interactive teaching and learning would make the process of learning prerequisite mathematics difficult, if not impossible. Therefore, as UG1, UG3 and UG5 confirm, interactive learning has been a tool for teaching and learning. On this note, constant interaction is a must when teaching mathematical modelling in prerequisite mathematics. This aligns with the view of a researcher who suggested that collaborative learning goes a long way in increasing the credibility of the process of teaching and learning in antenna design, and the mathematical concepts surrounding it (Soliman, 2019).

Lecturer-student interaction in prerequisite mathematics lectures: effect on performance

Probing further, participants were asked whether the lecturer to student interaction had had any effect on the students' performance in the mathematics related courses.

The academic participant, AC1 quickly responded:

> ***"****I don't believe that their poor performance in mathematics is due to their lack of teamwork…NO! …Mathematics is not a course that you need to come up together to discuss in a team. But, mathematics is only what you sit down to know on your own, so it is not lack of team work but, one, lack of desire from the students to know mathematics and two, lack of desire from the students to know how important mathematics is in relation to their course. Some engineering students just want to take engineering courses; they don't want mathematics. In fact, if they come to 3rd year or 4th year where they are free from doing mathematics modules, it will seem as if a heavy burden has been lifted from them. So, the problem is lack of orientation that mathematics is core to engineering and lack of desire to sit down and study mathematics. It is not the lack of team work that is contributing to their poor performance. Team work is an addition to their work but the main thing for them is to sit down and study mathematics and then see the importance of mathematics in their engineering related module."*

In addition to this, the researchers personally observed that:

> *"Traditional learning approach is mostly adopted in the university."*

Also, he observed that:

> *"Teachers take control of the teaching process, with this method; most of the students learn the process of modelling their mathematics concepts."*

Similarly, the undergraduate student, UG3 confirmed that:

> *"They answer questions, do class work and give assignments; they also discuss questions."*

From the views of the participants, it could be clearly said that, in the prerequisite mathematics course, the academic does have personal interaction with students when the need arises. More so, the researcher's observations support the view by noting that the teaching process, presently adopted by the university, permits lecturer-to-student interaction. The complex mathematics concepts, embedded in a mathematics related course, and students' low concentration span, have been reported as contributing to the low performance among the engineering students (Karakaya, 2020). This also aligns with Mohammed's view, which suggests that the traditional method of teaching is an indispensable tool in teaching mathematics related courses in antenna theory and design (Mohammed, 2019).

Lecturers' notes and task in hand in prerequisite mathematics course

Since a teaching and learning process cannot be concluded without considering the assessment style, adopted by the academics, this aspect was investigated. With regards to this, the researcher's observation confirmed:

> *R: "Lecture notes are given during the teaching process."*

He further confirmed that:

> *"Assignments are given after the teaching process and then the end of semester examination is conducted."*

It is from this point that the researcher can confirm that proper evaluation processes are carried out during the process of teaching and learning of the prerequisite mathematics.

Student-student interaction in prerequisite mathematics lectures

The researcher explored whether the whole group of students, taking the prerequisite mathematics courses, do interact with one another when learning the mathematics. The academic participant AC1 confirmed:

> "Yeah! During the tutorial sessions, they do interact with one another because there is a time for tutorials. So they interact, and are free to ask one another questions, and even copy one another anyway…. [Laugh], we encourage them to interact even during the tutorial time. They are also grouped during the tutorial time."

The same participant AC1 then explained:

> "Yeah, they have tutors."

A student's viewpoint was expressed in clear terms by participant UG1, who argued:

> "I prefer interacting with the person I know very well."

The researcher reports that it has been possible for students to express their views during the process of teaching and learning the prerequisite mathematics courses. On this note, AC1 confirmed that a tutorial class is always organised for the learners, after each main lecture. During the tutorials, their respective tutors could assist them in bringing out their best by explaining any points of confusion. UG1 commented that her group interaction depended on the careful understanding of her partner. This ties with the ideas of Soliman, who confirmed that the teaching and learning of a prerequisite mathematics and other mathematics related aspects of engineering courses should be done, using theoretical state of mathematics, with the assistance of tutorial lectures, to increase students' understanding (Soliman, 2019). This arrangement has improved the modelling of mathematical concepts, as reported by the participants.

Student-student interaction in prerequisite mathematics lectures

From the teaching and learning processes, adopted by the academics and the students, as suggested by the participants, and observed by the researcher, it could be clearly said that student-student interaction did exist. In 2020, this was done through online platforms as recommended by the university, due to the COVID-19 pandemic. It is on this note, that the researchers made observations and the views of the participants were captured, to get a good report of the students, individually. The researchers observed that:

> *"Students do interact with one another during and after lectures."*

When asked about this aspect, participant UG5 responded:

> *"Yes" as did UG4: "Yes, definitely."*

Participant UG1 explained further how this works:

> *"Yeah, we have a group chat on WhatsApp. Then when you have a question, you can put it on the group chat and someone will answer."*

While UG3 on her part agreed, and explained:

> *"Yes, we interact doing tutorials, maybe if we are studying for a test, we usually go to others, since we understand it better to study together than to study alone."*

Therefore, the observations recorded by the researchers and the participants' responses clearly indicate that some level of interaction does exist among the electronics engineering students, when learning prerequisite mathematics. As UG3 explains, the class interacts with one another when learning the mathematics related courses. She further argued that group learning does facilitate the learning process for her. Similarly, UG4 and UG1 also advised that the impact of student-student interaction, in the learning of prerequisite mathematics, should be taken seriously.

Student to student interaction in prerequisite mathematics lectures

Teaching and learning inherently involves students interacting with their course mates. Therefore, in confirming whether electronics engineering students interact with their course mates, in a group fashion, the researcher noted:

> *R: "Students do interact with one another during and after lectures."*

Although their classes were not particularly student-centred, the students could still ask their course mates questions in their personal time, which could be to avoid disturbing the main lecture due to time constraints.

Student-lecturer interaction in prerequisite mathematics lectures

The primary aim of this section is to probe whether the students are able to interact with the lecturer during the teaching and learning of their prerequisite mathematics courses. The views from the participants are reported below. Academic participant AC1 said that:

> *"After lecturing, I do give them some questions to attempt, which are meant for the tutorial session, and the tutors do check the answers whether they are correct or not. Also, I do lecture for some time, after that I give them some practice questions that must be done. And they will come to the tutorial session to ask questions or seek for clarifications."*

Similarly, the researcher noted in the observations that:

> *R: "During the teaching of a prerequisite mathematics, and other mathematics related courses, students are allowed to ask questions and suggest possible answers."*

Regarding the student interaction with the course lecturer, for the prerequisite mathematics course, UG5 argued that:

> *"Yes, I do whenever I have them."*

In a practical term, UG5 reported:

"Just by asking questions and help at tutorial sessions I will know if I am doing the correct thing or not. That is when I will ask for help from other people."

Similarly, UG3 reaffirmed:

"I can say that the maths part we learnt in the 1st, 2nd and 3rd years is only like a continuation thing. We usually study, and during lectures, we must ask questions. If you have more questions, you can go to the lecturer's office to meet him on one on one. We also use tutor-based teaching."

From the views of the participants reported above, it could be argued that there is student-to- lecturer interaction in the prerequisite mathematics courses, which gives room for modelling mathematics concepts at a high level. Therefore, interactive learning, during the teaching and learning of prerequisite mathematics, may go a long way towards addressing any poor student performance in mathematics related courses.

Student-lecturer interaction in prerequisite mathematics lectures

In this section, the researcher probed whether any group learning was organised for lectures on prerequisite mathematics courses during the process of teaching and learning. The responses captured are shown below.

The academic, AC1 responded that:

"No, we do not have any group in the class. When I am teaching at a particular period, I do give them class work. They then practise them later. We do have class work; after some period, I do go around the class. We don't have any group but I know some lecturers do have, but as for me there is nothing like group work."

Undergraduate student, UG1's response was:

"We usually have a tutorial session every week and sometimes they will split us to smaller groups."

It appears from the response of AC1 that during the formal teaching period, he had not allocated any students to work in groups. He added that some academics do adopt that approach when teaching their own courses, but on his part, he did not see any need to group the learners. More so, the researcher observed that group learning takes up a lot of class time. Since little contact time is allocated for a course like prerequisite mathematics, it is understandable that some academics see little value in team learning.

Student-course content interaction in prerequisite mathematics courses

In order to know the level of self-interaction adopted by the students, when learning prerequisite mathematics, the researcher probed further whether engineering students do undertake self-interactions during their studies in prerequisite mathematics. In response, the academic, AC1indicated:

"On my own I give them assignments. I have a reason why I do give them assignments, because I want them to interact, and then search from the internet themselves, or join with friends. I just want interactions, so I give them assignments. Another way of assessing them is by giving them tests and then examinations. So, in some modules, for instance, somebody who wants them to use a software in answering some mathematical simulations, can give them a software or they will go to the LAN to do it."

The undergraduate UG1 confirmed this approach:

"I have to refer to the textbook and sometimes I also use Google, maybe extra videos may help."

Similarly, UG4 asserted that:

"Yes, I do interact with a lot of research on the module by watching videos and just running different sources online that can be possible."

The view of AC1 suggests that it is common to expect engineering students to use internet facilities in the process of learning. Furthermore, the researcher confirmed that learning prerequisite mathematics courses involves a critical personal engagement for a successful outcome. From such responses, it can be said that self-interaction promotes effective learning among electronics engineering students, particularly when learning prerequisite mathematics. This is in line with the views of other researchers who suggest that personal interaction of the students, with their academics, will boost and increase the level of their understanding of the course (Cai, LaRochelle, Hwang & Kaiser, 2021). This has helped the process of learning among engineering students taking the prerequisite mathematics courses.

Summary of the level of interaction among engineering academics and students in antenna theory and design course

The recorded views of the participants and the observations of the researcher have confirmed that some level of interaction takes place when teaching and learning the prerequisite mathematics courses. The student participants indicate clearly that they interact with their peers; asking questions from one another. They also interact with lecturers, when need be, and discuss academics issues. Therefore, interactive learning also assists the process of teaching and learning in the prerequisite mathematical courses. From the responses quoted above, students also interact with other students, during both tutorials and lectures. In this regard, students use questions as a means of interacting with their peers. The same thing is applicable to their interaction with their lecturers when learning prerequisite mathematics courses. Therefore, interactive learning could be regarded as a key to the effective teaching and learning of mathematics related courses.

The extent of interaction among the participants during their practical design in COVID-19 era

The curriculum statement, from the handbook of the engineering department and the data collected by the researchers, gave them some opportunities to freely report on the extent of interactions in the teaching an antenna design course.

The research question that anchors this section is *"To what extent do engineering academics and final year engineering students interact, using mathematical modelling in practical antenna design courses in the way they do?"* Data collected were subdivided into three sections, which were further sub-divided into narrower categories, as shown below. This section reports data showing the nature and extent of interaction that exists between the academic and students when learning antenna design at a practical level. The researcher confirmed that due to the COVID-19 pandemic, the format of teaching the laboratory work for antenna theory and design was changed to accommodate lockdown regulations. Specifically, on the one hand, an online teaching approach has been adopted for teaching the course to undergraduates. On the other hand, some of the postgraduate students were allowed to complete their laboratory work, due to the individual working style they had adopted. The views of the participants and the observation notes, recorded by the researcher, are captured in the categories and subcategories below.

Student-to-student interaction in practical antenna theory and design lectures

The extent of interaction that exists among students, when learning the practical antenna theory and design course, is shown by data from the engineering department handbook and notes on Moodle made available to the researcher. From the handbook and notes, the researcher noted:

R*: "Student to student interactions are only possible using computer simulation learning."*

The researcher also gathered that:

"Personal contact was not allowed when learning practical antenna design course."

This indicates that because of the COVID-19 pandemic in 2020, the university administration had restricted contact teaching within the university. Therefore, to continue the 2020 academic year, the electronic engineering department switched to e-learning, using Moodle as the main platform for disseminating teaching and learning materials to the students, due to distractions caused by COVID-19 (Bower et al., 2023). Against this background, computer simulation learning had been a means of engaging the students when teaching the practical aspects of the antenna design course.

Student-student interaction in practical antenna theory and design lectures

To identify any possible student-to-student interactions during the teaching and learning of the practical antenna design course, the engineering department's online facilities, used by the researcher shows:

R: "Student to student interactions are always done through the Moodle and other social media."

He also confirmed that:

"Ideas and information are being disseminated and discussed in groups of twos."

It could be said that the data given above shows that any student-to-student interaction, even those in pairs, were only through available online services, such as Moodle, Zoom, and WhatsApp, amongst others. Therefore, the e-learning method was adopted due to C0VID-19 (Bower et al., 2023).

Student-lecturer interaction in practical antenna theory and design lectures

To explore the extent of interactions between students and the lecturers teaching the antenna theory and design course, the researcher again consulted the document available, and recorded personal observations. The researcher observed that:

R: "Student to lecturer interaction is done on Moodle due to the pandemic."

He also observed that:

"E-mail, Moodle and other social media are used as means of interacting with one another."

Furthermore, he confirmed that "Face-to-face consultation was totally prohibited by the university." From the second recorded observation of the researcher, it could be confirmed that learning, through Moodle, was one of the means of teaching the antenna design course, in the face of the lockdown regulations from the South African government. Therefore, face-to-face interaction was not allowed throughout the 2020 academic year.

Student-lecturer interaction in practical antenna theory and design

The researcher probed further on whether there had been student-to-lecturer interactions during the teaching of the practical antenna design course.

R: *"The submission of a group-prepared power presentation and study materials are sent to the lecturer teaching them the practical antenna design course."*

He further added that:

"The submission is done through email."

From the researchers' observations, it could be said that student-to-lecturer interaction did exist, but only through online media. On this note, e-interaction had been adopted during the period of teaching and learning. This goes in line with Mohammed's views, in his report, that the use of educational technology, when teaching an antenna related course, contributed to students' enhanced academic performance in engineering related courses (Mohammed, 2019; (Rapanta, Botturi, Goodyear, Guàrdia&Koole, 2020).

Student to course content interaction in practical antenna theory and design course

A self-study learning approach was an important principle for the course to be approved by ECSA, to equip students for individual engineering practices in their future. The extent of self-interactive learning, adopted by the engineering students, is indicated in the researcher's observation, recorded as:

R: *"The university has given a high priority to self-interaction by supplying the required resources to the learners, such as laptops and data for surfing the internet."*

He also confirmed:

R*: "Throughout the second semester, the teaching and learning process was meant to be done using a self-interactive process by the student."*

Considering these observations, the researcher can conclude that self-interaction had been a tool adopted to drive the process of teaching and learning, and which had assisted the students in the smooth running of the second semester, in the 2020 academic year. Furthermore, in order to report the teaching and learning methods adopted, when teaching and learning practical antenna design course, the researcher observed that: "All practical sessions allocated for this course were done using the university online platform." He further observed that: "Moodle, WhatsApp and other online platforms were explored for the teaching". Gathering from the observation stated above, the researcher could argue that a contact practical teaching for the class was totally prohibited, due to the spread of COVID-19 pandemic. Therefore, an online teaching approach was adopted for this section of the course.

Lecturer-student interaction in practical antenna theory and design course

On lecturer-student interaction, the responses of the participant AC4 indicate the following interactive levels:

AC: "My team includes design project students, vacation work students and postgraduate students. I work with one of my colleagues to take his guidance. I also have collaboration with other national/international universities."

He also commented:

"It promotes interaction among the students." Then he also observed: *"Power point materials are sent to the learners."* The participant revealed further that:

"Prepared tutorial materials, with answers, were also given to the students via Moodle."

The responses from participant AC4 confirm that he adopts a team or interactive teaching strategy during his teaching of the practical antenna theory and design course. In fact, the available learning materials, posted on Moodle, show that team learning increases the students' level of understanding in the process of teaching and learning. But due to the pandemic, the online interaction had to be adopted for this process. This echoes Soliman's view, when he suggested that e-learning, as a teaching and learning tool, would assist students (Rapanta, Botturi, Goodyear, Guàrdia&Koole,2020;Soliman, 2019).

Lecturer-student interaction in practical antenna theory and design course

To find out whether the lecturer does interact with the students when teaching the practical antenna design course, the researcher asked the academic teaching the course about his role in teamwork learning for the course. Participant AC4 then commented that:

AC1: *"In my team, my role is that of a supervisor in the team. I give the direction and knowledge of research and design methodologies to the students so that the students can progress in the right direction. As a team, we have more ideas to apply and improve the antenna parameters. Moreover, the design process includes fabrication and measurements also. So, to work individually will be more difficult."*

The view of participant AC4 shows that he supervises the research students and facilitates the process of teaching and learning among electronics engineering students, by taking antenna design as a course. Therefore, the lecturer does interact with the students, using online tools, when teaching such a design course, but the level of his interaction of late has been restricted due to the pandemic. This view is similar to that of Mohammed's, which confirmed that the role of an academic, during an antenna design course, among the postgraduate students, was to facilitate the design process which would lead to better productivity (Karakaya, 2020; Mohammed, 2019).

Teaching and learning theories adopted in practical antenna theory and design course

This section describes the teaching and learning process, adopted by the engineering academics who teach, and the students who learn, in a practical antenna theory and design course. From the teaching materials made available to the researcher, it was confirmed that the academic teaching the course on antenna theory and design adopted a realistic modelling approach for the course. Although contact teaching was prohibited, due to COVID-19, the teaching material that had been posted on Moodle elicited the following notes from the researchers that: "realistic teaching was being adopted during the teaching and learning period, using a computer simulation learning, coupled with audio application." Furthermore, the researcher also confirmed: "The learners also used the computer simulation in facilitating their understanding." From the recorded observations, it could be seen that the process of teaching and learning of practical antenna design was done using an e-learning and realistic approach, which gives room for explaining how mathematical concepts can be used in a real-world situation.

Realistic learning, therefore, is a reliable teaching and learning approach for modelling mathematical concepts. This resonates with the view of Mohammed, who suggested that using educational technology, such as computer simulated learning would be beneficial for teaching and learning in an antenna related course (Karakaya, 2020; Mohammed, 2019). It was adopted in this study to increase the students' understanding of antenna theory and design.

Summary on extent of interaction among the participants in antenna theory and design course

The findings show that an e-learning approach had been adopted as a means of interaction throughout the teaching and learning process in the core antenna design course. In fact, some of the participants observed, showed that theoretical teaching was done for the learning of an antenna design among undergraduate students, with the use of online tools. In the case of the postgraduate students, a self-learning approach had been adopted during their design process, in part, to avoid any form of plagiarism, which is academic cheating, and against the university rules for all

students. Therefore, contact laboratory sessions were not allowed during the 2020 academic year because of the pandemic.

The comparative observation and analysis of data by the researcher show that the practical teaching and learning in the antenna theory and design course leads to some insights. On the one hand, the undergraduate students lacked sufficient practical knowledge of mathematical modelling. Notably, some of them confessed that the pandemic had affected the level of interaction in their practical classes. Therefore, their knowledge of mathematical modelling, for a practical antenna design, seems to be very limited. On the other hand, postgraduate students showed better ability, in modelling mathematical concepts for core antenna design, but their level of interaction had also been limited, although less so, due to the principles adopted by the university, on individual learning at the postgraduate level. It was understandable, in view of their years of experience, that the academics showed well developed knowledge in mathematics in a practical way.

From the data above, students in the lecture room do interact with other students when being taught, and with other students even during tutorial lectures. Similarly, students can also ask questions, as a means of interaction with their course mates. The same thing is applicable to their level of interaction with their lecturers when learning prerequisite mathematics. Therefore, interactive learning could be regarded as a key to effective teaching and learning of the courses.

Gathering from the graph above, one could argue that, for an effective teaching and learning process to take place, the adoption of a situation-based judgemental learning should be adopted, when teaching and learning mathematical concepts (S-JIM).

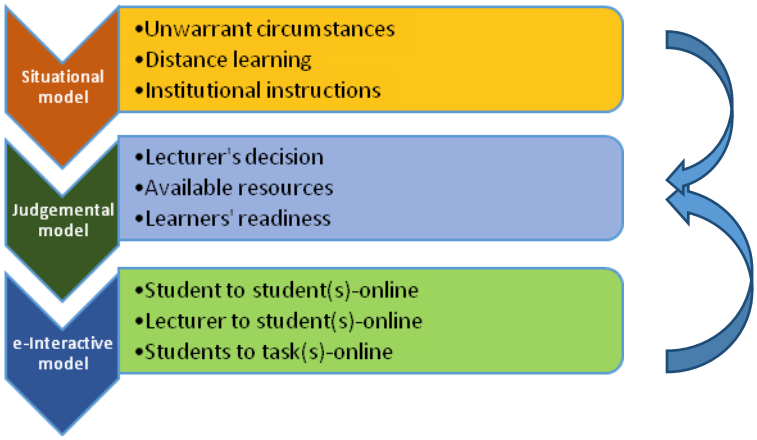

Figure 1: Situational-based Judgemental e-Interactive Model (S-eJIM)

During COVID19, the teaching and learning of an antenna theory and design became a problem, due to some practical sections involved, as stipulated by the curriculum. As a result of this, the university introduced an online learning platform known as MOODLE. This platform allows audio and video teaching, which invariably gives room for some partial understanding of some practical aspects. But the fact remains that the teaching approach adopted was based on the situation encountered by the sudden appearance of a deadly pandemic, which was ravaging the whole world in 2020. In view of this, the adoption of the S-JIM has assisted the level of interaction among students and lecturers to a certain level.

Conclusion

The findings for this study, on the extent of interaction that exists among electronics engineering academics and students, during the practical learning of the antenna theory design course, indicate the outcomes below. Engineering academics must do interactions, both within and outside the country but are limited by lack of funds. Postgraduate students' level of interactions was limited due to the university principle of self-interaction, as mandated for all masters and PhD students. Undergraduate students were not allowed to have any face-face learning due to the rule of social distancing, as a result of COVID-19. Again, the absence of laboratory work in 2020, due to COVID-19, has affected the collaborative strategies of interaction in practical antenna design.

Acknowledgements or Notes

The authors acknowledged the engineering students from a university in South Africa for their contributions,despite the impacts of COVID 19 pandemic on their study.

References

Ärlebäck, J.B., &Frejd, P. (2010). First results from a study investigating Swedish upper secondary students' mathematical modelling competencies. Paper presented at the EIMI 2010 Conference, 19-23 April 2010, Lisbon, Portugal.

Adedoyin, O. B., &Soykan, E. (2023). Covid-19 pandemic and online learning: the challenges and opportunities. Interactive learning environments, 31(2), 863-875.

Bates, A. W. (2020). Advice to those about to teach online because of the corona-virus

Bissell, C., & Dillon, C. (2000). Telling tales: models, stories and meanings. For the learning of mathematics, 20(3), 3-11.

Bing and Redish (2012) Bing, T. J., &Redish, E. F. (2012). Epistemic complexity and the journeyman-expert transition. 8(1), 010105.

Blum, W., &Leiß, D. (2007). Deal with modelling problems. Mathematical modelling: Education, engineering and economics-ICTMA, 12, 222.

Blum, W., &Niss, M. (1991). Applied mathematical problem solving, modelling, applications, and links to other subjects—State, trends and issues in mathematics instruction. Educational studies in mathematics, 22(1), 37-68.

Blomhøj, M. (2009). Different perspectives in research on the teaching and learning mathematical modelling. Mathematical applications and modelling in the teaching and learning of mathematics.1

Bower, M., Lai, J. W., Van Bergen, P., Hobson, L., & Stephens, R. (2023). 'Lockdown'learning designs–Parent preferences towards remote and online learning for their children during the COVID-19 pandemic. Australian Journal of Education, 00049441231204069.

Burkhardt (2006) Burkhardt, H. (2006). Modelling in Mathematics Classrooms: reflections on past developments and the future. ZDM, 38(2), 178-195.

CAES. (2020). Handbook for College of agriculture, Engineering and Science. S. A. University of Kwazulu-Natal. Durban, South Africa University Printers.

Cai J, LaRochelle R, Hwang S, Kaiser G. Expert and preservice secondary teachers' competencies for noticing student thinking about modelling. Educational Studies in Mathematics. 2022 Feb;109(2):431-53.

Cheng, A. K. (2009). Mathematical modelling and real life problem solving. In Mathematical Problem Solving: Yearbook 2009, Association of Mathematics Educators (pp. 159-182): World Scientific.

DBE. (2016). Curriculum and Assessment Policy Statement. Department of Basic Education. Pretoria, South Africa, Government Printers: 1-170.

Gallegos, R. R. (2009). Differential equations as a tool for mathematical modelling in physics and mathematics courses—A study of high school textbooks and the modelling processes of senior high students. Mathematical applications and modelling in the teaching and learning of mathematics,

Kahveci, M., &Imamoglu, Y. (2007). Interactive learning in mathematics education: Review of recent literature. Journal of Computers in Mathematics and Science Teaching, 26(2), 137-15319.

Kaiser, G., Blömeke, S., König, J., Busse, A., Döhrmann, M., &Hoth, J. (2017). Professional competencies of (prospective) mathematics teachers—Cognitive versus situated approaches. Educational Studies in Mathematics, 94, 161-182.

Kaiser, G. (2007). Modelling and modelling competencies in school. Mathematical modelling (ICTMA 12): Education, engineering and economics, 110-119.

Lingefjärd, T. (2000). Mathematical modeling by prospective teachers. Electronically published doctoral dissertation, University of Georgia. Can be downloaded from http://ma-serv. did. gu. se/matematik/thomas. htm.

Larrain, M., & Kaiser, G. (2022). Interpretation of students' errors as part of the diagnostic competence of pre-service primary school teachers. Journal fürMathematik-Didaktik, 43(1), 39-66.

Redish, E. F., &Kuo, E. (2015). Language of physics, language of math: Disciplinary culture and dynamic epistemology. Science & Education, 24(5), 561-590.

Hoth, J., Döhrmann, M., Kaiser, G., Busse, A., König, J., &Blömeke, S. (2016). Diagnostic competence of primary school mathematics teachers during classroom situations. ZDM, 48, 41-53.

Meeus, M. T., Oerlemans, L. A., &Hage, J. (2001). Patterns of interactive learning in a high-tech region. Organization studies, 22(1), 145-172.

Mohammed, M. I. (2019). Efficacy of antenna engineering research orientation among graduate students atMekelle University Ethiopian Institute of Technology. The International Journal of Electrical Engineering & Education, 56(3), 222-237.

Soliman, H. Y. (2019). Methodology of Teaching and Learning Antenna Theory at Port Said University. Paper presented at the 2019 IEEE Global Engineering Education Conference (EDUCON).

Palmer, M. A., Amat, S., Busquier, S., Romero, P., & Tejada, J. (2013). Mathematics for engineering and engineering for mathematics. In Educational interfaces between mathematics and industry (pp. 185-198): Springer.

Redish, E. F., & Smith, K. A. (2008). Looking beyond content: Skill development for engineers. Journal of engineering education, 97(3), 295-307.

Vanourek, G. (2020). Schooling COVID-19: Lessons from Leading Charter Networks from Their Transition to Remote Learning. Thomas B. Fordham Institute.

Vorhölter, K., Kaiser, G., &Ferri, R. B. (2014). Modelling in mathematics classroom instruction: An innovative approach for transforming mathematics education. In Transforming mathematics instruction (pp. 21-36): Springer.

Yates, A., Starkey, L., Egerton, B., &Flueggen, F. (2021). High school students' experience of online learning during Covid-19: the influence of technology and pedagogy. Technology, Pedagogy and Education, 30(1), 59-73.

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