FATHOM THAT!: AN ETHNOGRAPHY OF THE USE OF INTERACTIVE DATA ANALYSIS SOFTWARE IN A STATISTICS CLASS OF A HIGH SCHOOL SERVING LOW-INCOME STUDENTS

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This paper explores a high school classroom integration of Fathom software in the teaching of statistics. A majority of the students at this high school, serving a lower income community, are aspiring to be first generation high school graduates and learning in English as a second language. This paper will attempt to capture the "spots of time that glow"—episodes that stand out as being particularly enlightening. The guiding questions for the exploration in this paper focus on student reports of the highlights of their interaction with the software and curriculum, the teacher's strategies to integrate technology and how she adapts them as the year progresses, the nature of some of the challenges faced by the teacher, and the role that the software ends up playing in the classroom and the reasons for this role.

MOTIVATION AND METHODS

Fathom Dynamic Data® is a data exploration and analysis software used extensively in US high-school Statistics classrooms. As developers who strongly believe in backing our software design with real life needs and data, we are always on the lookout for insights that arise from implementing technology in classrooms. While there is earlier research with Fathom documenting issues around the learning of specific topics in Statistics (Lane-Getaz, 2002) and the use of Fathom as a tool for pre-service professional development (Confrey & Makar, 2005), this paper is mainly focused on the overall effect on a class when a teacher uses Fathom as an integral part of the course. This record of success or failure or something in between resonates for us. From our vantage point as developers of the software, we cannot solve the issues facing teachers about access to software, what we can do however is constructively use insights gained from studying the implementation of our software in typical classrooms. To this end, I decided to follow the rich tradition of ethnography as an educational research method (Eisenhart, 1988) and adopted the role of a participant observer.

I gained permission to observe a classroom and the teacher gave me access to her lesson planning site so I could see ahead and anticipate the lessons that she was going to teach. To capture the classroom observations while they were fresh in my mind, I created a blog. This was a collection of raw notes and my thoughts. Writing and reading my thoughts helped me to work on my bias as a researcher and clarify my role in the classroom. Additionally, it served as fodder for writing this paper.

This paper's goal is to present a proof of concept rather than a proof of efficacy. The intent is to capture "what happens when" technology is introduced in a classroom where the teacher is motivated and committed. It ponders the question of how the class dynamics influence the implementation of the technology. (Hancock & Kaput, 1992)

GLOWING SPOTS

Attempting to use technology in a meaningful manner is a lesson can be likened to a game of Whack-A-Mole (an arcade game where the creatures popup in disparate places and you have to hit them with a mallet). It is a delicate balancing act of fitting it into the curricular trajectory, keeping it relevant to the content, getting the technology to work right, and then making sure that the assessment somehow addresses this learning. The challenges facing a teacher trying to use creation oriented software like Fathom® in a Statistics classroom are only compounded by the fact that often Statistics classes in US high schools are preparing for a competitive national examination called the Advanced Placement Statistics test. However, even in this difficult climate, we hear stories of successful implementation. If we can capture the essence of what works then maybe we can operationalize it in the form of a toolkit to provide scaffolding for teachers.

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The title of this section is inspired by Sam Intrator, who in his book "Tuned In and Fired Up" (Intrator, 2003) provides detailed portraits of powerful learning episodes in a high school classroom

> to capture the lightning in a bottle so that I can study what went right and deconstruct the sequence of events. But these moments were more ineffable rather than understandable, and they always seemed to belie planning and predictability.

He called these episodes "spots of time that glow." In the same spirit, loosely structured by my guiding questions, here are the spots of time that glowed for me.

Nature of Challenges

The classroom observations were conducted in Memorial High School - a public charter school in Northern California. (The names of the places, people and locations in the paper have been changed to protect the identities of the concerned parties.) The student population consists mainly of low-income families. Most of the incoming student population will be the first college graduates in their family. A number of them will be even first generation high school graduates. A large proportion of students do not speak English as their first language. The social interactions in the classroom during non-instructional periods are largely conducted in languages other than English. While, I occasionally observed students using this shared non-English language to further the learning in the classroom by helping a fellow student, more often than not it interfered with their ability to engage with the question at hand which was phrased in English. Families of students sometimes paid little regard to attendance. E.g: John and Dean were two brothers who were absent for a period of over two weeks because their parents took them for a vacation. The teacher reported that this was their second prolonged absence. Another not uncommon situation is that of students entering high school with little or no exposure to formal schooling, e.g., Robert had spent his childhood traveling with his parents and for seven years prior to enrolling at Memorial High had not been in a school.

This city has been without a comprehensive high school since the school district shut down the local high school in the late 1970s and started busing the city's students to another high school 10 miles away. About four years ago, Memorial High School was started as a charter school with support from the School of Education at the local University. While this situation gave rise to many challenges around the area of student learning and preparedness, we want to focus our attention on those that specifically affected the integration of technology.

- *Lack of Proximity to Extra Resources*: Most students had no access to technology at home. Even though the teacher provided access to the lab at all times that she was on campus including time on weekends, the students found it hard to take advantage of this. As an open charter school, the school has no residency requirement. In any given year, 10-5 students live between 25-40 miles from school and this makes it hard for them to take advantage of any training other than during school hours.
- *Lack of Connection to Student Homework*: In our desire to promote exploration based learning, I realized that our Fathom activities rarely model the typical (and endless number of) homework problems.
- *Lack of Confidence with Technology*: Even for a bright and dedicated teacher like Jackie, it was hard to get over the mental hurdle of doing an entire lesson based on technology. There were two sessions that stood out when an entire lesson took place in the lab with time devoted to solving problems using Fathom. The first session was opportunistic (the computer lab was available) and therefore unplanned. Jackie just decided to make the best of the opportunity by teaching the students "*how to setup a Fathom document for sampling simulations*". The second time around, the teacher reported that just the knowledge that I (in her mind the technology expert) would be present "*made her brave enough to plan a modeling activity in the lab*".

Student Reports of highlights

Jackie Wilson has better access to the computer lab because she teaches in a room right next to it and can use the lab whenever it is free. Since student access to software at home is limited or non-existent, most of their interaction was in lab sessions. The two lessons described below both took place in the computer lab. The lab is in a room adjacent to the classroom. Each student has an individual iMac to work on. The students have assigned computers but they can access all their documents from any computer as they have networked logins. The lab is set up as six rows of six computers each. Each row is divided into two parts by a vertical aisle with four computers on one side and two on the other. There is a screen in the front that is visible from all computers.

- *Calculator-like Use of Fathom*: In one lab session, the students used Fathom to work on one of their homework problems (7.43 from "The Practice of Statistics" – Yates, et. al 2007). It was a simple discrete variable based simulation of creating a sampling distribution. It is in the section pertaining to the Law of Large Numbers. Students were modeling the process of solving this problem on a calculator. In all such problems, the first step is to "assign digits". What that means is given the table of probabilities; you have to create a list in your calculator corresponding to a random variable X (in this case discrete). It is a hard process for them to think through because they haven't practiced enough. Fathom offered one more way to model this process.

Toys	P(BT)
0	0.03
1	0.11
2	0.24
3	0.38
4	0.16
5	0.08

My natural instinct was to use a conditional formula however, the teacher had her students create a Fathom collection by pulling down a case table and adding cases by hand like so -

Enter a 0. Copy and paste it 2 more times to get 3 zeroes. Then enter a 1, copy and paste it 10 times... and so on...

"*Oh! I get it...*" exclaimed a couple of students after looking at the way they created the collection - by "assigning digits" and realizing how that was similar to their use of the calculator to solve the problem. They then proceeded to solve the problem in Fathom using text boxes to write their answers much like on the exam.

The way in which the use of Fathom enriched the solution of a very test-like problem points to a need to make it easier for teachers to use software to serve their one of their primary needs–preparing students for the test–while still keeping the avenues open and enticing for going further and exploring. The realization that Fathom can be effectively used to teach test skills while maintaining open channels along the learning trajectory is important and can influence how we structure and design activities that are a part of the software.

- *Easy to Follow*:

"*Why does Fathom create the third box?*" "*I don't know; for fun?*"

"*Why do you have different numbers?*" "*Oh because we got different samples!*"

Another remarkable lab session led to an interesting validation of our interface while bringing up some sticking points as well. In this session–largely unplanned–the class modeled a discrete variable simulation of sample means. (This is activity 7b from The Practice of Statistics (Yates et al., 2007) third edition. The gist of the activity is captured below:

  - *Let X be a random variable whose values are drawn from {1,1,2,3,5,8}*
  - *Take a sample of two values from this set. (Treat the two 1s as separate values).*
  - *Compute the mean for this sample.*
  - *Repeat this for all possible samples of size 2.*

Jackie didn't have a student handout for them to work from. She had only that very morning decided that she would use Fathom after she confirmed my attendance. She reported her worry that if she had tried this activity solo then in case she ran into a snag she would get nowhere. Whereas with a physical simulation, she may only do a few runs but she had the confidence that she would get the point across. As it turned out, the only real Fathom help that I gave her was to point out that you could escape out of animation when collecting a 1000 measures. At other times, when she looked a bit puzzled, I just waited for a moment and eventually she figured it out (An example being - which menu to choose from and which collection to have selected when wanting to collect measures).
On the whole, the students seemed not to have a difficult time with this activity and with Fathom. Jackie modeled the process of "*putting together a Fathom document*". The students followed along and recreated the document as she modeled it on her computer whose display was projected up front. At the end, she asked them to look at their neighbor's computer and see if their graphs looked similar. While there wasn't much conversation around questioning the differences in the way the graphs looked, the three students who had used a different sample size from what the activity specified discovered their mistake when they compared their graphs and wanted to know they looked different.

These two lab sessions were an exciting and satisfying experience for me. I had gone in with a conjecture that it would be harder to keep the students on task in the lab, because a) it is harder for the teacher to make eye contact with them when they are behind a screen, b) the computers are internet enabled, and c) they didn't have a clear set of instructions to follow. In reality, I was surprised at how on task and productive the students were. In a 45-minute session, they go through the usual housekeeping (attendance, collecting homework, look ahead at the class schedule), moved to the lab next door and finished this activity. Maybe it was the fact they were in front of a computer and all doing something. The individual computer in fact to some extent may have made it easier to stay on task as the large screen blocked the distractions.

In a strange counter-intuitive way the computer leveled the playing field because they were all equally new to what they were doing. The software interface posed little trouble for them when they were following instructions. Fathom was very well suited to modeling this simple activity. There was none of the cognitive baggage associated with putting together a probability simulation involving cards or a "real-life" situation. It brings to light yet again, a need for us as software developers to make it easier to use Fathom for modeling a "typical" textbook situation.

Teacher Strategies

Jackie Wilson, an American of Armenian descent, is a high school teacher with over 20 years of experience in various teaching situations. Her stints working in the military and in corporate arenas have given her a worldview that tempers her idealistic beliefs with a dose of realism. She is really committed to teaching and believes that "*when a whole system works together, everything is possible right now!*" Her commitment to "*doing what it takes*" to provide access to technology and other tools is demonstrated by the fact that she has written grants, solicited donations, and spent personal money to provide students with resources like graphing calculators, software, on-line applications, outside reading books, field trips, etc. She organizes all her lessons in Google Docs and the class has a website which has the homework answers, notes from each lesson, homework assignments and all class policies. She has been working in charter schools that she helped to open and/or develop since 1999, so she has had prior experience with the challenging nature of the school demographics and economics.

- *Tracking*: An astonishing development that went contrary to the strong equity oriented mindset demonstrated by Jackie was her implementation of a tracing system within the classroom. She created a new seating arrangement based on the latest test scores. Jackie divided the class into three groups – passing, can pass but not there yet, need a lot of work. She reported that her motivation behind this was that she wanted to give some undivided attention to the third group. She moved them out of this arrangement in the following semester. To me this was evidence of her using whatever technique it took to motivate the

students to engage with their work. It was yet another example of how she spends a significant amount of time managing motivation, expectations and class policies.
She had an interesting characterization of the middle group–based largely on their intrinsic motivation.
"that's why you are in this middle group - because you don't want to learn new things. You only want to coast in your comfort zone. You are not willing to put in the effort needed to be in the passing group, but you aren't in the last group because you are using what you have."
Similarly, she identified the most important distinguishing feature of the top group as their desire to apply themselves.
"*No, they are not the smartest. They are the best prepared. They don't pass everything they do - they just never stop trying. They are always asking for help. They turn up for office hours. This group has near perfect homework submission rates. That's what will help them succeed in the course.*"

- *Technology Expert Support*: Jackie missed a few opportunities to use technology when the class was not in the lab. In a class session to familiarize the students with the concept of Venn diagrams and probability, she did a probability simulation by hand, but didn't follow that up with one done in Fathom. On being asked her reasons, she explained that she had not "prepared" for doing it, was worried that her attempt may take the students further off task, and hadn't remembered that I may be in the classroom that day. When, Jackie didn't use Fathom, I was in a dilemma around how much I should influence what happens in this classroom. I wanted to point out the opportunity but didn't. The conflict was a result of my perception of my role in that space. If I do then, I am an actor in the space not just an observer. If I don't then I am depriving the students of a learning opportunity.
In the lab session described earlier in the paper, Jackie was grateful for the fact that my planned presence in the lab gave her the "*courage to try this activity*". I did not provide any actual technical support just the reassurance that help was near at hand if needed.
This points to a need for us as developers to integrate the feeling of an expert at hand in the software to scaffold the classroom learning experience for teachers.

Role of software and reasons

Fathom played a role of the supporting actor in the classroom. It was never a principal player in the lesson plan or the classroom interaction. The students used this opportunity to interact with a tool that some of them used in other projects that they were engaged in. Jackie pointed to the fact that when students have sporadic attendance it is much harder to build a learning trajectory for, that the class can follow as a whole. Jackie emphasized that Fathom had the potential for students to engage in more creative problem solving in homework. The use of Fathom spurred the teacher to organize a video chat with an alumnus who did a remote demonstration of how to use Fathom in a real life project.

CONCLUSION

Despite the teacher's best intentions, Fathom did not end up becoming an integral part of her teaching repertoire. The demographic and economic dynamics of the school were challenging enough that the observation did not in nay way document a "typical" classroom situation. The ethnography gleaned valuable user interaction insights as well as curricular implications.

But the chief aim–to observe a technology implementation and document the effect on the classroom dynamics and learning–was only partially achieved. To further the aim of the studying the why of what happens, under the aegis of a new NSF-funded grant, we will pilot the activities and software prototypes we create in a high school classroom. Along with observing for efficacy of the activities and games, we will also study what happens when technology is used in a more integrated way in this classroom than it is under normal circumstances.

In conclusion we can take away three spots that glow and use them to light our future development path. Firstly, that the software based activity sessions increased student engagement and helped them stay on task. This points to an important need for us to make sure that we provide

ways for software to be more easy to integrate in classrooms perhaps on more devices that more ubiquitous than lab computers like mobile phones. Secondly, it is essential that the software make it effortless for the teacher to use it for the quotidian work of homework, preparing for exams and administering quizzes. But at any given time in this interaction, the software must provide affordances for the teacher to see how to go beyond the mundane towards the sublime. The ability that Fathom provides to turn "*wanderers into wonderers*" (Olive & Makar, 2009) must be exposed to all teachers and students. Lastly, Jackie provides us with the motivation we need to create a supportive environment within the software for teachers to turn to for help.

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