The Effect of Bifocal Modeling on Students' Assessment of Credibility

Objectives

The primary objective of this study is to investigate the effect of using Bifocal Modeling framework on students' assessment of credibility.

Introduction

The availability and diversity of educational materials have greatly evolved over the past decade. In particular, resources such as online content and simulation tools more pervasively have been used by students as learning materials. Although this opens up greater access to a variety of educational resources, it also introduces the need to critically evaluate the accuracy and underlying assumptions of these educational materials. Thus, it is crucial for learners to meticulously evaluate the credibility of these new resources that technology offers them. The literature suggests that new technologies with different affordances could affect and somehow diminish their audience's credibility judgment. Couture [4], for example, suggests that many design characteristics of a simulation environment would affect users' evaluation of credibility. Sundar [7] also discusses the fact that different technological features such as modality, agency, interactivity and navigability can influence credibility. In his study of simulation credibility, Winsberg [8] warns that learners tend to overestimate the credibility of scientific computer models.

In their recent study, Blikstein et al [3] explained three main building blocks of a Bifocal Activity: design, develop, and interact. In this paper we examine during a Bifocal activity [2] how changes in resource allocation between these three phases could influence students' perception of credibility particularly in a case of virtual simulation. We qualitatively studied the approach students took in the face of discrepancies between a simulation and a physical experiment, and also looked at students' perception of computer model accuracy and strategy they took for improvement.

Methods

The first study took place in an after-school workshop session with two female high school students. The other two studies happened during a month-long workshop with 13 high school students from 9th to 12th grade.

1. **Physics-** The first study was about Newtonian laws. The study lasted for a total of three hours. Students were asked to study the laws governing a ball rolling down a ramp. We started with a short introduction and a movie about the phenomenon. Afterward, students' first task was to design their own physical experiment with the ramp, using a microcontroller-based sensing interface, [6] infrared sensors, and balls of different masses. When finished, they were prompted to look at different factors, which influence the time for the balls to reach the end of the ramp. They investigated the effect of the ball's mass on the time, and documented it for for different masses. The next task was to design a virtual model of the same phenomenon in a physics-engine platform called Algoodo [1]. This platform offers students a complete virtual world with all the laws of physics, and many construction blocks for them to build a variety of systems. Using

Algodoo, students tried to recreate the same conditions under which they had conducted their physical experiment and measure time for balls of different masses. Finally, they were asked to interact with a second computer model: a pre-made agent based model about the same phenomenon. Students, again in this model measured the time of rolling for the same set of masses. Afterward, they compared the three sets of data collected from the physical model and two different virtual models. Students were encouraged to explain the existing discrepancies. The whole study was audio and video recorded. Students were given pre, mid and post tests. Mid-test was conducted after gathering data from physical experiment. All three questionnaires contained the same questions.

2. Biology- This study was about bacterial growth. It lasted for a total of ten hours, split across three sessions. Students' initial task was growing real bacteria using a supplied toolkit. They divided into three groups, and each prepared a Petri dish with agar and applied the bacteria from different places around their environment. When finished, they used a provided time-lapse camera that captured images of the dishes every 30 minutes for ten days. The images were automatically compiled into a video that showed the growth pattern of the bacteria. Because of time restrictions, we also showed students a movie previously made by the research team of bacteria growth pattern, using the same toolkit.

Afterward, students were grouped into pairs and conducted an Internet research on the bacterial growth curve. Then, students joined their original groups; each group mentored by a researcher started to model the phenomenon. For this purpose, they first did paper modeling [Blikstein, 2009; Blikstein, under review]. Each group listed the variables affecting bacterial growth and the interactions amongst these variables. After three hours of paper modeling, each group members shared their ideas with other two groups in a 45-minute discussion panel. After enhancing their initial ideas with the feedback received from other groups' members, each group started programming with close help of its mentor. The last two hours of the study, they worked on coding their virtual model and comparing the results with the counterpart data from data gathered from real world.

3. Open-ended Bifocal Project- The final study was conducted during the last week of the same workshop and lasted for five days, in total 20 hours. This study was designed as a more open-ended Bifocal Modeling activity. Students divided into five groups. During the first day, students brainstormed about different phenomena for their projects, in groups. After deciding on three top candidates for their model, according to the materials and sensors available in the laboratory, they decided on a project topic. During next four days, with slight variations, all five groups went through following steps: studying about the selected topic; developing a physical construction for their experiment; Embedding sensors in their construction; Gathering data from the physical experiment; Designing and developing a virtual model of the same phenomenon; Comparing the results of a virtual model with the data gathered from the physical experiment; and finally explaining the possible reasons of existing discrepancies between the two data sets. For each group, the whole process was audio and video recorded. We also did a pre and post test to evaluate how students' knowledge changed over the course of the Bifocal project.

Results

It should be mentioned that this is an ongoing study and we are still analyzing our data. That said, in the following we will discuss our preliminary findings about different perceptions of students about computer models' accuracy in each study. For this purpose we have selected one group from each study and examined data gathered from that group.

First study

In this study, right after accomplishing physical experiment, students started modeling their virtual model in the Algoodoo platform without pre-designing their model. They did not list the effective variables and the underlying phenomenon like in the second study of bacterial growth. After completing their models and simulating the phenomenon, they encountered that there were huge discrepancies between the physical data set and the virtual one regarding the effect of mass on the rolling time. At first, the main discrepancy came from students' misinterpretation of the data. They figured out the issue by closer look at the data set. *"Our Observation was that the heavier is faster but our data shows that the heavier time is twice less, wait, it means... it's faster!"* However, they could not that easily determine the other reasons for remaining differences. We observed that students had an inclination to attribute errors and discrepancies mostly to themselves and human errors than to possible issues of the virtual model. Some of students' utterances during the activity illustrate this finding:

Student 1: "Maybe it's more accurate!"
Student 2: "Because it is the computer doing it!"
Student 3: "We had some problems to position sensor, but here, Algoodoo, we do not have it!"
Student 4: "When I dropped it, I dropped it in different place"
Student 5: "it's because of me!"

Similarly, we found that other groups exhibited the same type of behavior. When confronting the two models (physical and virtual) they would never attribute to the virtual model any shortcomings. In the full paper, we will present the rest of this dataset with more detailed comments and coding.

Second Study

In the bacteria study, before programming their virtual model, students spent considerable amount of time designing a virtual model. In groups, students brainstormed about influential variables and the underlying dynamics. Students, also, using pseudo code, developed the initial logic of their virtual model. When finished, they went through an iterative process of modeling the phenomenon on the actual NetLogo [5] platform. Each time, they compared simulated results with the real reference pattern from physical experiments. Students were encouraged to discover discrepancies and design a solution for each. This time, students step by step improved their virtual model and solved unrealistic assumptions in their modeling. They observed how refining an underlying assumption of their model could lead to more similar data to the data they had collected. This iterative process shed light on possible deficiencies of their code. The way they addressed accuracy suggests that they comprehended that neither their virtual model are totally accurate nor all discrepancies are rooted in a physical experiment and human errors. *"However, now that I have experienced the inaccuracies that virtual models produce, I will be able to comprehend in my head, that those models are not completely accurate." "I think knowing the differences between a virtual model and a real model is important, because it makes people use a skeptical perspective*

Third Study

This study holds some similarities and some differences compared to the other two. Similar to the first study, students did not spend much time on designing a virtual model and they did not do "whiteboard" pseudo coding. Students right after finishing their physical experiment started developing a virtual model of the same phenomenon. However, similarly to the second study, students also dedicated time to comparing the two data sets, one gathered from a virtual experiment and one from the physical experiment. This time students were aware that the discrepancies could be either caused by problems in their physical experiments, or coding procedures. This result deviated from what was observed in the first study, however the result of this study was also different from second study in this regard. This time, instead of trying to come up with a more realistic assumption, they just tried to define an assumption, which would fabricate data that would just resemble what was gathered from the physical experiment.

Discussion

Preliminary results of this study suggest that different adjustments in a bifocal activity could affect students' perception of credibility and accuracy of a virtual model. Results indicate that design and interaction phases in a Bifocal activity are both essential for students to develop a better comprehension of computer models' accuracy.

In the first study, students did not spend sufficient time on designing their virtual model before developing it. At this study, students tended to overweight the accuracy of a virtual model. Accordingly, although they brought up valid concerns about human errors, they left behind the evaluation of their virtual model. In the second study, students spent evenly divided time on each three phases. That could be a reason that at the end of the study, they had more acceptable approach toward solving an existing discrepancy. Unlike the first group, students showed to understand sometimes a false assumption in a model or limitations of the virtual platform caused discrepancies. This results suggest that compared to the first group, these students developed better understanding of virtual model accuracy and its credibility. However, on the last study when students spent very little time on designing a virtual model and more time on interacting with a model, although they seems to understand some of the limitations of their virtual model, they inclined to solve those by including false assumptions in their code. This may suggest that although they gained a better perception of virtual model accuracy compared to the first study, the general concept of accuracy became less critical to them.

References

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