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Using *LiveMath* to Enhance Teaching and Learning of Mathematics

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Abstract: The study investigated the effects of using an interactive computer algebra system called *LiveMath* on the cognitive development and attitudes of First Year Junior College students. The teacher used the software to engage the students in the experimental class by guiding them to explore mathematical concepts involving topics such as reciprocal curves, Maclaurin's expansion and applications of integrations. There were two control classes. The first control class used the same guided discovery approach as the experimental class but without the help of technology. The second control class underwent traditional teacher-directed teaching. This paper will discuss the pros and cons of using *LiveMath* to engage the students and it will present the findings of the study and their implications for teaching and learning.

INTRODUCTION

Many junior college teachers in Singapore have been exposed to software which they can use to infuse information technology (IT) into their lessons. But many of the computer algebra systems (CAS) only allow the user to perform traditional symbolic manipulations, such as factorisation, differentiation and integration. As the tests and examinations still require students to perform these algebraic manipulations by hand, many teachers do not see the point of letting their students use CAS to do so. Thus they may find it difficult or impossible to incorporate IT for most algebra and calculus topics for more effective teaching.

However, *LiveMath* is a CAS which provides "a unique user interface that allows one to perform 'natural' algebraic maneuvers even more 'naturally' than one can achieve them on paper" (Kaput, 1992). This software is very interactive: by changing the value of a variable, all the algebraic equations and graphs linked to the variable will also change automatically and instantaneously. Berry (1997) believed that the future of Mathematics instruction with technology will be exciting for both teachers and students and that it will change the overall learning climate in classrooms. By incorporating this technology into lessons, students will have an additional tool for them to explore mathematical concepts and theorems, especially in algebra and calculus, without having to do the tedious calculations and manipulations.

In this paper, we will highlight some of the benefits and concerns in the use of this software in the teaching of mathematics and how we overcame some of these concerns. Then we will discuss the findings of an intervention program where students explore mathematical concepts using *LiveMath*.

BENEFITS OF USING *LIVEMATH*

Interactive computer-based visual representation of dynamic objects presents opportunities to students for constructing mathematical knowledge. In the study of "What are Virtual Manipulatives?" by Patricia Moyer, Johnna Bolyard and Mark Spikell (2003), it was said that 'user engagement distinguishes virtual manipulative sites from those sites where the act of pointing and clicking results in the computer's providing an answer in visual or symbolic form' (p. 373). The key is for students to be able to construct meaning on their own by using the mouse to control physical actions of objects by sliding, flipping, turning and rotating them.

The usage of computer software provides further opportunities in keeping with the progressive movement of discovery and inquiry-based learning when used in the right context in classroom teaching. Such usage also increases exploration possibilities to develop concepts and test hypotheses for students, especially those at the higher level of ability.

LiveMath is a CAS which can allow one to manipulate mathematical equations and expressions in a symbolic or algebraic manner, for example, to factorise, differentiate and integrate algebraic expressions. This feature thus makes LiveMath different from most programs which require the users to use numerical values. With this software, teachers could use the constructivist approach in teaching by allowing learners to investigate mathematical concepts and to construct their own knowledge (Jonassen, Peck & Wilson, 1999). With its online enhancement, it can also be a good technological tool for an online distance learning course for students.

CONCERNS IN THE USE OF *LIVEMATH*

A major problem in modern-day classrooms is the resistance to change from traditional teacher-centred teaching to the use of computer-based technology in teaching. According to Waits and Demana (2000), one of the great problems faced in mathematics education is communicating the real nature and value of mathematics. By simply providing teachers with information about how the software functions, it is not likely to result in effective integration in the classroom. To overcome this, substantial professional development and support is necessary for teachers to make informed decisions about how to best use the software in the classroom.

Another problem is that the students may be put off when they see a lot of equations in a *LiveMath* template at first sight. This could easily be overcome by hiding the non-crucial workings or steps using a special feature in the software.

INTERVENTION PROGRAM

Much time and effort were spent exploring the *LiveMath* software and designing the worksheets with the objectives of students learning through exploration from the worksheets. We selected four topics: Graphs of Reciprocal Functions, Maclaurin's Series, Applications of Integration – Areas under a Curve and Volumes of Solids of Revolution, and implemented the lessons from Term 2 to Term 4. Some examples are given in the Appendix.

Three classes of First Year Junior College students were selected based on their similar O-Level Elementary and Additional Mathematics Examination results. The experimental class used *LiveMath* in the computer lab to explore the mathematical concepts of the four topics selected. There were four one-hour lessons, one for each topic, spread over three months. The first control class used the same guided discovery approach to explore the four topics but without the use of *LiveMath*. Instead the graphs were printed for the students in their worksheets. The second control class was taught using the traditional chalk-and-talk method. All the three classes were taught by the same teacher.

TEST INSTRUMENTS

There were three test instruments. The first instrument was a test on conceptual understanding of the four topics taught. The second instrument was a test on procedural skills of the same four topics taught. The third instrument was a survey on students' affect towards mathematics. The first two tests were administered to all the three classes after the intervention program. The last test was administered before and after the intervention program.

RESULTS

There was no significant difference in the mean scores of the conceptual test, the procedural test and the affect survey among the three classes. There was also no significant difference between the test scores of the affect survey for each of the three classes before and after the intervention program. These results may be due to the short intervention program: there is only one computer lab session for each topic.

Nevertheless, some students were impressed with the capability of the software. At the end of one computer lab session, one student from the experimental class suddenly voiced out her opinion: “I have learnt that mathematics is alive!” The teacher asked her to elaborate and the student replied, “The graph can just change like that: it is alive!” The student was referring to the ease of changing the equation and all the graphs that were linked to the equation and its Maclaurin’s approximations would also change automatically and instantaneously.

CONCLUSION

It is the intention of the programmers of ***Live****Math* to make mathematics a***live*** to students. Although the effect is not significant due to the short intervention program, the software has definitely made an impact on some students. Moreover, a similar research by Yeo (2003) using the same software shows significant improvement in the conceptual understanding, procedural skills and affect towards mathematics for two classes of secondary three students. Therefore, more research needs to be done to study the effect of this software for both secondary and Junior College students in order to substantiate the different findings.

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APPENDIX

1) Investigating the Relationships Between Reciprocal Graphs

Figure 1 below shows the *LiveMath* template that was created for students to explore the relationships between reciprocal graphs.

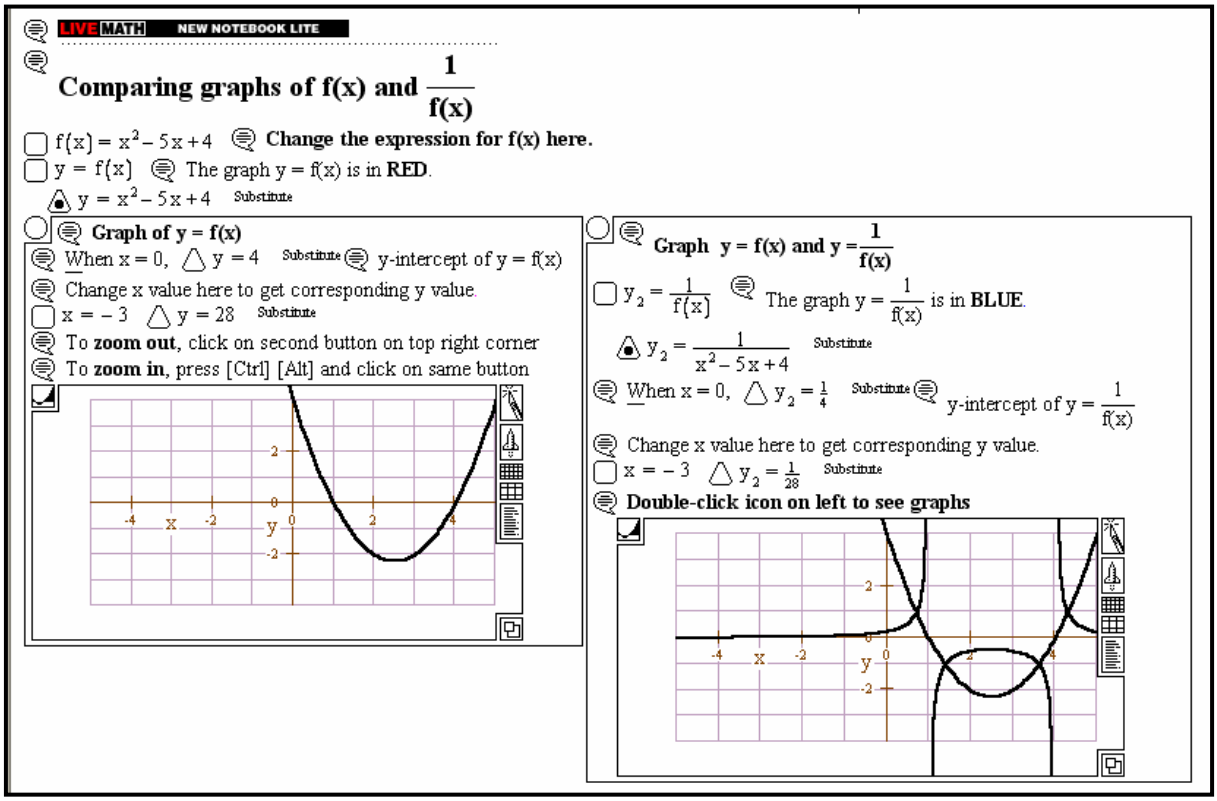

Figure 1

Colours were used and instructions were given in the template itself to guide the students where to change the values for their observations to be made. The necessary workings for observations are all laid out in the template. Mathematical calculations would be changed automatically as students change the values or expressions as instructed. Worksheets are provided to go along with this template, to provide guidance and to record their observations and deductions made.

2) Volume of Revolution

Figure 2 below shows the *LiveMath* template that was created for students to explore the volume of solids obtained by rotating a curve about the *x*- or the *y*-axis.

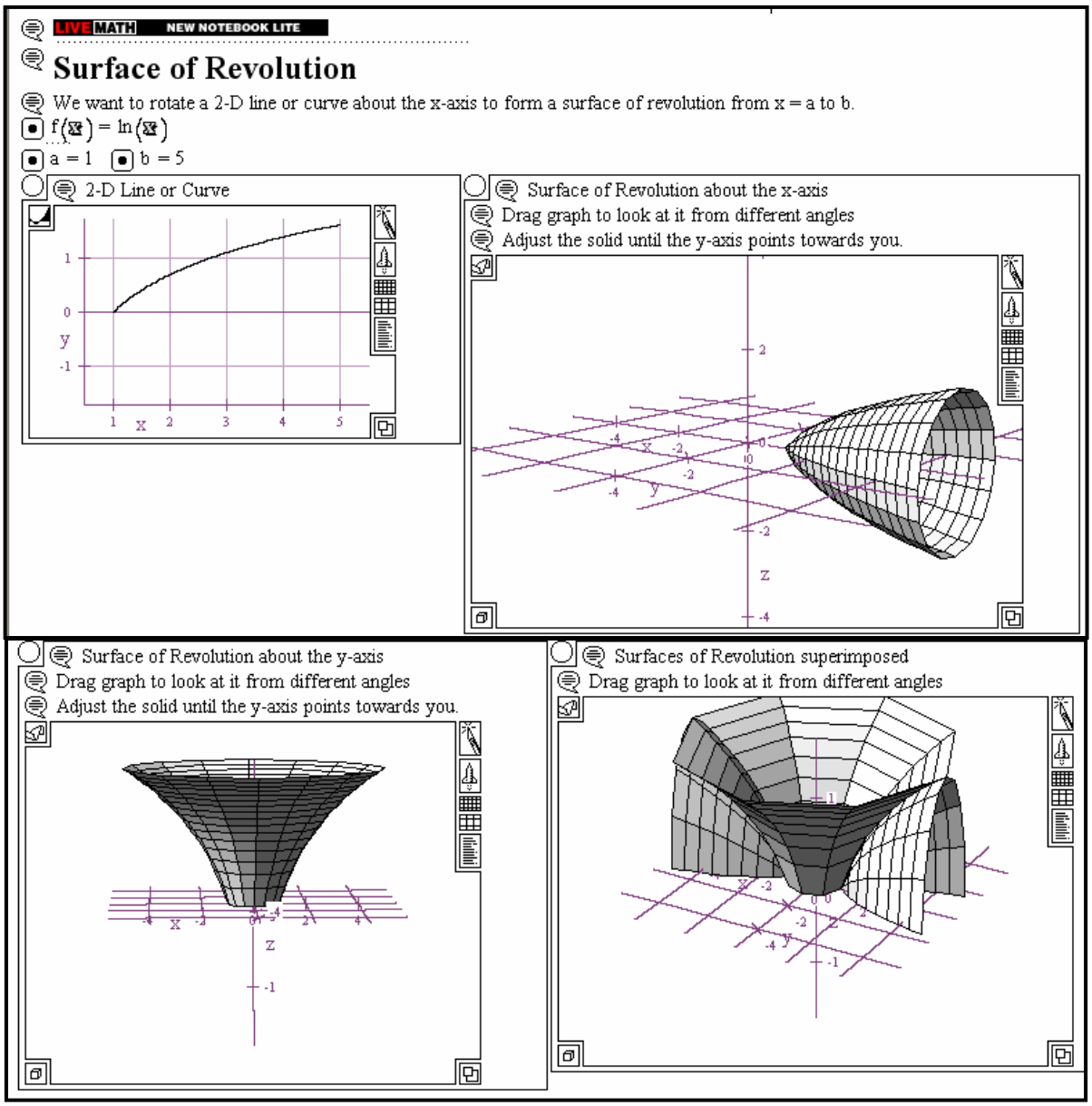

Figure 2

In the template, students can change the equation of the 2-D line or curve and determine the range of values that they would like the graph to be rotated about the *x*- or the *y*-axis. The template will display the resultant surface of revolution, allowing students to visualise the outcome in 3-D space. Students can also look at the solid from different angles by dragging it.