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Mathematics Teaching in Higher Education

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ABSTRACT: Teaching mathematics can be challenging since almost all new concepts depend highly on the sound understanding of prerequisite topics, and more importantly on the approaches that students used to learn those prerequisite subjects.A clear understanding of various teaching approaches is required when it comes to teaching mathematics. It is a discipline that contains a wide range of topics, and there is no "one size fits all" when it comes to communicating the theories behind these topics to students effectively. Students come to university from various educational backgrounds and research shows that both the mathematics knowledge as well as the mathematical mindset may differ for many students. A well thought-out teaching layout makes a major difference in the level of engagement from students during the lecture or any teaching session. A few points to consider when planning a lecture:

- Know what the students know at that point, and do not assume that they know other information useful to the theory that's about to be taught.
- What information is going to be given in an expository way, and what parts will be exploratory?
- How can previous topics seen be deepened in a cohesive way with the new topics?
- When are you going to have a break? A lot can happen in a two- to five-minute break. Students can reflect back on that "mad proof", they can (re)solve a problem on their own, or if it's an online lecture, they can use those few minutes to simply look away from their screen.

KEYWORDS: mathematics, students, education, higher, session, discipline, lecture, knowledge

I.INTRODUCTION

A common thought that many maths students have is along the lines of "when is this theorem ever used in real life situations?". Whenever possible, use a relevant topical example where the theory taught was applied. This brings benefits such as:

- Giving students the opportunity to connect what they are learning to real-life situations, allowing them to engage more and understand how they will transfer skills into their postgraduate studies or job.
- Encouraging students to apply their skills creatively in other modules and topics too. This strengthens their skills in reasoning, logic, and communication.
- Giving students an opportunity to speak to and interact with their peers.

This involves students learning collaboratively in small groups. Student-centred learning acts as a catalyst to students identifying what learning techniques work best for them, as well as what their strengths and weaknesses are in a particular topic. It builds trust, confidence and excitement where metacognition and teamworking takes place. This is particularly useful when there's more than one method to solve a problem or prove a mathematical statement

- Working together on a problem: (i) first presenting the new material or problem, (ii) asking students to troubleshoot individually while making notes on what definitions or theorems are relevant to the problem and what they need to do to solve it; (iii) then discuss their solution with other students, in pairs or small groups, and collectively.
- Brainstorming is a great way to open up a new unseen theorem or method. This allows students to revisit their existing knowledge in order to grasp the content of a new field. This can be done out loud, using a physical shared board, or using online responseware such as Mentimeter. Set a time limit. Encourage students to express any ideas they have even if they think it's irrelevant or wrong. "Quantity breeds quality" so keep the responses coming through.
- Ask students to teach a proof or algorithm to a friend. Teaching something you're not entirely competent in actually helps you understand it better. A good homework exercise for filling gaps in

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knowledge is to ask students to choose a theorem or proof or example presented in the course, and then try explaining it to a friend.[1,2]

Mathematics concepts are most commonly given auditorily via sequential instructions. Although this method has benefits, it can be enhanced by the use of visualisation techniques. The process of visualising aids the interconnections within the mathematical mindset, from the use of colour and images to the cohesion of various types of objects.

- Transform an algorithm into a stream of visual cognitive procedures, such as via a flow chart. This allows for creativity and reduces processing time.
- Place the separate components of a mathematical method or proof using labels, colours or visual shapes and then bring them together to form the final result. Visualisation is not only an illustrative tool, but an important component of reasoning. When students are able to visualise, they are deeply engaged with the conceptual understanding and not only what they are seeing.
- Use charts, Venn diagrams, and graphs whenever possible to illustrate relations or any solutions found to a given problem.[3,4]
- Use grouping, mind-mapping or flow-mapping techniques to illustrate how an algorithm works. Organise it as a network or other non-linear diagram incorporating verbal and symbolic elements, with or without colouring.
- Invite student participation that does that not involve writing such as drawing, recording video explanations, taking part in a game, using art, or completing a hands-on project.

Not all mathematics topics, such as calculus, logic, analysis, geometry, among others, make use of the same teaching methods. Having well planned teaching styles, resources, as well as fair and well conducted assessments is fundamental to learning. All teaching approaches have pros and cons, so we must be mindful to capitalise on the advantages and minimise the disadvantages.[5,6]

II.DISCUSSION

The action of a person who teaches is known as teaching. It is a process of transferring knowledge from teachers to students using different methods i. e., it is a process of imparting knowledge or skills. Smith defines it as certain tasks or activities the intention of which is to induce learning.There is a difference of teaching in school, college and university level students. A school teacher basically helps students to learn. Whereas college and university teachers (or professors) conduct research and commonly teach undergraduate, professional and postgraduate courses in their fields of expertise. Professors may mentor and supervise graduate or postgraduate students also conducting research for dissertation. So we find the difference of teaching at these levels.Raghwan (2015) says that the difference lies in the principles and methods of teaching, namely the pedagogy. He states that there is no pre-training programme available for university and college teachers prior to their taking up teaching as their profession. He stresses that the art and science of teaching, instruction and training school students is different from that of college students. In school, the emphasis is on making students learn facts and skills while college provides a learning environment where the student is required to think through and apply what s/he has learned.[7,8] He sees college lectures as in capsule form, presenting in a summarized form the main points of the topics of discourse. He believes that teachers in college deliver their lectures and expect the students to note the important points. They expect students to do self study, think and synthesize about different view point.According to him the college teachers must have adequate scholarship and expertise in the area they have specialized at the master level. There is no prescribed pedagogy to follow but they formulate their own pedagogy to create in the students a keen interest in the topics they lecture on and leave ample scope for the students to think, analyze, deduce and reach a conclusion based on their reasoning. Therefore college teachers function as catalysts to make the students think for themselves. That is one of the reasons why college teaching has not insisted on pre-training.As far as approach to teaching is concerned, formal teaching tasks include preparing lessons, giving lessons, and assessing students. Weimer states that “when teachers think the best, most important way to improve their teaching is by developing their content of knowledge, they end up with sophisticated levels of knowledge, but they have only simplistic instructional methods to convey that material”. He expresses that a love of the material and a willingness to convey that to students only enhances learning. He stresses on what we teach and how we teach it are inextricably linked and very much dependent on one another. Even though both are tightly linked, they are still separate. Development of one doesn’t automatically improve how the other functions.[9,10]

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If the method used to convey that knowledge are not sophisticated and up to the task, teaching may still be quite ineffective. It may not inspire and motivate students. It may not result in more and better student learning. The best teachers do know their material, but they also know a lot about the process. They have at their disposal a repertoire of instructional methods, strategies, and approaches—a repertoire that continually grows, just as their content knowledge develops. They never underestimate the power of the process to determine the outcome.Kelton mentions that we can write up syllabi by simply handling all of the mandated material first. After that, go through each portion and decide if there is anything that you want to add or elaborate on i.e., prepare a general list of the material to be covered. Raghwan (2015) states that instead we lecture on topics, provide the historical information, identify interdisciplinary connections related to the topics, discuss research about those topics and leave the students to relate the lectures to the reference books. Vaske (1998) says that the one goal of education (teaching) is to develop students' critical thinking. Entwistle (2008) quotes that "the best practice is whatever helps students to engage more deeply with the subject and to become more actively responsible for their own learning" is more important than others.[11,12]

As far as mathematician's approach is concerned, lecturing remains the prime delivery mode for teaching college students. Shellard et al (2002) states three components to effective mathematics instruction: Teaching for conceptual understanding, Developing children's procedural literacy, and Promoting strategies competence through meaningful problem-solving investigations. Protheroe (2007) instructs to increasing abstract reasoning including thinking hypothetically, comprehensive cause and effect. He stresses the students to think deeply about the problems they are solving, reaching beyond the solutions and algorithms required to solve the problem. Thus encourage the learners to investigate further to generate new knowledge. He also suggested for interdisciplinary connections of different disciplines. Barton (2012) mentions that we lecture through three components: lectures and their development; student perspectives on mathematics; and interactions in the lecturing environment.Yadav (2016) states that teaching completely depends on the basics required for the development of the subject. He propounded that mathematics is the study of assumptions, its properties and applications. He also claimed that every subject is the study of assumptions, its properties and applications. Therefore all mathematical and non-mathematical subjects are the study of assumptions, its properties and applications ', whether it is sciences, arts, commerce, literature, etc. These three terms give the clue of teaching not only mathematics but other subjects also. He suggested that in teaching we must maintain the order of assumptions, properties and applications.[13]

To the question raised by Ronning (2008) ' What should we emphasize when we teach mathematics? What kind of understanding do we want the students to develop? What kind of mathematics, and how much, do all students need to know ?', Yadav (2016) stated that "every chapter must be divided into three parts: assumptions, properties and applications". He stated that when we start teaching, we must mention "what are the basic assumptions in the chapter" keeping in view that definition is itself an assumption. What can we obtain from the assumptions and in last how and where can we apply these concepts? In this way students learn the definition, formulae and understand the basic structure of the chapter, which makes them perfect in application and for further research. Thus our motives become more and more successful in increasing the interest of mathematics among students.

As far as teaching in higher educational institutions is concerned, the content knowledge of the teacher and the contents of the lesson play an important role. The development of the contents of the lesson depends on the content knowledge the teacher and his interest in teaching and research or both.A good teacher having interest in teaching without research experience would always focus on basics needed to understand the lessons, the assumptions, its properties and applications to complete the course of study required for graduate and postgraduate students. A very good teacher with research experience having interest in teaching would focus on the historical background of the lesson, basics needed to understand the lesson, its properties, its applications, its limitations, and current research going on in the related areas. But the best teacher having keen interest in teaching as well as in research would also focus on the philosophy and social values of the properties and results, interdisciplinary relations with different disciplines, future scope of research in the lesson, and would suggest the students to think critically to generate new knowledge including other subtopics as contents of the lessons.[14]

III.RESULTS

Thus the content of the lessons depends on the interest of the teacher in the subject and their teaching and research experience. As far as the subtopic basics needed is concerned, it completely depends on the teacher's experience of teaching whereas the inclusion of the research related subtopics and the philosophy of the results are due to the research experience of the teacher and his (her) deep knowledge in the lesson.From above we find that in preparing the lesson to teach college and university level students in higher educational institutions, we should collect the following important subtopics in order:

- Historic Background with its Development
- Basics Needed to Understand the Chapter (if any)
- Assumptions and Definitions
- Related Properties
- Applications in Real and Imaginary World Problems (if any)
- Interdisciplinary Connections of Different Disciplines (if any)
- Limitations of the Concepts (if any)
- Philosophy and Social Values of the Results and Properties (if any)
- Critical Thinking to Understand the Chapter (if any)
- Current Research Going on and
- Further Scope of Research to Generate New Knowledge

Thus in teaching we can include the above important subtopics before delivering lecture in class room in higher education institutions but in the era of completing course of study as first duty, it's not always possible to follow the same. Therefore on the basis of the contents of the subtopics in preparing lectures, we can name them as follows:

Realistic Method

This method consist only three subtopics: assumptions, properties, and applications. This is the more realistic method than others because under the constraint of limited time and period allowed for each subject, a teacher cannot discuss others subtopics. This method is useful for graduate and postgraduate students. In this case students are supposed to know the basics needed to understand the current lesson going on or to be started next.

Realistic method can be divided into two parts: Inductive Method and Deductive Method. Inductive method consist assumptions, properties and applications in order while deductive method consist these in reverse order as applications, properties and assumptions. The procedure discussed by Yadav (2016) is inductive. It would be better to call inductive method as realistic inductive method.[15]

Idealistic Method (Research Oriented Approach)

For research oriented students of doctorate and post doctorate work, a teacher needs deep knowledge of the subject and the chapter. In such case the subject is limited to a topic or a finite number of topics. Therefore a teacher can prepare the lectures on a particular chapter containing: Historic Background, Basics, Assumptions and Definitions, Properties, Applications, Interdisciplinary Connections, Limitations, Philosophy and Social Values, Critical Thinking, Current Research, and Further Scope of Research to Generate New Knowledge.[16]

IV.CONCLUSIONS

As far as mathematician's approach to teaching is concerned we conclude that the realistic inductive method containing only three subtopics assumptions, properties, and applications are sufficient for graduate and postgraduate students whereas idealistic method is more useful for research oriented students.All mathematical and non-mathematical subjects and its chapters can be studied (or taught) and its lessons can also be well prepared according to the subtopics contained in realistic inductive and idealistic methods, which opens the scope for further research.[17]

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