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Remedial Tutorials for Differential Equations

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Abstract: Many factors may contribute to students not making the grades of a course. More so daunting if the course(s) of concern are prerequisites to other higher-level courses. The compulsory core Differential Equations EBB1113 course is that hurdle for some first semester engineering undergraduates at Universiti Teknologi PETRONAS. These students do not fulfill the minimum passing grade and are required to repeat the entire course. Redoing it means having to attend lectures and tutorials all over again. What could be the best approach to tackle the situation so that these students do not repeat the same mistakes and fail again? The objective of this study is to discuss several steps taken up by the instructor with full support for change from the management that could provide some insights as to the efforts made to manage the challenges faced. The students face the tasks of overcoming factors of inferiority complex and disorientation, doing and repeating the same mistakes. The instructor faces the tasks of boosting motivation to the now less motivated individuals who will be attending lectures together with their juniors, and to design an alternative approach in creating a desired difference while fulfilling the continuous quality improvement that is required of the university. A special 2-hour tutorial session, workbook-based learning is reserved and conducted weekly for 10 consecutive weeks. The outcomes of the effort, although not a total desired 100% was an encouraging 92.9% rescue success rate. The results also include what the students have to say after passing the final exams. The comments and recommendations offered by these students after going through the learning experience are important for a continuous quality improvement.

Key words: Differential equations, remedial tutorials, quality improvement

INTRODUCTION

The January 2009 semester witnessed a failure rate of slightly more than 13% in the EBB1113 Differential Equations (DE) course, a first semester mathematics course for all engineering disciplines in Universiti Teknologi PETRONAS (2008). As a result, the lecturers teaching this particular course must take up appropriate initiatives for Continuous Quality Improvement or CQI. This strictly called for immediate measures aiming for improvement. The high failure rate also meant that there will be students repeating the course in the July 2009 semester. One of the biggest challenges for the repeaters would be undergoing the course with their juniors. Where lectures were concerned, the repeaters attended the same lectures with the rest of the class, their attendance closely monitored, just like the others. A lecture would normally be attended by about 100-150 students and a regular tutorial session normally catered for 45- 50 students. In the past, repeating students re-enrolled for the course and followed through the course, attending regular lectures and tutorials, not segregated and treated equally with non-repeaters. With the CQI status, it called for a change, and immediate action was inevitable. All lectures were delivered by two lecturers and some tutorials were facilitated by lecturers while others were conducted by UTP graduate assistants. The instructors collaboratively delivered lectures and conducted tutorials using a newly published textbook, written by them. The book has a complete set of notes and exercises for the entire course. It was written and customized to meet the EBB1113 syllabus for UTP students (Zainal Abidin and Faye, 2009). Published in June 2009, it provides, for each section of every chapter, a recollection of relevant topics as pre-requisites before covering a new topic, easy-to-follow lecture notes, which guide readers with systematic worked examples and in-class exercises with spaces provided for students to write their solutions in order to assist them in measuring the expected lesson outcomes of each section. Each section ends with a short summary and seven homework problems. The lecturers expected students to utilize this book by engaging themselves in completing the homework exercises as follow-ups and in preparation for the subsequent lessons. Topics covered include introduction to DE, methods of solving first order and higher order DE. The higher order equations include Cauchy-Euler equations, Power Series solutions to DE, Laplace transforms, solving DE using Laplace transforms

and an introduction to Fourier series. The book provides no end answers to the homework problems. Four hundred and thirty two first semester engineering undergraduates made up the class of EBB1113, UTP July 2009 semester. The class consisted of mainly first-timers for EBB1113 with 14 of them repeating the course.

Problem statement: The large number of failures in EBB1113 posed a concern to the university. Some of the failure cases came from students who were repeating the course. Under the outcome-based education culture, effective measures are necessary for improvement. The CQI for EBB1113 challenge was to show, the least, an improvement. Having repeating students in class posed an even bigger challenge to the instructor. Teaching and learning demands a different but definitely a more objective approach. It was decided by the lecturers that the repeaters for the EBB1113 course be isolated from the first timers as far as the tutorials were concerned. Would this intervention initiative ensure the improvement amongst the repeating students?

Objective: The objective of this paper is to discuss the outcome of implementing such measures to help participants who were having academic difficulties i.e., by isolating students repeating the course from the other fresh learners for tutorial sessions, conducted by a lecturer, two hours weekly for a span of 10 weeks.

Literature: The EBB1113 (DE) is a three credit hour compulsory common core Mathematics course that each first semester engineering undergraduate must pass in UTP. Each semester, there are students who fail to meet the minimum passing grade and are required to re-take the course for an entire semester. There are various reasons that could have contributed to their poor academic performance. Blai (1975) conducted a study at Harcum Junior College in Pennsylvania and found that 30.5% selected poor study habits; 29.2% selected lack of knowledge and skills; 22.2% selected lack of motivation; and 18.1 % selected poor classroom participation. A research done in the Medical School, University of Otago New Zealand found that remedial help is beneficial for medical students who repeatedly fail the in-course assessment program in improving their performance (Schwartz and Loten, 1998). How best do students learn? Confrey (1990) noted that constructivism is the belief that each individual constructs knowledge and that this construction is adaptive and influenced profoundly by our experiences and our own cognitive lenses. According to Vygotsky (1978), "Every function in the child's cultural development Appears twice: first, on the social level and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological). This applies equally to voluntary attention, to logical memory, and to the formation of concepts. All the higher functions originate as actual relationships between individuals". What are effective ways of improving and not failing the course again? Russell (2010) provided tips and steps for learners of mathematics of all levels; from primary schooling to university that are useful. The tips quoted; Strive for understanding rather than memorizing, Be an active rather than a passive learner, Keep on practicing, Do more than what was asked for, organize or get a study group, share or teach someone else about what you have known, if all else fails, seek for clarification from a friend or tutor to avoid frustration. Polovina (2006) mentioned about the Learning Pyramid shown in Fig. 1 was developed and used by National Training Laboratory or NTL Institute at the Bethel, Maine campus in the early sixties and is believed to be accurate. According to Polovina (2006) the original source research that supports the numbers is unknown. Summarizing, learners retain approximately: Ninty percent of what they learn when they teach someone else/use immediately. Seventy five percent of what they learn when they practice what they learned. Fifty percent of what they learn when engaged in a group discussion. Thirty percent of what they learn when they see a demonstration. Twenty percent of what they learn from audio-visual. Ten percent of what they learn when they have learned from reading. Five percent of what they learn when they have learned from lecture. A research was conducted by Tall and Razali (1993) in Universiti Teknologi Malaysia (2008) with the primary task of identifying the difficulties encountered by students

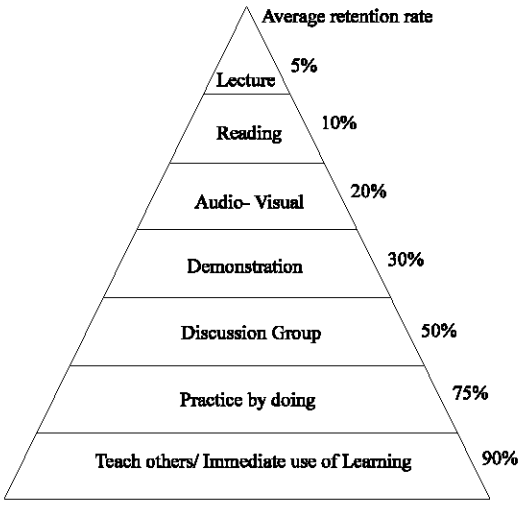

Fig. 1: Average retention rate

and then to use this information to develop remedial procedures to overcome these difficulties. It implied that "The less able students are likely to need special treatment. If this is not done, the students are likely to become progressively more confused and in the long run they may not survive in post-secondary mathematics programs." They believed that "The difference between the thought processes of the more able and less able leads inexorably to a growing divergence in performance in which the more able can only get comparatively better and the less able worse as the subject progresses. The more able flexibly manipulate symbols either as process or concept, whilst the less able tend to be more concerned with process and get locked into the strategy of accumulating procedures to 'give the answer'.".

METHODOLOGY

Research design: The formation of this single group of participants was according to the participant status; a fail grade (F) in EBB1113.

Instruments: The remedial tutorial made use of a text workbook with the set of seven homework problems at the end of each section of a chapter. The participants attended a weekly 2 h tutorial session for ten successive weeks. Each one of the participants used the whiteboard to reason out their problem solving approach. Participants were to submit all their work done throughout the 10 weeks tutorials. In the following January 2010 semester the author received acknowledgment and appreciation remarks received by e-mails which were noted. Data collection included the participants' attendance record, submission record of work done in tutorials, final grades obtained by participants and e-mails received in response to seven questions posed by the author to participants after the final and official results were announced.

Participants: Fourteen participants; 2 girls and 12 boys from various engineering disciplines were involved in the study; all local Malaysians who had previously not fulfilled the minimum passing grade. Five of them were repeating the DE course for more than once and for each attempt they made before earned an "F" grade. Nine others were repeating the course for the first time.

Procedure: The EBB1113 remedial tutorial took place on the premises of UTP in July 2009 semester. During the first session, the author clarified the objectives and the expectations of the remedial tutorial to the participants and stressed the concern that the lecturer and university had for them. She arranged the remedial tutorials to include participants writing and demonstrating his/her solutions to problems on the white boards, participants active learning while being seated at a round table, allocated time for practicing the 7-homework problems, and describing their solutions to others and assisting their peers who were still having difficulties. The tutorial room set up was with ample white board writing space. Judith (1999) and Weber (1997) indicated that the round table learning method capitalized on the experience base and strengths of students and will lead to enhanced understandings in content areas. This round table learning was adopted to promote open and informal discussions. The lecturer sat amongst the participants, initiated discussion, posed questions, and encouraged questions and answers from the participants. For each problem solving session, a participant would show his or her solution on the white board. Others with difficulty in understanding the solution needed to ask to obtain answers from their colleagues. Despite refraining from 'teaching' in the remedial tutorial, a brief explanation or clarification by the author was sometimes inevitable. The author noted participants' attendance of participants religiously. The meetings schedule was for each Wednesday of the semester at 3:00 P.M. and lasted for about 2 h. The text workbook used for lectures was fully utilized here in these remedial tutorials, where students attempted all 7-homework problems assigned towards the end of each section of any chapter. Each participant was required to do write up of all solutions to all the homework problems and submit to the lecturer towards the end of semester. It was not always that discussions in the remedial tutorial were all about mathematics. Participants showed more interest and were more responsive when the author brought up topics on learning preferences and learning strategies. On many occasions, when participants discussed some more difficult topics such as the Laplace Transforms and solving DE using Laplace transforms, participants expressed their never-ending fear of failing again. Such concerns were diverted by taking a step back and giving them easier-to-handle and back-to-basic problems on Laplace Transforms first and then progressively challenging them with the more difficult ones. The grades adopted by UTP grading system is; A = high distinction = 4.00, A- = distinction = 3.75, B+ = good credit = 3.50, B = credit = 3.00, C+ = good pass = 2.50, C = pass = 2.00, D+ = marginal pass = 1.50, D = unsatisfactory pass = 1.00, F = fail = 0.00 (Universiti Technology PETRONAS, 2008).

RESULTS

Table 1 indicates the attendance scores out of ten meetings, their new grades obtained in July 2009 semester, and record of their work submission. The remedial tutorial attendance record indicated that there were times when it recorded a turnout that was as high as 100% and at times as low as 36%; reasons for absenteeism offered were mainly due to laboratory activities, health reasons and oversleeping. This group of participants started as quiet and passive, but with persuasion and encouragement, they were able to play an active role in contributing their

Table 1: Remedial tutorial report

Participant	Attendance Max10	July 2009 grade	Submission of work
A	9	B	yes
B	3	C+	yes
C	6	C+	yes
D	8	C+	yes
E	5	C+	yes
F	4	C+	yes
G	8	C	yes
H	8	D+	yes
I	6	D+	yes
J	8	D	yes
K	7	D	yes
L	7	D	yes
M	3	D	partially
N	1	F	partially

Table 2: Remedial tutorial report

Questions	Responses from participants A, D and H respectively
What were the reasons that made you fail the course before?	Lack of exercises, misunderstanding of concepts and correct steps Due to my poor performance in Calculus.Ionly passed with a D Lack of exercise and practice.lack of self-motivation when achieving poor result; the failing mindset which deprived me of facing the difficult question
What were the contributing factors leading to your passing the course?	Doing more exercises and paying full attention in class The remedial class has helped me a lot to undrestand the subject in detail and also provide me with enough confidence to sit for test and exams of this subject. My tutor's guidance in this class was inspirational. My parents have always supported me when I was repeating this course. They have always been understanding and helpful during the holidays. Friends who were also repeating this subject have been very helpful Exercises and practices from the workbook helps; the tutorial session is significant in ensuring topics understanding and problem-solving techniques are properly used; motivation from lecturer and friends promotes an uplifting environment to strive harder and the realization that failure is not going to come twice for me
Was the remedial tutorial a major reason?	Yes Yes Yes, the tutorial extensively helps in understanding the question and tackling the problems given. A lot of common errors and confusion are straightened out; repetitive lectures on basic derivation and integration techniques help us remember the steps involved
Was segregating (separating) the repeaters from the others for the tutorial a good idea?	Yes Yes it is because the group of student this subject was also affected mentally in the aspect of confidence. Putting them togehter with the non repeater would slightly affect thier self esteem Yes, the repeaters are slow-learners and need extra work on technical subjects. Combining the repeaters and the first timers is not justified unless the first timers are also having as much difficulty as the repeater were. Hence there must be a pre-evaluation of performance such as thier foundation mathematics studies grades etc. By the way, it,s also crucial that the class be conducive enough that no more then 15 students/session so as to ensure attentiveness and learning opportunities for the students remain high
Does it matter whether the lecture or some one else (a graduate assist or GA for example) conduct the tutorial?	Yes, I prefer the lecturer to conduct the tutorial because I doubt that GA can fully understand the repeaters' situation. Yes it matters. I prefer if the lecturers themselves conduct the tutorials. This is because the lecturers know where their stand in sense of performance and achievements in test quizzes and also exam. This will also enable the lecturers to the real problems faced by the students'. During lectures the student group is big. Even when the lecturers ask if there the students don't understand. Some will tend to hesitate to ask even if they were unclear about the lecture The repeaters require not only the informative guidance but also the attachment towards the teacher. The important part is that the teacher must be caring and supportive and yet at the same time strive to ensure the students success. If the G.A can perform this; it's fine for me but honestly I would say my lecturer had done an excellent work on this part. May be these are skills acquired through inter personal experience; whomever it is it does not matter as long as they are sincere, caring and supportive towards the student and are passionate about the subject
Was the textbook of any help to your learning?	Yes, it helped a lot Yes the new text book by the lecturers was way simpler and also easy to understand. The previous textbook was complicated and too much of information to digest Yes, the textbook contain all the exercises and notes, enough to equip the students with the necessary skills and understanding. Albeit having several typing errors, there is not much to comment. Maybe adding pictures can light-up the book better
What are areas of improvement to ensure that your juniors will benefit further?	Remedial class should also be compulsory for non-repeaters that fail Test 1to curb the problem early If the repeaters group is big I feel that separating them even for lecture hours will also help. Personally when I was repeating the course, my biggest problem was to face the juniors in the same class. Most of the time the repeaters like me find it is hard to mingle with them during lecture hours. We end up sitting alone either in front or at the back of the class. Reviewing the students Calculus is also important. If the students enrolling themselves into this course have lower grade than C it is vital to refresh their memory on calculus primarily the Differentiations and also Integration part The repeaters could be assigned to a study group, doing 30 min to 1 h session/week to recap on their problems and solving them together. The chapter-by-chapter homework can be continued as last semester where every one should submit the homework once the chapter has been taught

solutions; right or wrong. Twelve out of fourteen participants submitted their work faithfully as required. These carried no marks but were required of them as evidence of their work done during the remedial tutorial sessions. Thirteen of the fourteen participants managed to at least obtain a passing grade for the course. This passing grade indicates a 92.9% passes, with one participant achieving a B grade, five with a C+ grade, one with a C grade, two with a D+, four with a D grade and one participant still failed the course despite all efforts. This particular participant unfortunately had some financial difficulties and juggled between classes (lectures and tutorials) and work, thus contributed to his poor attendance.

In the beginning of the new (January 2010) semester, the author asked participants to respond to 7 questions via email. These questions pertained to the reason(s) that participants thought were the contributing factors to failing the course previously and what they thought were factor(s) contributing to their success in passing the course. She received some feedback of which responses from participants A, D and H were included in this paper; The final grades obtained by A, D and H were B, C+ and D+, respectively. Table 2 shows excerpts from participants A, D and H who have obtained grades B, C+ and D+ respectively. It was also noted that the overall failure rate for EBB1113 July 2009 dropped from more than 13 to 8%, indicating a dip of about 5% reduction in the failure rate for the July 2009 semester.

DISCUSSION

These 2 h tutorial weekly sessions were over and above the course requirement of a 3-credit hour course. However, under the high failure rate circumstances was an intervention initiative deemed necessary to assist participants overcome their difficulties in the learning of the course. The effort put in by the author, backed by the university full support for the remedial tutorial implementation was reassuring for the participants. The author's field notes indicated that their morale was boosted by the fact that the lecturer and university were showing some concern. Friends also played an important role in their learning experience. Amongst the participants, five of them repeated course for the third or fourth time and they commonly had trouble due to poor recollection of Calculus and pre-Calculus, thus explained why most struggled whenever Algebra, Trigonometry, Differentiation and Integration of Trigonometric and Logarithmic functions appeared in DE learning. The round table discussions promoted an informal tutorial set up that allowed participants to feel less stressed, thus the ability to communicate better. The small number in the remedial tutorial made it possible for the author to provide the necessary attention and guidance to the individuals. Via the e-mails received, it was apparent that restricting the remedial tutorials to repeaters was important in safeguarding their self-esteem. Therefore, the segregation played an important role in ensuring their commitment to attending the sessions. The participants preferred that the tutor was also the lecturer who taught them. The same text workbook used during lectures played an important role as an adequate material for the remedial tutorial. With no final answers in the textbook used, participants realized the need to attend lectures and tutorials. Results revealed that the remedial tutorials had helped participants in passing the course and in decreasing the number of failures. The overall performance had improved tremendously and the bigger challenge is for the lecturers responsible to maintain, if not improve it further.

CONCLUSION

The success rate achieved in this study showed that the remedial tutorial was a worthwhile effort in assisting participants to at least pass the course. The remedial tutorial created a different learning environment to the participants repeating the course; small in number and cohesive in nature. With less cognitive stress, they were able to perform better. Changing the scenario from working alone to working with others in a dedicated and well supported tutorial session reflected that the repeaters' learning can be improved. High commitment of the tutor in conducting the remedial tutorial sessions was important in gaining the confidence and inspiration of the learners. This remedial tutorial certainly contributed in improving the quality of learning for the students who had faced difficulties in learning the course.

RECOMMENDATION

For future work, the author considers the suggestion of early identification of high-risk student for such remedial tutorials and plans to investigate justifications of raising the minimum passing grades of the prerequisite courses.

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