Tutorial Reform

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For the past seven weeks I have been regularly attending the tutorials for Steve's physics course, and for the past seven weeks I have been submerged in learning environment created by McDermott and Shaffer. While I see how this format more effectively meets its goals than a traditional recitation, I have also seen how these tutorials might be improved, both by a reconsideration of the goals and by a reconstruction of the problems presented in the tutorials.

Goals Of the Tutorials

In "Research as a guide for curriculum development… pt 1" McDermott and Shaffer made apparent that many students lack conceptual understanding of physics. Through interviews, formal testing and student feedback, they make a convincing argument that there is a need for a reform in the way physics is traditionally taught, and from their research they developed a curriculum to fit the constraints of a traditional physics course (McDermott & Shaffer 1992 pp 994-1003). This curriculum (the tutorials) was developed with a few key goals in mind, set to improve upon the student problems

that their research uncovered. In the following few paragraphs I will discuss these goals, and the strategies used in the tutorials to attain them.

Qualitative understanding and scientific reasoning skills

The preface of the tutorial booklet makes the clear that the main objective of the tutorials is to create a qualitative understanding of physics. They state in the second sentence of the preface:

"*The emphasis in the tutorials is on the development of important physical concepts and scientific reasoning skills…*" (McDermott & Shaffer, 2002 pg iii)

By introducing topics and concepts in a sequential manner, and having the students apply their interpretations to predict the outcomes of those ideas in different contexts, they hoped to that the students would construct a functional, qualitative understanding of physics. The sequential manner in which the problems are presented are designed to let the students will *discover* the principles of physics for themselves.

Active Engagement

The second goal of the tutorials is to create an active and engaging learning environment. Again from the preface of the tutorial booklet:

"Tutorials in introductory physics provides a structure that promotes the active mental engagement of students in the process of learning physics." (McDermott & Shaffer, 2002 pg iii)

The active engagement that they aim to provide lies in the social environment created by the tutorials, paired with their slightly ambiguous problems. The students are

required to form groups of three or four, and asked questions that are designed to spark discussion. Hired LA's and TA's are to help discussions along, and mediate the progress of the students (McDermott and Shaffer, 2002).

Resolve common misconceptions

The research done by McDermott and Shaffer uncovered many common misconceptions held by introductory physics students, thus steering the development of the tutorials toward the treatment of such misconceptions. Their goal is apparent in the following passage:

"Many students cannot develop a functional understanding of the materiel unless certain difficulties are addressed" (McDermott & Shaffer, 1992 pp 1008)

The approach that they take to address these problems, "…may be summarized as a sequence of steps that can be characterized as : *elicit confront resolve"*(McDermott & Shaffer, 1992 pp 1008). This method of confronting misconceptions can be seen within the structure of the tutorials. The students are required to make and test predictions about certain physical systems, and then observe the actual outcome. They are forced to come to some conclusion and reform their conceptual framework to incorporate the observation.

Real World Understanding

The final goal of the tutorials is to create knowledge that can be applied to real world situations. Their goal is apparent:

"*Questions in the tutorials guide students through the reasoning necessary to construct concepts and apply them in real world situations*." (McDermott & Shaffer, 2002 pg iii)

Real world application comes in the form of "hands on", or interactive learning tools, designed as an application of the concepts learned previous to their use. Real circuits: solenoids, bar magnets, charged rods, etc are observed in different scenarios to test student predictions with actual observations (McDermott & Shaffer, 1992 pp1003-1010).

My Observations

I have observed the effectiveness of the tutorial program while monitoring the conceptual development of my students, yet I have also observed the failure of the tutorial to meet some of its goals. In the following few paragraphs, I will present my observations regarding each goal mentioned above, and discuss strategies of reform where necessary. My observations in accordance to the goals of the tutorial are as follows.

Qualitative understanding is developed

My interpretation of the word "qualitative understanding" is not a very concrete one, and all definitions for this word have failed to harden my understanding of the term. Thus, to narrow the focus of my arguments concerning the qualitative understanding of

the students, I will look specifically at the students understanding of diagrammatic representation.

Throughout my experience as a learning assistant, I have seen students progress in their understanding of diagrammatic representations. When working through the earlier tutorials on electric flux and Gauss' Law, many students had troubles creating and interpreting visual representations necessary to complete the problems. Many students were reluctant to draw electric field lines escaping a closed cylinder, and would do so only under explicit instruction. Even when instructed to do so, I had four cases where students would draw an incomplete visual representation (a couple field lines from a dipole escaping a Gaussian surface) and try to interpret that (FN #2). I also noticed that during the tutorial on electric potential, many of the students were hesitant to come to conclusions concerning work required to travel about different paths in an electric field (FN #3).

As time progressed their ability to design and interpret diagrams improved quite a bit. They seemed less reluctant to draw magnetic field lines coming from a bar magnet, than electric field lines from charges, and they were less hesitant to come to conclusions about magnetic flux. One of the students whom was reluctant to draw field lines escaping the surface encasing an electric dipole (FN #2), needed no guidance when drawing the magnetic field lines escaping a magnetic dipole (FN #7). Thus I would conclude that their overall diagrammatic understanding of physics was improved, as their confidence improved.

The improved understanding can also be seen in the results of the BEMA scores. The BEMA is a concept intensive exam, designed to expose the qualitative, or

diagrammatic understanding of the test takers. The results of the BEMA for Steve's class revealed an enormous gain, improving their scores to that of the LA's final score average. Thus the qualitative understanding of the students was drastically improved.

I think that the tutorials are remarkably successful in this aspect, leaving very little room for improvement. Thus if I were to preserve the qualitative understanding that the tutorials provide, I would make very little changes to the strategies used by McDermott and Shaffer.

Real world understanding sometimes developed

Although it would be very difficult to measure exactly how students incorporate the tutorials into their life, and to what level, I feel that I have evidence that shows little success in this realm. Many students would treat the hands on activities as an extension of the handbook, using them as tools to aid their writing. During the tutorial on Lenz' law which incorporated an electric motor, I found that all the students would "reluctantly use the device only to answer a question, and rarely examine the parts…". This was a common occurrence in my experience, as I noticed that the students seemed uninterested with the "real world" presented to them. The tools designed to make connections to the real world ultimately made very little connection to the students lives.

I think that the main failure of the tutorials to create a real world understanding of physics, is that the tutorials utilize a hollow definition of what the real world *is*. McDermott and Shaffer attempt to make connections to the real world by incorporating "hands on" activities. While these hands on activities might give the students physical objects to relate their knowledge, the lives of the students lie far outside the realm of light

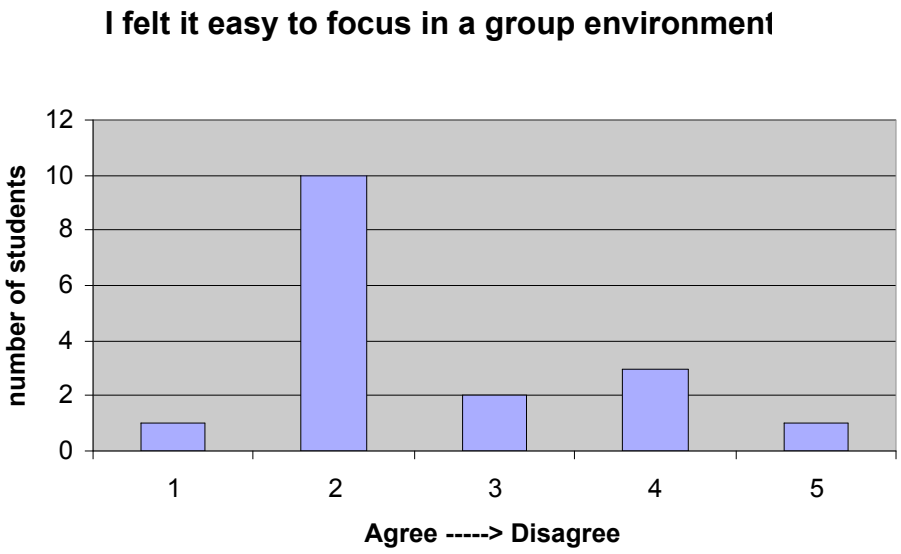
bulbs, capacitors and batteries. These tools will not be used in any context outside of the culture of education. Brown would say that the hands on experiences provided by the tutorilas are inauthentic, as they apply only within the context of the culture of the educational system. Thus if we were to attempt to create a solid connection to the lives of students, the tutorials must more resemble an ordinary practice of the culture of which the students live in (Brown et al

Attempts to create an authentic learning experience would call for a drastic reconstruction of the curriculum. The problems would have to be focused around something more closely related to their lives, having each topic revolve around something that the students experience on a daily basis, and the methods required to solve the problems would have to incorporate the type of reasoning used in their daily lives. This is why I would make the problems incorporate objects from their daily lives, with a more open ended problem structure.

Maybe the tutorial on Lenz' law could have focused on determining the inter-workings of an electric toothbrush that uses changing magnetic fields to charge the motor within, while having the questions require estimations to predict the toothbrush's tooth cleaning power. Another way to improve the real world aspect of the tutorials might be to make connections with the technology focused elements of their lives. My class was restricted to use only real circuits, but I think that if they had access to PHET, they might have felt more situated staring at a bunch of blinking lights, and using reasoning commonly needed to succeed in video games.

Active learning environment sometimes created

During my experience as a learning assistant I have seen some groups interact very productively, engaging in discussion about the topics and pooling their resources to solve problems, but for the most part, I would say that this is not ensured by the structure of the tutorial. Throughout my experience I noticed that many students kept to themselves, they would work independently of their group and rarely speak up. On a given day, roughly three fourths of the students from a given group would engage themselves in conversation. Although this is a very rough estimation, about the same fraction (4/17) of the students who filled out my survey disagreed that they "felt it easy to focus in a group environment". This approximately agrees with Steve's findings as 22% of his class of 384 disagreed that they "enjoy talking about physics with [their] group in

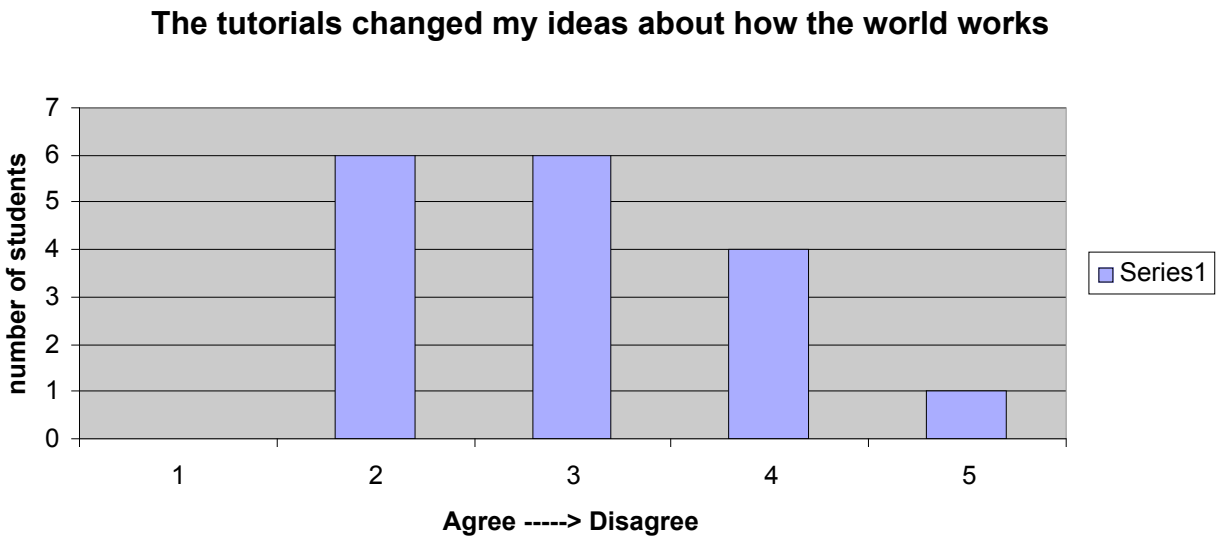


tutorial", implying that they did not find the tutorials engaging.

Thus a fifth of the students are not fully engaged with the materiel, implying the partial failure of the tutorials to meet this goal, and while it is difficult to create *anything* that engages more than seventy percent of a classroom, I think that the tutorials could be made to be more engaging. This I think that a can be done by making the tutorials more enjoyable, which can be accomplished by reconstructing the goals of the problems to focus on aesthetics. If the tutorial on Lenz' law were to be focused on attaining increasing the speed of the motor, the students might feel more inclined to experiment with the apparatus. Most people are more inclined to aesthetics rather than filling out a worksheet.

Common misconceptions sometimes resolved

Testing the conceptions of students has proven to be quite a horrendous task. My observations have revealed no clear conceptions of the students, and while the BEMA scores have proven that the students have developed a better understanding of physics, it is unclear what their understanding of physics consisted of before the exam. My survey also came back inconclusive, as there is a wide distribution of my exceptionally small class. Thus I feel as if I can come to no conclusions about the conceptual change of the students, and I will leave it as such.



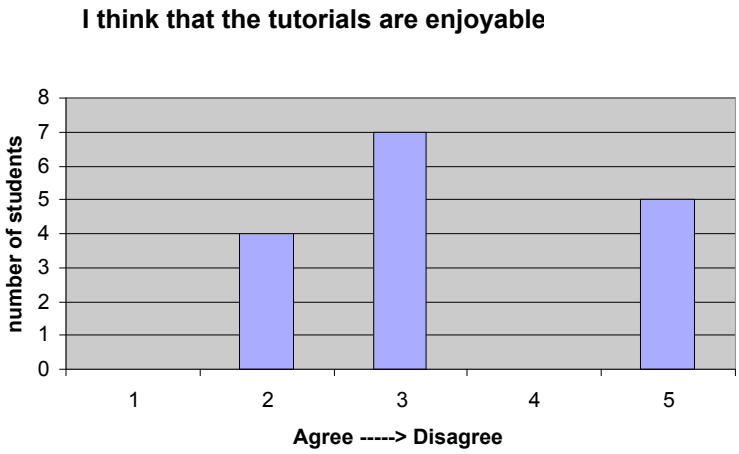
Other Observations

Other observations have led me to doubt the success of the tutorials to achieve its goals. There were certain problems in my classroom that persisted throughout the entire semester, problems that hindered the experience that McDermott and Shaffer were aiming for.

The biggest problem that I noticed lied in the extreme displeasure that some of the students seemed to exhibit when participating in the tutorials. Many of the hands on activities seemed to loose their appeal when students were constrained to use them in a structured manner. I observed many students use the motor designed for the Lens' Law tutorial minimally, using the devise as an extension of their handbook, only lifting their heads from their books and using the instrument when absolutely necessary.

The displeasure experienced by the students was also shown in Steve's survey, as 48% of the students answered disagree or strongly disagree to the question "I enjoy the tutorials".

My class seemed to enjoy them more than the general physics population, but



notice how the students who disliked the tutorials disliked them strongly, implying that their displeasure was extreme.

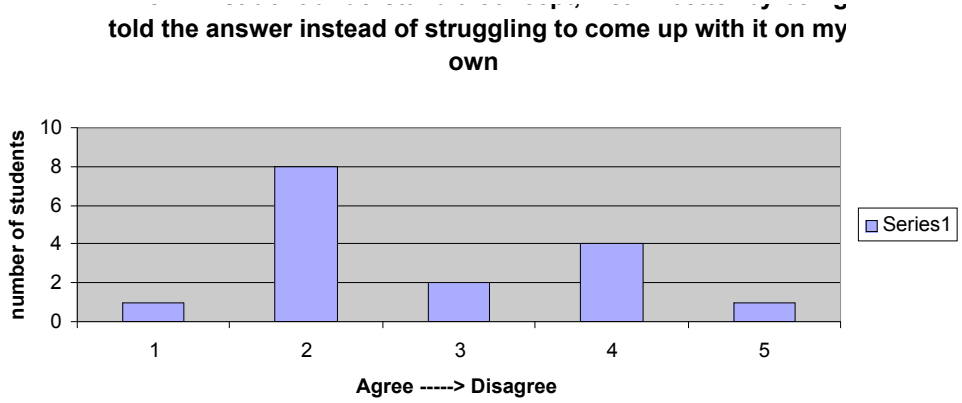
If students don't enjoy the tutorials, they will be reluctant to actively engage themselves in the materiel. Group discussions and active engagement is hindered when a student resists the information presented to them. This resistance can also create a distance between the materiel, and the students willingness to incorporate the knowledge into their lives.

I think that if the tutorials were more engaging on a level that incorporated elements from their own lives, they would become more enjoyable. Thus, as described earlier, the problems in the tutorial must be changed so that As I have stated earlier, learning can be made more enjoyable as the boundaries on the learning experience are loosened. If an enjoyable tutorial were to be created, one would need to create an open-ended problem structure that maintains interest in the students.

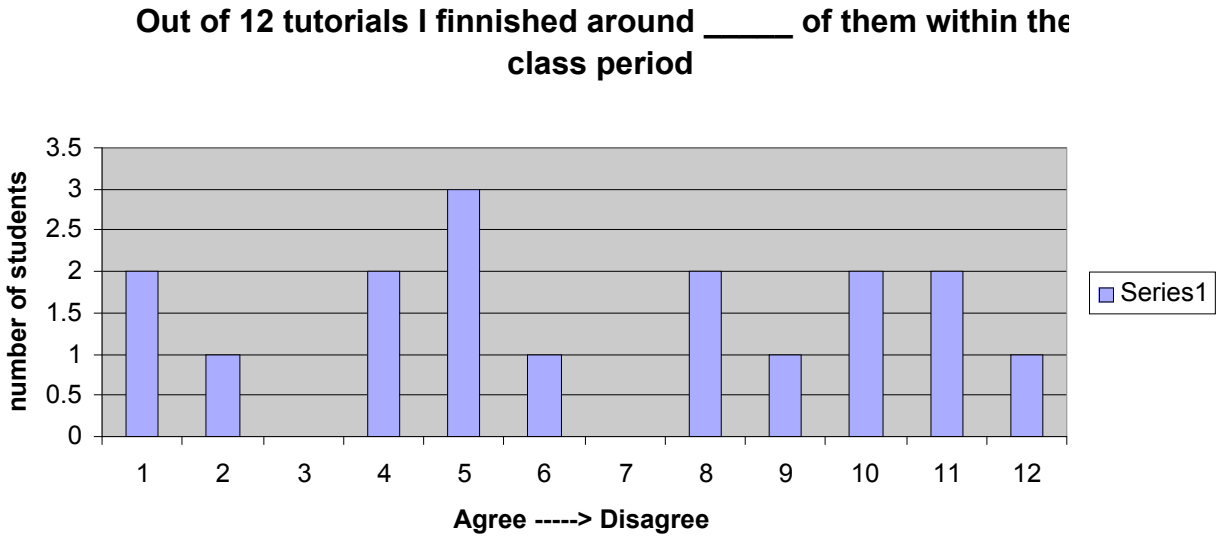
On a similar note I have also observed that many of the students accept information gained from the tutorial passively. It seemed that a large fraction of my class were concerned only with answering the questions presented in the tutorial and rapidly moving on. Almost fifty percent of my student interactions ended with the full table of students glued to their tutorial books, and moving on without any follow-up questions. Out of roughly fifty documented encounters with students, only four of them had discussions that were steered out of the frame of the tutorial.

Most of my students agreed that they learn better when told the answer to a problem, thus implying their preference of avoiding the struggle required in a reconstruction of their knowledge basis.

This is a sign that the students are not engaging themselves in the materiel. Contrary to the goals of the tutorial, I think that the passive acceptance of information in the classroom could hinder a students application of their knowledge in their own lives, as well as prevent the students from fully confronting and resolving their common misconceptions. Again I think that if the tutorials were incorporated elements from students' lives, and utilized a more open ended problem solving scheme, the students would feel more inclined to deeply consider the ideas and concepts presented to them.



Finally, one of the most obvious problems I have observed from my experience is that students *rarely* complete the tutorials. My survey shows that less than half of the students finished over 50% of the tutorials. Overall, only 53% of the tutorials were actually completed within the class period, and thus the sequential manner in which the tutorials were presented was broken almost 50% of the time.



The solution to this problem simply lies in the need to shorten the tutorials. By reducing the work load, and focusing on a few essential topics and misconceptions, I think that more of the students would complete the tutorials. A good way to do this might be to break the tutorial

Because of these observations, I conclude that something must be done to make the tutorials more enjoyable, engaging, short and make more ties to the real world. I think that these changes would sufficiently help meet the goals of the tutorial.

Conclusion

Throughout this paper I have provided several strategies designed to improve the faults that I observed in the tutorials. Thus the following modifications to the tutorial have been designed to make the tutorials enjoyable, more engaging and make ties to the real world, while maintaining the excellent qualitative understanding that the tutorials give.

Make problems shorter

Make problems more open ended

Make deeper connection to students' actual lives

This I think would sufficiently help meet the goals of the tutorial, while creating a more enjoyable experience that is able to fit in an hour class time.