A Technology Friendly Mathematics Teaching Methodology

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Abstract: *Mathematics fear is an unaddressed reason that has a great effect on the unexploited capacity of young students. All over the world, the problem is so vast that huge amounts of money are being pumped into research grants to find out why competent students are terrified of Mathematics even when they get good grades in other subjects. In this research, we demonstrate and rigorously analyze a number of innovative and new teaching methodologies that incorporate the use of modern technology to encourage freshman students to participate and take an active role in Mathematics courses More precisely, we introduce for the first time two innovative teaching methodologies: 1) Dynamic Lecture Notes: A lecturing technique that automatically changes the next lecture slide based on the live student response to in class questions using wireless voting systems and 2) 24/7 Student-Teacher Portal: A Mobile Social Networking (MSN) application that attempts to bridge the gap between the students and the teachers outside the walls of a classroom. Both methodologies were researched thoroughly in a number of local university class rooms and the results were collected to investigate whether they would lead to a dramatic increase in the overall performance and therefore successfully enhance the learning experience of the students.*

1. Introduction

Many educational techniques have been proposed before and yet we still see a major decline in the number of students who are interested to further pursue their Mathematics potentials by engaging in a university degree that majors or even minors in Mathematics. Why is that? In this research, we investigate and utilize the latest advancements in technology to provide a different learning experience to college students both at intermediate and higher levels in their academic career. This research is a collaborative work that is currently being conducted both at the American university of Sharjah and the University of Wollongong in Dubai in collaboration with some other local universities in the United Arab Emirates (UAE). Some major objectives of the research include the following concerns and counter measures:

1) There is no such thing as a brain type that makes one person better than another at Math. Studies show that there are different brain types, but those types just concern your approach at problem solving. One factor that affects math performance more than any other is confidence. Studies show that positive thinking can improve math performance. Basically, in this context, our research includes the following objective:
   - How can we (as teachers) make students ***think positively*** about their mathematical capabilities by involving them in class activities and also by ***creating a bond*** with them both inside and outside the class?

2) If our students avoided math in lower grades or they just didn't pay enough attention in middle or high school, they might be stressed out considering they might have a weak background. Identifying each student's level is usually done though quizzes and exams both of which might be too late as some students might have already lost interest in the subject or even specific

details would not be evident through some traditional assessments. In this context, our research includes the following objective:

- How can we make our students overcome this problem by treating each student differently both in class and outside class? Maybe the first and most important point would be providing ***immediate feedback*** and reinforcement. We will be surprised at how much our students really know if we were able to dig deep into their minds.

3) It is true that math involves some very complex formulas which will in turn discourage a lot of students to pursue further studies in Mathematics. However, if we, as teachers, were able to zoom into what each student's specific weakness is, we can in turn isolate the problem, examine it, and finally break it down into little parts. Every formula is made of little skills and steps that have been learned in the past. It's a matter of building blocks and if necessary going back to one of these blocks to re-build it again. Basically, in this context our research includes the following objective:

- How can we identify which building blocks need to be rebuilt when we come across a formula or process that seems too complex? How can we ***break it down*** and just go back and work on the basic concepts before moving on to more complex information. We need to remember that if one topic is not excelled, teaching the following topic will be a waste of time and even some times result in disastrous effects in the learning experience of the student.

4) Finally, local colleges and schools are excellent at providing interesting views of different subjects, to spark a student's curiosity and interest. History is an easy subject for students to relate to, especially when a teacher can focus on how the history of the world brings us to where we are today or how an X-president made some choices that affected our daily lives. Also, for example, in geography, it's much easier to answer "What are the main sources of income in China" than to show them the business model used in china in a complicated mathematical form. In this context our research also includes the following objective:

- How can we raise students interests in Mathematics and link the study of Mathematics (in its different domains from basic Pre-Calculus to advanced Calculus, linear Algebra, Number Theory, Discrete Mathematics, Numerical Analysis, Partial Differential Equations, Statistics and even Topology) to the students' own lives and personal thoughts. This is indeed a very challenging task especially if our students have already built a monstrous picture of Mathematics during their earlier foundation studies. We need to ***show appreciation*** and interest in what our student are doing - this can send a strong message of support for their efforts.

The listed objectives eventually boil down to the following general objectives:

1- How can we make Mathematics Teaching and Learning more efficient?
2- How can we make students in the love mathamtics rather than fear it?
3- How can we acheive greater learning outcomes that those acheived earlier?

The rest of this research paper is divided as follows. In Section 2, related research work are summarized. In Section 3, our proposed methodology is discussed thoroughly. Section 4 concludes this paper and provides some future insight.

2. Related Work

Our literature review is multidisciplinary as it includes three separate literature searches. In general, research on technology integration in mathematics education has examined the effectiveness of spreadsheets and dynamic geometry software on student performance [1]. The findings of the studies support technology in mathematics teaching and learning. The authors [1] investigated the effect of spreadsheet and dynamic geometry software on mathematics achievement. The results indicate that using technology effectively as a learning tool improves students' mathematics achievement. Olkun *et al.* [2] found that students who did not have computers at home initially had lower geometry scores. Therefore, they suggest that in schools, it seems more effective to integrate mathematical content and technology in a manner that enables students to do playful mathematical discoveries. On the other hand, research has also examined teachers views on instructional technology in teaching [3]. In [3], Di *et al* examined the impact of instructional technology in an educational foundation course on student's perceptions of instructional technology. The results indicated that while utilizing the Internet for research, students improved their perception of instructional technology related to confidence and comfort level, frequency of computer use, and views on instructional technology in teaching.

The other part of literature search included current research addressing the use of wireless voting systems for teaching. It was concluded that an interactive approach is the most effective way to achieve a high quality of teaching and learning in the classroom [4,5]. However, the difficulty of organizing interactive teaching and learning activities with a large, lecturing class size is also well recognised [6]. Other research aims were to engage students in a lecture environment that was traditionally regarded as requiring passive student participation [7], and to introduce overseas students to a more interactive learning approach, a technique that was proven successful as per the investigators conclusive results. Up to our knowledge, there is no published work that discusses the possibility of introducing automatic and dynamic lecture notes that automatically direct the lecture slides based on the student feedback from different in-class questions.

Finally, education practitioners and researchers have been creating and studying teacher communities for more than a decade [8]. Historically, research on teacher networks has been dominated by richly descriptive but localized accounts of school-based networks [9]. Research has shown that teacher networks, in its different forms, are effective alternative and supplemental interventions to traditional workshops and institutes for learning content. A parallel body of research has focused on *online* teacher communities [10] inspired by both the descriptive literature on face-to-face teacher communities and the quantitative social network research literature outside K-12 education [11]. These studies have been limited by their focus on small groupings within larger communities. Lastly, SNA [12] is a an evolving mathematical approach that is used to analyze the interactions and relations of entities in a network and creating a visual representation, called a sociogram, mapping the structure and strength of relationships.

The above cited research discuss the successful usage of technology to teach mathematics and more specifically the use of computers and wireless voting devices and related social networking measures. Our proposed research focuses on the development and usage of modern technology to create a new and nonexistent teaching methodology.

3. Proposed Teaching Methodologies

According to National Council of Teachers Mathematics, technology plays an essential role in teaching and learning mathematics as it influences the mathematics that is taught and enhances students' learning. With technology, what changes is the pool of problems to choose among and the ways they can be presented. Some problems are too hard to be posed in a pencils only classroom. Some lessons require students to experiment with certain mathematical objects and see how they respond. Some require visual representations such as graphs, diagrams, geometric figures, moving images that respond to students' questions, answers, or commands. Some others require out of class discussions and analysis. In this research we look at two different aspects of modern technology and how they can be utilized in modern educational methodologies to achieve the research objectives stated earlier which include:

- Making the students think positively about mathematics
- Creating a bond with our students both in class and outside class
- Providing immediate feedback to students performance
- Zoom in to students mathematical problems
- Treat each student based on their mathematical skills
- Raise student interests in Mathematics by relating it to their lives

A. Dynamic Lecture Notes

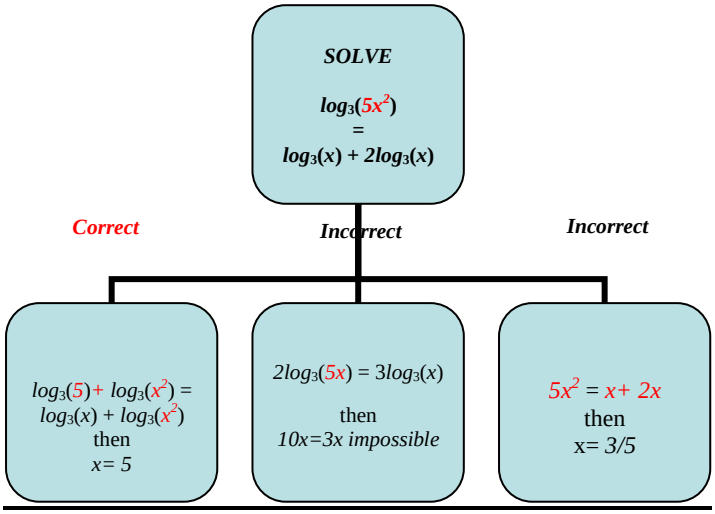
Typical wireless, interactive teaching promises an innovative solution to many of the objectives stated. When the lecturer asks a question, students can use this technology to answer such questions anonymously. From the percentage of correct answers, the lecturer can identify any learning problems immediately, and so, ***take remedial actions***. The peer instruction teaching technique can also be used to allow students to discuss ideas with their neighbours, and to challenge one another on the veracity of their answers. We would like to focus on the 'Remedial Actions' taken by the lecturer himself. In this research, we propose an enhancement to the typical wireless voting system that has been used worldwide in many universities where we, for the first time, introduce the concept of "***Dynamic Lecture Notes***". We have successfully implemented the *beta* version of an easy to use application that combines the feedback received from the students to well designed questions to automatically decide what the next lecture slide would be. Student participation enhances lecture delivery, and provides improved learning outcomes. From student interaction enabled by these wireless interactive devices, the system will be able to gain a much better insight into the students' level of understanding of lecture materials ordered in sequential sections which will therefore modify the sequence of lecture content to address student-learning needs without the lecturer's intervention. An illustrative example includes a small discussion on solving linear equations that was presented during the delivery of a Basic College Algebra course taught by one of the authors. Assuming the lecturer had already explained logarithmic and exponential functions explaining their corresponding rules in three sections ($Sec_{1,2,3}$) as follows:

$Sec_1)\ log_b(mn) = log_b(m) + log_b(n)$; $Sec_2)\ log_b(^m/_n) = log_b(m) - log_b(n)$; $Sec_3)\ log_b(m^n) = n \cdot log_b(m)$

Suppose the question that was asked was to solve the following equation:

$log_3(5x^2) = 3log_3(x)$ and were given 3 choices: A) $x = 5$, B) *No Solution* and C) $x = 3/5$.

We would therefore construct a decision flowchart depending on the possible mistakes a student might encounter based on their learning experience. Obviously, there are still other possibilities a student might end up doing based on some misunderstandings from the lecture notes which would result in the flowchart branching more. So what is the purpose of this example? Once a set of questions are designed at the end of each section, all the different branching should be considered and fed to the application proposed which will in turn build a mapping between the student responses and the mistakes encountered and therefore direct automatically the teacher's next lecture slide into where the majority of students have not understood the concepts.



In our previous example, if the majority of the students answered (A), the next lecture slide will be a ***new topic*** regarding logarithms and exponential. Again, the system will automatically direct the teacher to the next topic. If most of the students answered (B), then the next slide generated by the system will go back to Sec (3) to explain the concept $log_b(m^n) = n \cdot log_b(m)$ and probably do another example in that section. Now, if most of the students answered (C) then the next slide generated by the system will be at the beginning of the chapter to explain again the major idea behind logarithms and their applications. Now, the threshold to consider the majority of the students is set by the teacher at the beginning when starting the lecture but intuitively that would be at least 50%. Some important aspects related to the proposed research methodology include:

- Using this system requires a lot of initial planning and course designing however it pays off in the end after repeating the same course a number of times and analyzing the different students feedback. The system is incorporated in PowerPoint to make it easy for future teachers and lecturers teaching similar courses and using the proposed system. The current plan include developing a Dynamic Lectures for a complete Pre-Calculus course and make it available to other teachers interested in using such a technology.

- Using such an interactive system, students will be engaged more fully with the lecture material, solving problems and answering questions either individually, or on the basis of discussion with peers and ***would not notice any manual control*** from the lecturer or any pinpoint weakness as the system seamlessly blends with the whole learning experience. Students will have a greater level of understanding of the lecture material from lectures where this strategy of increased interactivity is employed.

- Another important aspect is that at the end of each day/week/month/semester, the lecturer can use the system to identify some patterns encountered when asking specific questions in specific sections. Also, some student's performance analysis can be made by looking at the percentage of questions answered correctly during separate periods in the semester and could discuss some 'undisclosed' issues with the students which might have affected their performance considering that the students would not have shared these information otherwise.

- So far, this system has proven to be successful as the students are more comfortable answering questions anonymously with wireless interactivity devices, and are more likely to respond to lecturers' questions than if required to answer orally which would result in more insightful information before conducting midterm or final exams.

To validate the need and benefits encountered by using such devices (in a normal scenario with no automatic dynamic lecture system implemented), we surveyed more than 200 students who were part of two second year Mathematics courses that used a beta version of the proposed interactive systems and asked them whether they thought such systems increased their mathematics learning experience and the results are depicted in Figure 6(a).

B. 24/7 Teacher- Student Relationship

One part of our objectives were met by utilizing the proposed system of wireless devices discussed above that will make learning mathematics more interactive and the learning experience will seamlessly blend with the lecture materials. However, another part of our objectives include answering two major questions:

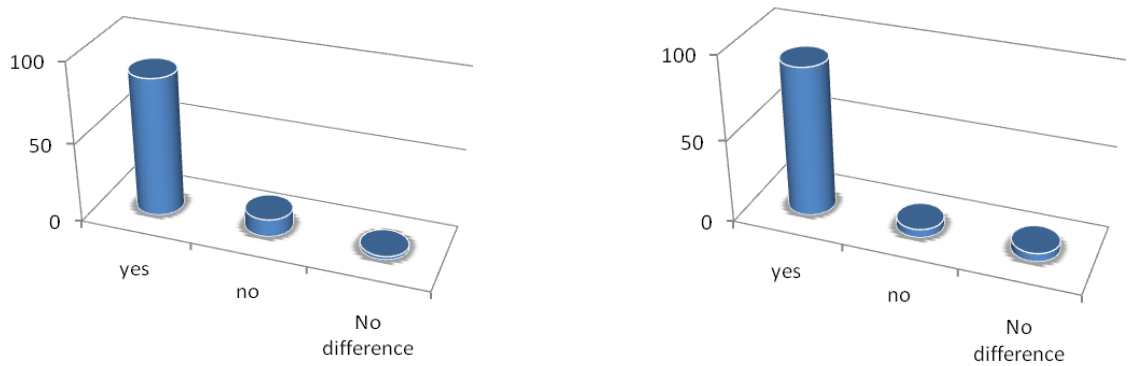
- How can we create a bond with our students both in class and outside class?
- How can we raise student interests in Mathematics by relating it to their lives?

Research results suggest that a lot of students learn best from their friends and family. The things we learn from our loved ones are often more immediately relevant to our lives than what we learn from a teacher in a classroom. Also, when we are relaxed at home or in a cafe, we are more open to suggestions and new ideas. One way to bond with our students is by being part of their lives outside school and by being there for us when they actually need us, simply by being their 'virtual' friends which hopefully one day evolve to real friends. These days, everyone has a mobile phone. In Asia, more people have mobile phones than land-line phones. In the UAE, people own more than one phone each on average. Young people get more new information from the technology they use outside of school than they do from their teacher in the classroom. When young people are on the Internet, they feel 'connected' to people and want to learn more. In the classroom, they can feel 'disconnected' and 'isolated'. They sometimes feel that Mathematics isn't particularly relevant to their lives. In this research, we propose the use of social networking and more particularly, FaceBook Mobile App. to teach mathematics outside our classrooms as depicted in Figure 3. Using, this we can blend in with our students and showcase both our ideas and theirs in a very informal and comfortable environment. We introduce the term: "***24/7 Teacher***" which would basically imply we are there for our students 24 hours a day and 7 days a week by replying to their posted comments on the class group wall almost instantly especially with the proliferation of smart phones and smart applications. We implemented a beta version of a smart phone FaceBook application that will further enhance the learning experience provided by social networking. Using FaceBook, we

can monitor common student doubts and encourage online participation in wall discussions. Also, the need and relation to Mathematics can be strengthen using video links from YouTube and other 'cool' up to date technologies which will in turn eliminate any fear or anxiety some students might have. To validate some of our initial assumptions, we implemented some of our proposed techniques and gathered some student feedback (see Figure 4(a).) . A Facebook group on Mobile Social Network App. was implemented for a Statistics course taught by one of the authors in Spring 2010 and Spring 2011 respectively. A nice and typical scenario can be depicted in Figure 4. A question was raised by one student regarding a sample exam question posted by the lecturer and students in the class/group were discussing several explanations and therefore raising interest in the subject and allowing the instructor to also answer common doubts by students when needed or provide extra online support and links to those who need more help. To validate the need and benefits of using Mobile Smart Phone FaceBook Application in Teaching, we surveyed more than 200 students who were part of two Statistics courses that used such a FaceBook Interaction for teaching and asked them whether they thought such systems increased their Mathematics learning experience and the results are depicted in Figure 5. Other factors including cultural acceptance as well as teacher's willingness to sacrifice some time to implement such methodologies for the sake of the students are part of our ongoing research.

(a) (b)

Figure 3.1 (a) The Mobile FaceBook Application where the 24/7 Teaching Methodology is utilized. (b) A discussion regarding a sample exam question posted by the instructor.

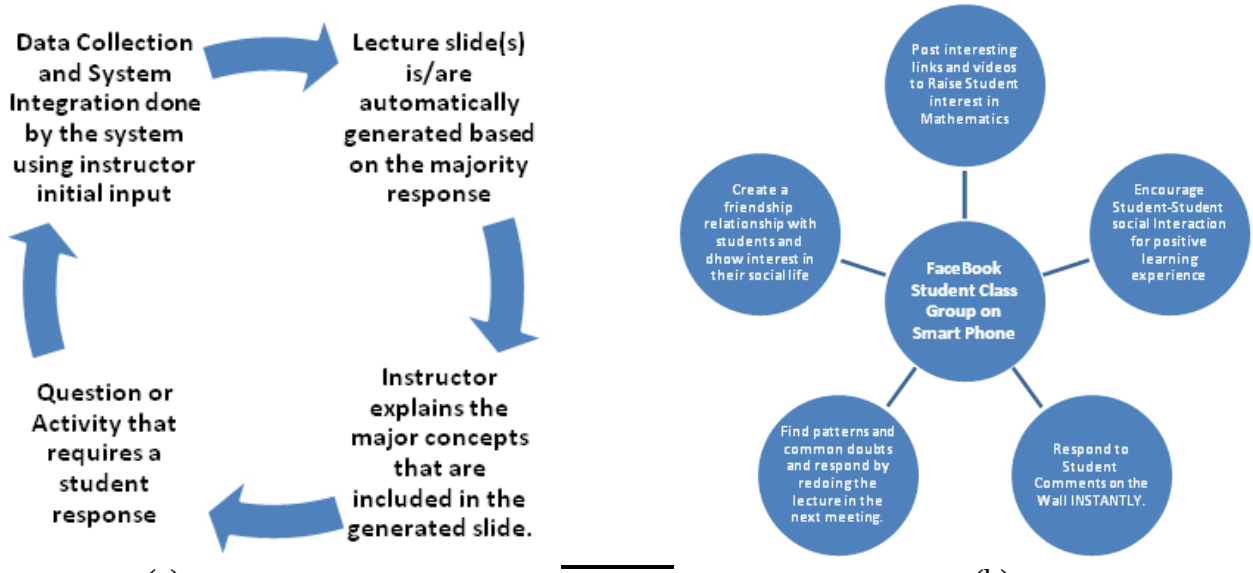


(a) (b)

Figure 3.2 (a) More than 200 students surveyed on the benefits of the use of Dynamic Lecture Notes Teaching Model. (b) Student results on the benefits of the use of 24/7 Teacher Model.

C. Conceptual Framework and Performance Analysis

The two proposed teaching methodologies involve a number of sub activities to reach the ultimate goal. Figure 6(a) depicts the conceptual framework for the Dynamic Lecture Notes system while Figure 6(b) details the conceptual framework of the 24/7 Teacher-Student communication.



(a) (b)

Figure 3.3 (a) The conceptual framework of the Dynamic Lecture Notes system
(b) The conceptual framework of the 24/7 Teacher-Student System

Aside from the high percentage of student acceptance of the proposed teaching methodologies and the intuitive benefits in learning Mathematics experience, we conducted a small experimental study in a Statistics course with more than 300 enrolled students separated in three different groups and analyse the effect of using the proposed techniques on the performance of the students. At this stage, the only measure used was the grades of the students in exams although other measure are currently being researched including the in class participation percentage, improvement of

individual students over the semester and the correlation between in class performance and exam performances. We started the semester using the normal approach (lecture notes, office hours) and after Exam 1, we shifted to using the beta versions of the proposed techniques (Dynamic Lecture Notes, 24/7 Mobile Social Networking). We made sure the difficulty level of both exams were consistent and also used the data from previous years to compare the performance of the students on both exams. As evident in Figure 7, The failure rate (letter grade F) decreased drastically by about 50% while the other letter grades had minor increases. This result is not a surprise as using the proposed methodologies will have an impact more on the students who need more help understanding the concepts or are shy to disclose their weakness in a specific topic that might influence their performance in the exams. Our proposed system highlight those weak students and helps them perform better. Obviously, this result does not provide us with conclusive results but rather opens the door s to further research and experiments in this area.

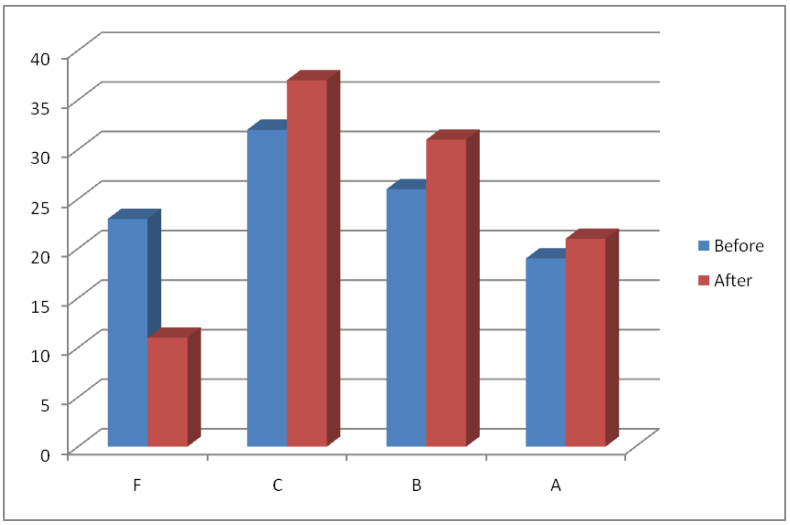


Figure 3.4 The performance (Letter Grades) of the students before and after using the proposed teaching methodologies in a Statistics Course for Engineers.

Currently we are investigating further performance measures that will validate the need of such teaching methodologies and their corresponding effect on the performance of the students. Assessing the effect of our newly introduced teaching methodologies is a very difficult. One way to do it is to base it on student performance in two different but same difficulty level of exams as mentioned in the previous experimental study. However, student reactions cannot be measured with voltmeters. Instead, changes in things such as student achievement, are very difficult to measure with certainty and subject to the wide variations. Currently, a "virtual control group" is being created using a simple performance prediction model based on the students' incoming cumulative GPAs. The choice to base the prediction solely on prior college performance was motivated in part by the likely availability of GPA information hoping to use this technique, and partly by the prior research, which indicates that college performance is generally a good indicator of performance in a specific course. We want to compare between the actual performance of the students in the course and the predicted performance based on previous semesters. However in order to make it more realistic, we decided to look only on the students previous grades in Math courses. The experiments are in progress and will be part of a longer journal version of this work.

4. Conclusions

In this paper, we proposed a number of innovative techniques using both modern voting systems and social networking to introduce a new learning experience of Mathematics and associate concepts in local universities. This work is still at its infancy and current work include developing a fully enabled Graphical User Interface (GUI) for teachers to design their whole Mathematics course and incorporate dynamic lectures in their curriculum. We are also working on developing a FaceBook Smart Phone Application that can easily be downloaded by any teacher without the need of any pre-installation package to facilitate the use of mobile social networking in teaching Mathematics courses worldwide. The proposed research project has a number of direct positive implications on the society as a whole and more specifically on the coming generations of graduates and teachers.

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