Learning Differential Equations: A Meta Synthesis Of Qualitative Research

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Abstract

Teaching methodology is developing time by the time. There is need revision to the methodologies those have been planned and examine. In this research explore the development of teaching Differential Equations methods in year 2000 an upwards. The methodology used in this paper was by doing metasynthesis research. In the last chapter, the researchers purpose of using online learning as new method of teaching.

Keywords: metasynthesis, Differential Equations, teaching methodology, online learning, technology

INTRODUCTION

There are many frameworks presented in engaging students in learning mathematics. It is very important to change the teaching techniques or blended the traditional and modern techniques of learning. Rapid development of technology is influenced the teaching techniques among the teachers and lecturers. It also affects the teaching and learning differential equations for undergraduate students.

Kashefi, Zaleha and Yudariah (2010) in finding the obstacle the students' faced found the undergraduate students have problem with non routine problems. This matter was contributed by the weakness of students in understand the basic concept and the symbols used. in addition, the students also have difficulty in doing graphical representation for 3 dimensional graph.

Although that in a research done by Soon, Lioe and McInnes (2011) in a university in Singapore, the students did not have problem in drawing the diagram. But the students still have problem in connecting between the real life-contexts with the mathematical representation. So this current research to glance the development of methodology of teaching differential equations in education filed. Seems like the research done by the …..on development of learning statistics using computer. Moreover, there is no research on meta synthesis in reviewing the learning differential equations.

As discussed before, there are some problems for students to understand the differential equation. This research is very important to come across the development of teaching method in teaching learning differential equations. Furthermore, the technology change over time caused the teachers and lecturers make the teaching approach in assorted way with some tools and aids. The most important, the techniques can engage the students with the subjects and increased their understanding and reasoning. Separating the technology from teaching is a such losses for the education field and the students ability. Tall and his friends (Dubinsky &Tall 1991, Kashefi, H, zaleha Ismail, Yudariah Mohammad Yusof and Roselainy abdul Rahman, 2012; Zaleha Ismail, Zeynivandnezhad and Yudariah, 2012) proposed many framework in integrating computer or technology in their teaching in classroom.

STUDY BACKGROUND

Differential equation is one of the core subjects for undergraduate students whose took major in mathematics/science and also for engineering students. For undergraduate students, this subject is very difficult since the answer of the questions is not numbers. As taught in secondary school especially in Malaysia, all the answer of the questions is numbers. So it is rare for students to adapt with this subject essentially.

In traditional teaching methodology teachers and lecturers are give the notes, demonstrate the procedure and explain to the students. While, the students have responsibility to copy the notes, listen to the explanation and do exercises in the textbook to sharpen their skills in procedural learning.

Inquiry oriented differential equation has been introduced to help the students understand differential equations by reasoning. The students are exposed by the realistic tasks, the small group discussion to investigate the problem and also group discussion to present and making argument between the colleagues about what they learned. So that, the students can upgrades not only procedural knowledge but conceptual knowledge also. (Kwon, 2005)

There are some researchers and the mathematics lecturers integrate the learning differential equation by reasoning with computer or using technology. Dubinsky and Tall (1991) believe by fully utilizing of computer ability in various ways, it can be a tool to help students' mathematical thinking. So the purpose of this paper is to do overall view in development of learning differential equation for undergraduate students.

Why learning differential equation is important?

Differential Equation (DE) is one of important knowledge that most of sciences students need to acquire. Most of the colleges and universities were placing Differential Equation in their syllabus of mathematics (Bajpai, calus & Simpsona, 1970). Same goes to the universities in Malaysia, for students whose major in Mathematics and engineers have to take this subject such as in International Islamic University Malaysia and Universiti teknologi Malaysia. Even though both of these universities offer DE in their mathematics syllabus, UTM has put DE in one subject. UTM also placing DE as perquisite subjects before the students take Calculus. So the students should more skillful in this subject.

Differential Equation is not a new subject for undergraduates' students in Malaysia. Especially science stream students, they were taught DE since in secondary schools. Even if in the universities level is higher than school level. However what is Differential Equation actually? The most frequent answer are, DE is about function and its derivative (Matd44h3F, 2011: Penick 1997) and Dawkins (2013) added, DE is an equations contains either ordinary or partial Derivatives.

OBJECTIVE OF THE RESEARCH

1) To see the development of methodology of teaching differential equation for years 2000 and upwards.
2) To study the students' problem in this new era and the effect of technology in their understanding of Differential equations.

METHODOLOGY

Qualitative meta-synthesis approach

Meta synthesis is uses in academic writing to bring the previous research findings into new era. This is very important to avoid any repetition of research by the new researchers. since the meta synthesis features is on tentative manners, the researchers can follow the development of one issues arises. The gathering information in different resources also based in knowledge. (Hallberg, 2011)

There are many varieties of reasons in making the Meta synthesis papers. Some studies are analyze the connection structure (Chun-Li L & Lin-na H, 2012), to get wide understanding about an issues (Ponggenpoel M, 2009: Halai N, 2012) and also to exploring issues arise (Liu Y, Niu g & Gu, 2007; Douglas et al 2008). Moreover there is also Meta synthesis intended to look the regular view of problem for the next exploration (Tang 2009).

The papers in this research are categorizing in academic papers and peer review. The papers are retrieved from mixed resources online such as science direct, emerald, Springer, sage, e-journal of UTM library, Google and also Google scholars. The keywords used to find the related papers are learning differential equations, differential equations and inquiry oriented differential equations. Some authors name also chosen to review their papers such as Rasmussen and Habre.

The numbers of publications is 50. Then the inclusion criteria for this research are 1) all the publications must be qualitative research in design 2) the data of the research is primary 3) qualitative data collections including interview, observation and students worksheet 4) the researchers has defined the sample use in the papers 5)there is innovative strategy of teaching methodology. The papers publication left only 35. The next step is applying exclusion criteria which are 1) papers those entirely conceptual, theoretical background and research design 2) an examples of questions based. The remind publications are 8 only for this research,

ANALYSIS

In this research there are 8 action researches have been reviewed for the purpose of to glance the development of learning differential equations. In Table 1 the details of the studies in terms of the writers, methodologies used in the each papers and the also the respondents. All the papers are used Differential Equations as the subjects and the responses from sample as the indicator. See at the Table 1. Papers written by Rasmussen and Habre are frequently reviewed in this research. The objectives of the studies are 1) to introduced new methodology of teaching to educators 2) to explore the issues in learning differential equations by the students

Table 1 : Description of studies reviewed

Article (no)	Objective	Methodology	Sample
[1] Wagner F J, Speer M N and Rossa B (2007)	Examine knowledge other than content knowledge needed by a mathematician in his first use of an inquiry-oriented curriculum for teaching an undergraduate course in differential equations	Classroom teaching, videotape, notes in the class, interview, self report	19 undergraduate students, major or minor mathematics and biology, chemistry, Physics Teachers' view
[2] Stephan M & Rasmussen C (2002)	to present an analysis of the classroom mathematical practices that were established over the first half of the semester including instruction on first order differential equations	15 week classroom teaching experiment Video recording of class and interview, copies of written works, instructor journal, research field notes, audio recordings and debriefing sessions	Mid-sized university in the US, Engineers
[3] Miller RH & Upton S B (2008)	we present the rationale for such computer innovations, the philosophy behind their design, as well as a discussion of their careful development and implementation	Students provided with computer, and the computer screen was videotaped and the verbal exchange was recorded as participants worked	8 students from an introductory ODE course, 4 men, 4 women Different level of mathematical ability
[4] Habre S (2000)	Examines whether students consider slope (or direction) fields as a means for solving first-order ODEs and studies students' success in reading information from these fields. investigates students' abilities converting symbolic information into graphical ones and vice-versa	Classroom observation, observation from lab session, copies of students' exams, copies of IDE assignments, questionnaires, transcripts of semi structured interview- 9 students	26 undergraduate students, major in Biology, Economics, Biometry, Statistics, Chemistry and math
[5] Rasmussen C & Blumenfeld H (2007	Analyze the case of students reasoning with analytic expressions as they reinvent solutions to systems of two differential equations	Classroom teaching experiment Video tape Students' homework, board postings, examinations Interview	37 students for class 21 students for interview Majors in math and science
[6] Rasmussen C (2001)	to offer a framework for interpreting students' understandings of and difficulties with mathematical ideas central to new directions in differential equations	Individual interview, interview with instructor, copies of students' quizzes, exams and computer assignments and questionnaire (use of mathematica)	6 students – scientist and engineers
[7] Kendall M & Stacey K (2001)	his study examines how two teachers taught differentiation using a hand held computer algebra system, which made numerical, graphical and symbolic representations of the derivative readily available.	Questionnaire, assignments, two written test 2 groups with different teaching methods	33 year 11 (17 years old) All female students
[8] Habre S (2003)	This paper investigates students' acceptance of solving a differential equation geometrically.	Students copies of IDE assignments, exam papers, last question on the first exam, photocopies of all students answer, questionnaire Interview with semi-structured questions – 6 students	36 students with engineering, math edu and chemistry

Most of the researchers used classroom teaching experiment in their research. Students' copies of works, assignments, quizzes and also final examination answer were kept by the researchers for further analysis. In looking for the students' reasoning in mathematics, students discussions are recorded either video tape or audio tape. Majority of the researchers used computer as aided tool to assist students' understanding.

Respondents for the papers were from different universities and also involved undergraduate students only. Just research paper [1] and [7] were using teachers as the subjects. Many of the undergraduates students were taking Mathematics or sciences such as Biology, Chemistry and Physics as minor or major courses. Moreover engineers students also among the samples analyzed by the researcher.

In the Table 2 is listed the problems faced by the respondents in learning and understanding Differential Equations. Not only students have problems in learning DE but also the teachers also have problem to teach differential equation. Most of the report on the papers showed the students view of learning DE still in traditional ways which is solve by analytical. While the is another way to solve Differential Equations which is by draw the graph of equation or visualization solutions.

Table 2 : Respondents' responses in learning differential equation

Article (no)	Students' responses
[1] Wagner F J, Speer M N and Rossa B (2007)	1) The teacher beliefs the teaching is not only procedural and analytical, there are should some discussions between the students, to broaden students' experience.
[3] Stephan M & Rasmussen C (2002)	1) Students can solve the situational problem of differential equations 2) Students could answer the questions by analytical and graphical
[5] Miller RH & Upton S B (2008)	1) time framing to do the task is too long, students' did not like it 2) the explanation of the graphs shown were insufficient for students to relate the analytic and geometrical solutions
[6] Habre S (2000)	1) most of the students are reluctant to solve the differential equation by graph 2) they preferred to give solutions in analytic or symbolic because of exactness and pertinence
[7] Rasmussen C & Blumenfeld H (2007	1) student's assumed, slope is not proportionality constant 2) students can give the solutions by sketched the graphs of differential equations
[10] Rasmussen C (2001)	1) Students cannot made justification to reject or accept the solutions 2) Students' did not sense that graphical expression as the solutions other than analytical expression 3) Equilibrium solution is not the solutions for differential equation 4) Students read the graph line literally
[12] Kendall M & Stacey K (2001)	1) CAS was used by the teacher A for symbolic representation 2) Teacher B used CAS as pedagogy aids to help student interpret the differential equations
[17] Habre S (2003)	1) 67% students define the differential equations in analytic definition 2) 17% students think graph as a solution 3) 25% choose geometrical approach to solve differential equation

Lastly, in the Table 3 shown the technology was used in the changed of teaching approach. The researchers using assorted tools to help the students understand DE. As Mason and Scrivini (2004) believe if the teachers can change the negative belief of mathematics to positive, the students can obtain higher achievement. Almost the tools use gave the answer by visual or graph view and just need the students to interpret it.

Table 3: Respondents' respond towards using technology used

Article (#)	Technology	Purpose of technology	Approaching problems	Students responses
[3]	Interactive Differential Equation Calculator	Used graph to look graphical image for further investigation and deep understanding	Situational problem	Students used the graph to visualize the changing parameters
[6]	+ODE	Visual approach to find the		Students had positive view

[17]	With background used mathematica	solution	Conceptual understanding,	towards IDE in reading slope and classified the solutions IDE & ODE is very effective in develop visual skill and understand the DE in graphical way
[5]	Mathlets: JavaTM Applets for Math Explorations	To draw graph – visual image of analytical question		Positive responses toward Mathlets
[10]	Mathematica			
[17]		Solution in visual approach	Conceptual understanding	Positive response Prefer analytical then graphical solution
[12]	Computer Algebra System	1) Symbolic differentiation 2) Pedagogical purpose	Arithmetic	1) Just translating the formula 2) Interpretation
[1]	N/A	1)Maple has been used before by the educators, but have negative feedbacks from students		The lack of seeing the big picture – too much syntax to learn
[7]			Situational problem and analytic problem	Sketching the graph at the board

Interactive Differential Equation

Interactive Differential Equations or IDE is a collection of more than 90 lab activity for mathematical subjects. The characteristics of this tool are dynamics, simple with no struggle for key in the syntax and also giving illustrative of concepts. So the students and the teachers can focus on understanding the concepts by using visualizations. There are many topics covered in this tools, such as first order differential equations, second order differential equation, linear and non linear and others. In all the researches those applied IDE purposely to visualize the graph and also to understand the connection between graph and equations.

In the paper [17], the researcher did pre test to the students about geometrical or visual solutions of differentia equation. Most of them are preferred to answer differential equation analytically than solve by using graphical approach. The accuracy of the answer by graph is question by the students. After the researcher introduced IDE, all the students give positive response in using graph for solution of differential equations.

Mathlets

The second tool used in the respective research is Mathlets. Mathlets is Java applets cover many topics in mathematics for example calculus, differential equations and linear algebra. Same as like Interactive Differential Equations, students no need to remember all the syntax to look the output. Moreover Mathlets has covered many topics also can interpret the equations and graph the equation for understanding in visual.

Computer Algebra System

There are many types of computer algebra system available in this new era. Either there are accessible with free software or need to buy from the suppliers. Examples of computer algebra systems are Maxima, Maple and Math lab. Maxima is free software which can be found through internet. Compare to the Maple and Math Lab, the users need to buy them. The similarity of these three software is the users have to learn the syntax before master the software.

CONCLUSION

From this small research, we found the development of technology used by the teachers or educators nowadays. However there is one method of teaching that still not try by any researcher, which is learning DE by online learning such as discussion and e-learning. the online learning has positive effect on the students grade (Dowell and Small, 2011; Fernandez, Llinares and Valls, 2012). Karadag (2011) stated in reducing students

cognitive load, they can use online cognitive tools well. Changing of method of teaching is not novel in education field. The purpose of several of teaching style is too helping the students engage with the learning from time to time.

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