THE CHAIN AND PRODUCT RULE (CPR) TOOL: AN E-LEARNING TOOL FOR THE ASSESSMENT OF COLLEGE LEVEL CALCULUS

Rasha Morsi, PhD., Latrice Tolliver

Engineering Department
Norfolk State University
Norfolk, VA 23504
{rmorsi, l.m.tolliver}@nsu.edu

1. INTRODUCTION

This paper discusses a 'work in progress' NSF funded research project (EEC-0530493), that involves the design and implementation of the Chain and Product Rule (CPR) tool. This is an assessment tool for use in college level calculus. The overall objective is to design and implement an effective interface as well as use appropriate algorithms for the assessment of the students' responses. The research will also involve the exploration of how the use of the CPR tool is beneficial as a study aid for students in and out of the classroom. A survey of available interactive calculus tools resulted in the conclusion that no assessment tools existed. Current tools available to the public are mainly tutorial based and provide solutions to the problems. The CPR tool will help students review and where possible enhance current knowledge on the use and visualization of the Chain and Product Rules.

It is known that one of the main reasons Electrical and Computer Engineering students either drop out of or struggle with their degree is Mathematics. These Engineering degrees are very math intensive and in many instances, students get into the degrees unprepared in math.

A survey was performed on senior engineering students at Rose Hulman college [Graves, 2005] and it was concluded that students agreed that Mathematics was essential in their education and in their future careers. So students entering Engineering degrees realize that Mathematics will play a major role in their education. When interviewed the students said that it was "good to have the ideas of calculus reinforced and incorporated into other areas" and that "their engineering courses used a lot of calculus ideas from the freshman year". One student's comment from the paper stated "When I started, I knew I'd be taking a lot of math, but until last year I didn't know why." [Graves, 2005] Which is a statement common to many students where they don't really understand why they need all the math during their first few years of higher education.

A number of Universities [Klingbeil et al, 2004, Leland et al, 2005, Lavelle and Keltie, 2004, Monte and Hein, 2003] have intervention programs to retain the freshman students in their engineering degrees. There is by far a larger list of programs. The authors are using these as a few of the more recent examples. Usually these programs devise methods for teaching students

engineering applications as opposed to just giving them the facts and basics and progressing to applications in the senior years. The programs mainly focus on the student performance in calculus since calculus is the core of any engineering curriculum.

Klingbeil et al (2004) states that "the inability of incoming students to successfully advance through the traditional freshman calculus sequence plagues engineering programs across the country" and "the correlation between retention rates and the inability of incoming students to progress through the required calculus sequence cannot be ignored".

One way of alleviating this problem is to help students be more comfortable with the concepts of Calculus outside the classroom as well as inside. Providing students with help away from a teacher or a professor is difficult and finding a tool that suites the students' need is a key factor. In order to provide this type of aid, a tool needs to be developed to allow students to review as well as practice basic calculus concepts. In doing this, the students will have the opportunity to solidify their calculus concepts that will surely be used in their upper division Engineering classes.

Morsi (2004) developed a new concept in e-learning tools, better described as practice tools. These tools allow the student to interact with a web-based tool as he or she would interact with a professor in a classroom. That is in the regular classroom setting, when a student starts working on a problem, he/she does so by going through a specific sequence of steps at the end of which would be the final solution or design. If the student has trouble along the way, the professor is approached to let the student know if he/she is on the right track. Using this concept, the Karnaugh Map Evaluator Tool [Morsi, 2004] was developed. This is a tool that allows students to practice the minimization of Boolean expressions using Karnaugh Maps. Based on a successful implementation of the KMAP evaluator, funding was acquired to replicate this novel approach to e-learning in the core class for all engineering students, calculus. The concept of assessment and design used for the KMap tool are being applied to develop a similar tool for Calculus. Since calculus is a vast subject, the authors were in close communication with the Mathematics Department Chair at Norfolk State University in order to determine which area of calculus students find the most difficulty visualizing. The decision was made that the starting point for developing Interactive web based e-learning tools in Calculus should be by developing the CPR tool. The CPR tool is a tool that generates randomized problem statements for practicing the application of the Chain and Product Rules.

1.1. Existing Product and Chain Rule online tools

A survey of available interactive calculus tools was conducted to find out what types of tools exist for the Chain and Product Rule. The search resulted in a number of tools but these tools were all tools that the authors choose to label "tutorial based", prompting the student with a question along with an option of finding the solution. The following are sample tools found for the Chain and Product Rules.

Visual Calculus, is tutorial site that catches a students' attention by making students feel at ease with the content. Visual Calculus also gives a variety of questions, but students have an option

of finding the solution for the given problems. Cramster.com, gives one knowledge of the material by given students hints, step by step detailed solutions so they can compare with their work, and a actual message board post difficult questions for a feedback response either from an actual tutor or a fellow user of the actual site for a small monthly fee.

Another alternative for help is an actual tutor at hand. These tutors allow students to enter questions and they will receive feedback from Dr.Math. There are pros and cons to this due to the fact if one needs immediate help he/she might have to wait days for a response. Last but not least video animation of Chain and Product Rule, derived from the site "Tutorial for Calculus Phobe" demonstrates a live classroom setting and step by step way of solving each problem. This tool brings school and a teacher to a student's house at any hour.

It can be seen from this review of existing tools that no assessment tools exist for the chain and product rules in calculus. It is the authors' expectations that the CPR tool will help students review and where possible enhance current knowledge on the use and visualization of the Chain and Product Rules similar to the results produced by the KMap tool. This CPR tool is expected to help promote student learning in calculus as well as make the process easy and fun for students.

2. THE CPR TOOL

The CPR tool is an assessment tool that randomly generates problem statements for students to practice on. Rather than giving the student the solution, the tool will prompt him/her for a step by step answer sequence and provide the student with a 'correct' or 'not correct' response. The student will have an option of novice, intermediate, or expert for their level of visualization and understanding of both the Chain and Product Rules. The complexity of the functions will range from easy to moderate to more complex functions. This will allow the student to have a broad understanding and provide them with the ability to solve problems at any level of complexity. Because the CPR tool is designed to generate the problems in a step-by-step manner, the interface of the design should make any type of function, even complicated ones, seem simple to the student.

The following segments show the planned layout of CPR's interface. The tool will allow the user to choose between the Product Rule sub tool and the Chain Rule sub tool. In each of these tools the user will have the choice to choose the level at which they would like to practice. Each level provides a step by step process to solving randomly generated problem statements.

The CPR tool will be the first step in helping students become more familiar with visualizing functions and then being able to solve them based on this visualization. It is anticipated that this tool will support the student's ability to differentiate functions and improve their ability to excel on homeworks and tests.

2.1 Chain Rule sub tool

The following figures show the different stages in which the tool will present the problem statements. At each stage the user has the option to submit their answer for assessment or clearing the answer. Each page in the process will have access to the Manuals that will be animated step by step examples introducing how to use the tool. Also each page will contain a link to tutorials. These tutorials will be developed using Macromedia's Captivate to allow for developing movie like tutorials.

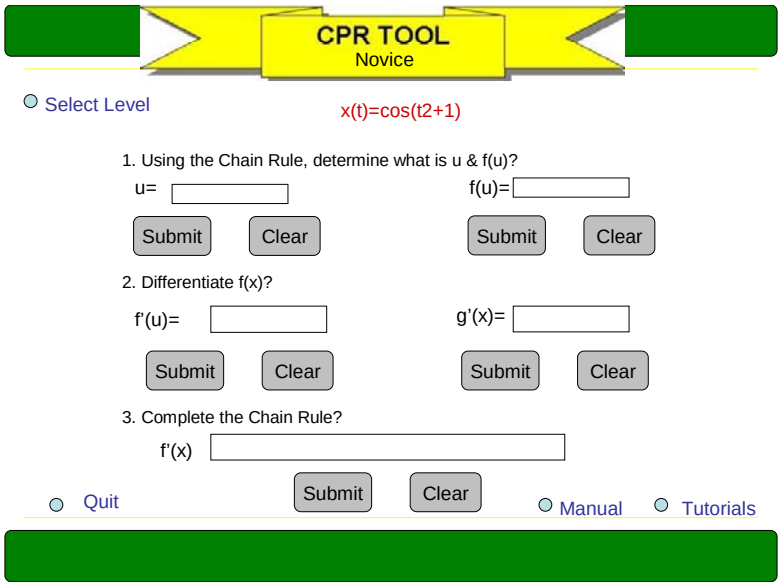

Figure 1: CPR Tool- Chain Rule Sub tool Novice level

Figure 1 shows the Chain rule sub tool design in the novice stage. In the novice stage of these tools, the user will be prompted for every step of the solution process. This allows the novice user to solidify their understanding and memory of the step by step process. As the level of the user increases, the prompts decrease as can be seen in figure 2.

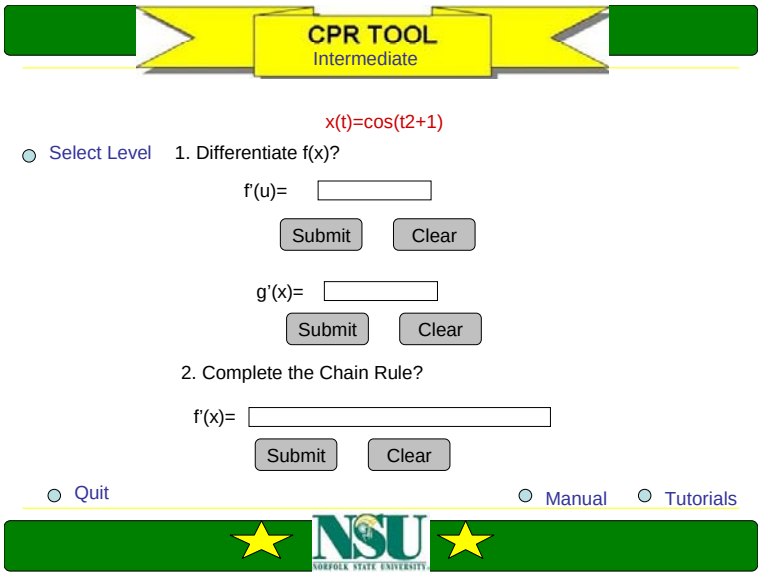

Figure 2: CPR Tool- Chain Rule Sub tool Intermediate level

2.2 Product Rule sub tool

Figure 3 shows the Product Rule sub tool design in the novice level. In this level, again the user is allowed prompts for each step needed to reach a final solution to the problem. At each stage the user will be provided with validation of their solution. However, the solution will not be provided. As the user advances in their level, the prompts are reduced to allow for self pacing.

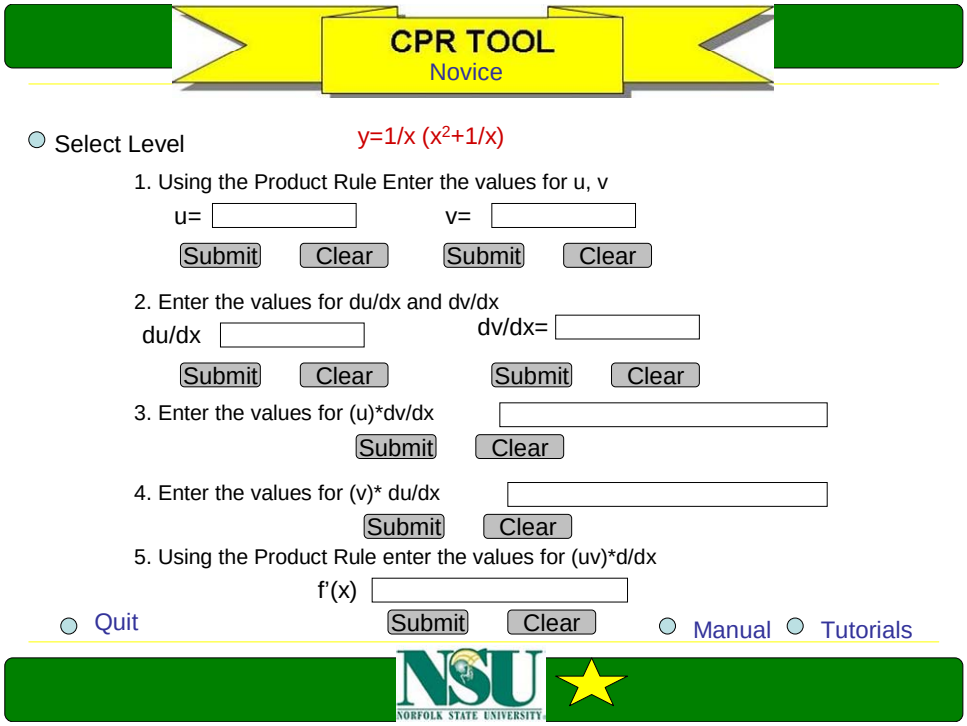

Figure 3: CPR Tool- Product Rule Sub tool Novice level

3. SOFTWARE AUTHORING TOOLS

This research is conducted in the Modeling and Simulation Center (MSC) at Norfolk State University, founded and directed by Dr. Morsi. The tools planned for use with this project are Adobe® tools (formerly known as Macromedia tools). This includes Macromedia Flash for the interactive development of the CPR tool and Macromedia Captivate for the tutorials.

4. WORK IN PROGRESS STATUS

This project is an NSF funded project (EEC-0530493) that is to be completed in October 2006. At the time of writing this 'Work In Progress' paper, the design of the tool has been developed and the implementation of the random problem statement generator is underway. The tutorials and manuals as well as the assessment portion of the tool are in the design phase.

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