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# **Looking at How Technology is Used With the Bodies Over There to Figure Out What Could be Done With The Technology and Bodies Right Here**

**Victor R. Lee**

*Utah State University*

## **INTRODUCTION**

Design is a complex practice. In the worlds of human-computer interaction and interaction design, the most strongly recommended first step is to understand the end users and participants who will be involved with and impacted by the eventual intended experience (e.g., Rogers, Sharp, & Preece, 2011). For example, contextual design (Beyer & Holtzblatt, 1998) recommends conducting observations and interviews with people at work as they are engaged in the activities that they normally encounter. Noted design firm IDEO directly involves members of their team in site-based research of activity and also places team members in the role of trying out existing tools and processes themselves so that they better understand the user experience (Kelley & Littman, 2001). By engaging with the target population from the very beginning, accountability to actual needs is established and maintained throughout the design cycle. The core idea behind this focus on users and their activities as they exist in situ is that it generates valuable insight into why work is done in the way that it currently is, and that will eventually influence the shape of a designed solution or tool to be introduced by a design team later.

Education also has its own traditions and set of recommended practices for design. One is to focus early on learning goals and to truly articulate them in a manner that clarifies what a learner should be able to do and under what conditions after participating in a designed learning experience (e.g., Dick, Carey, & Carey, 2001; Krajcik, McNeill, & Reiser, 2008; Wiggins & McTighe, 1998). Another is to utilize design frameworks that are informed by appropriate educational theory. These frameworks can emphasize a number of different aspects of the learning process, such as how to support knowledge development (e.g., Edelson, 2001), learner motivation (e.g., Edelson & Joseph, 2004), or specific kinds of distributed social interaction (e.g. Brown & Campione, 1996), to name a few. In addition, a push has been made for educational experience designers to consider what learners have as resources from their daily experiences that can be brought into a designed learning environment (e.g., Ito, et al., 2013; Moll & Greenberg, 1990). There are many documented cases of success when these approaches have been used.

In recognizing that these approaches have all borne fruit over the decades, I am not offering any specific critique. However, I would like to propose another approach that in a number of ways, blends aspects of both interaction design approaches, which emphasize understanding how things work for an intact community in situ, and educational design approaches, which emphasize attainment of specific learning goals and carefully introduces ways to nudge learners toward ways of understanding some aspect of the world. This approach basically involves doing a kind of user or community based research to understand how things are done, but it does not require that the community in question be the same end users. Then it involves identifying aspects of that community that appear to make it work the way that it does, be they tools, work routines, or

ways of interacting with people or technology. Once those are identified, they can be imported into an educational space, and over time, “grafted” in such a way that they can be used to help serve intended learning goals.

How does this notion of imported design relate to technology and bodies? Currently, what we see now is a proliferation of mobile and wearable devices that are appearing in the market and are being custom built (e.g., ref). As these devices have become more omnipresent, groups of people have emerged who are appropriating these technologies in ways that are meaningful for purposes other than specific disciplinary learning. There are hobbyists who are using devices to track their sleep habits or nutrition, athletes who track their performance, fitness aficionados who track workouts, GPS users who track their travels, individuals under medical care supervising their blood pressure, and so on. And presently, it turns out that with very few exceptions (e.g., Choe, et al., 2014), we as a research and design community still know very little about what is being done in within these groups of people who are involved in body-data tracking. Yet I am inclined to believe that there are likely some ways of doing things with technology that have emerged from within those communities that could be promising and worthy of importing. In light of that inclination, this chapter provides two examples from my own work that involved looking at how technologies are used in a non-student, non-school based, body-data collecting communities to inform how to improve learning activities with wearable technologies targeted for students and within schools. The first involves looking to the Quantified Self movement to change how wearable technologies were being used in an elementary school classroom. The second involves looking at how and why athletes track their data to get students to rethink their school day recess time.

## **LOOKING AT HOBBYIST SELF-QUANTIFICATION ACTIVITIES TO INFORM CLASSROOM INSTRUCTION**

For multiple years, my students and I have been involved in iterative cycles of design-based research (Brown, 1992) involving the conceptualization, specification, and implementation of classroom-based activities for fifth-grade students to participate in the collection and analysis of personal physical activity data (e.g., Lee & Thomas, 2011). The motivation for this was the assumption that prior knowledge of physical experiences that generated a set of data could serve as a bootstrap with which students can more thoughtfully and productively make sense of what kinds of data they are interpreting (Lee & DuMont, 2010; Nemirovsky, 2011). Indeed, research in science classrooms (Hug & McNeill, 2008) and in science laboratories (Roth, 2014) has demonstrated how prior knowledge of data sources plays an important role in both thinking and interacting with science content and representations of data. In recognition of this, we have looked to technologies that passively collect data about one's body and one's physiological experiences, by virtue of being worn. By taking out the need for classes to set up specialized instruments and apparatus, we were hopeful that wearable devices could make data collection more efficient, more abundant, and more familiar to students.

Our early efforts have been promising, and a number of classroom activities have been developed and adapted in order to help realize our goals (Lee, Drake, & Williamson, in press). These most often involve students participating in a series of classroom lessons and activities that emphasized class discussions and some specialized days for technology-supported data

collection and analysis activities. While students involved in these kinds of activities appeared to be making significant learning gains (Lee & Thomas, 2011), we had the suspicion that more efforts could be made to cultivate a greater sense of ownership from students with respect to the data and the claims that they would ultimately be making from them. That is, we wanted to support students in doing more than just one or two whole class, facilitator-seeded activities and instead pursue more individualized, personally meaningful questions tied to their own individual interests.

To support this, we considered where might we see people outside of school already doing such things. This led us to pursue an investigation of adults who, in their free time, are involved in the “Quantified Self” movement (see also Ching & Schaefer, this volume). Briefly, Quantified Self (QS) is a term used to refer to the capability for people to readily obtain data specific to their activities. It has been propelled by the increased availability of off-the-shelf wearable tracking devices and the existence of a California-based support organization that helps to manage online communications and organize meetings and conferences that bring together these adult hobbyists and technology industry leaders to discuss self tracking experiences and explore new possibilities for self-tracking in the near future. By many measures, QS has, for the past six years, been rapidly growing and self-sustaining (Lee, 2013). A number of custom self-tracking projects have been documented and published online, and this led to a question of what aspects of QS encourage or enable the pursuit of custom projects. The hope was that a better understanding of QS could lead to the importation of activities or routines that could benefit students and encourage more custom explorations of data on their part.

Over the course of a year, participant observation at meetup groups and at the QS conference and archival analysis of public videorecords (e.g., Lee, 2014) of presentations of individual QS projects have led to the identification of a few features among QSers that seem to encourage personalization and pursuit of custom projects. These include:

- **Continual and longitudinal collection of data.** QSers each often collect large amounts of data for extended periods of time that can span several days to weeks, months, or even years. For example, I have documented how in a QS hobby project involving analysis of one's own reading patterns, one QSer collected records of all the books that he read over four years (Lee, 2014). In contrast, the elementary students with whom we have previously worked have, out of respect for existing norms and preferences of their respective school and classrooms, collected data for very short bursts of time (i.e., for a few minutes during a class lesson). Students that we had worked with were able to work with reasonable data sets with a couple dozen data points in them, but that was because of the moderately large numbers of students in the class in which each student contributed one data point to a collective corpus.
- **Frequent intermediate reviews of data.** The ability to examine data *as it is coming* can be quite important for QSers. Seeing variation as it emerges in their data and having prior familiarity with possible causes of that variation can seed questions for subsequent investigation. It can also motivate future data collection activities. For example, QSers discuss the ability to view data about their weight and their changes in diet or exercise as they are recorded as a critically important and necessary part of self-quantification. On the one hand, it helps to inform them that they are reaching their goals (e.g., they see they



are indeed gaining, losing, or maintaining weight as intended). On the other, it also can give them a nudge as far as what new programs or routines they can try to change an outcome of interest (e.g., walking to and from work seems to have led to a slight but significant decrease in weight). With the classes that we partnered with, the relatively brief amount of time and multi-day delay before they saw their data did not allow students to generate new hypotheses or raise specific questions drawn from a broad range of everyday experiences.

- **A privileging of unexpected findings in routine activities.** QS is often treated in popular press as being most consequential for and relevant to personal health, and many talks at QS conferences and the packaging of off-the-shelf wearable tracking devices would further confirm that personal health is a major focus. However, strands of self-quantification that take highly familiar and routine activities specific to an individual are often elevated in status among QSers. At the QS conference and in meetup groups, projects that track one's transportation habits, laundry, recreational reading, or parenting routines are specially featured, in large part because of those activities' routine familiarity. Finding something unexpected from routine activities is recognized in QS as both empowering and enlightening. It reflects the true power of self-quantification because there are unrealized tendencies in our lives that, when quantified, become visible. Typically, the students we have worked with, knowing they had limited time to collect data and use a specialized and highly distracting wearable device in school, would express desires to measure highly unusual behaviors (e.g., heart rates when being shoved by other kids (Lee & Thomas, 2011)). Measuring something routine, in the ways that the

technologies were then allowed to be used in the classroom, was considered relatively unexciting by students unless properly seeded ahead of time.

In light of these observations, we have sought to import some of these ways of relating to data – continually collecting activity data, frequently reviewing and interpreting data as it is being collected, and privileging findings from routine activities - from adult QS hobbyists into the classroom. We also have sought to bring in some of the same tools that are used by QSers (e.g., the Fitbit activity tracker, also used in Ching & Schaefer, this volume) and some of the same out-of-the-box data display tools that QSers encounter in their own self-tracking projects. This involved willing school partners who were open to deviating from what would normally be allowed in their classrooms (which we greatly appreciated!). But once a case was made that this could enhance the learning experience for the students, we were able to make some changes.

Specifically, in order to support continual data collection, we provided students with activity trackers to wear and use all day, every day if they so choose, and starting on the first day of school. Students were allowed to take the devices home and use them outside of school and over the weekend. They could wear them to practice, church, family trips, bed, and so on. This enabled them to truly check their activity levels at any time during the day that they wished.

Doing this served a number of purposes. First, students became more familiar with the devices and what they could do. Because they wore them throughout the all day, they had ample time to explore the different modes (step tracking, calorie tracking, total elevation gain in terms of floor equivalents) in the device and get used to how the devices worked as recorders of physical

experience throughout the school day. We observed that this greatly decreased the urgency for students to something out of the ordinary on designated data collection days at school. An added benefit of this was that data synchronization and storage could take place at any time throughout the day. (We placed some wireless antenna in the classrooms connected to internet connected computers always available in the classroom, and because students were already wearing the devices at all times, information would be wirelessly transferred automatically and often while kids were present). This greatly reduced the data transfer overhead (i.e., the multiday time delay before data were available) that comes with using data sensing technologies in the classroom.

In addition, the ability for students to check their devices at any time throughout the day provided them with time to develop a sense for what kinds of numerical values would typically appear with different activities. We have documented elsewhere how even a few hours of exposure can change expectations for what is normal for a given activity (Lee, Drake, & Williamson, in press). But beyond getting a sense for their own activities, the students would notice, for instance, that the numerical values for numbers of steps taken in a day were always integers (rather than decimal values), or that elevation gain was shown in terms of the equivalent number of floors climbed if the student had been walking upstairs. As will be described in data excerpts below, these kinds of details were indeed consequential for students when they interpreted data from investigations that they had designed.

Additionally, and with the newly negotiated agreement of the teacher and school, we had established designated times on most days for students to share and review the data from their activities. I noted earlier that QSers frequently reviewed their own data as it was collected as a

means of sparking questions and for helping to orient them to what their data seemed to be saying. Students and classes with whom we previously had worked would only occasionally review data during the course of a unit and when they did so, it was after a data investigation was being completed. Part of this was due to the overhead associated with data transfer. As an alternative and because we had data transfers going on behind the scenes all the time, we were able to instead rotate through students throughout the semester who were willing to share the data they had collected on the previous day or on the current day's morning with the rest of their class. Doing so helped other students to observe models of how their peers examined and interpreted data displays and also helped to stimulate whole-class discussions about how highly familiar activities associated with school looked in displays of data and discussing why. They even could draw on their own individually developed awareness of the device capabilities to help them to interpret the data.

This was especially powerful for the classroom environment, where the students are all involved in learning with one another how to make sense of data. To illustrate, consider the excerpt taken from video during a fifth grade class that was involved in this informal, whole class data review. In this excerpt, a student, Justin, was sharing his data from the previous day and discussing why his data looked the way that it did (Figure 9.1). His classmates served as a resource in that they chimed in with their recollections and did work alongside him to interpret the data he had collected based on what they also had remembered and what they expected given their knowledge of the tracking devices.



Justin: [Changes where he points] Moving around in Mr. Brush's room on [wheeled] chairs did it [the increase in points around 10:30].

...

Justin: [Pointing near 11:00]: Yeah, that's about... Cuz we started lunch at like 11:10, walked downstairs, and then we go.

Kai: Maybe that's when you were walking out [of lunch] to come [upstairs to] play on the computers.

Milani: Check the floors for that time - that will, that way we'll see.

In this excerpt, it is worth noting that Justin was adept at translating certain changes in his data at certain times to activities he recalled from his school day. He could confidently identify when he put on his tracker (he opted to use it only at school and did not want to take his home), and how the morning meeting and transition to math time would look in the data display. There were a few occasions when he needed a bit of assistance from his classmates, but all together, as evidenced by the outbursts from the students trying to situate the data with specific events from their recall of the day. Eventually, there was a settlement on the low bars in the data being from math class, where they were practicing timed memorization activities at the desks, which was typical for their math class. Similar sorts of limited movement activities would take place during reading, but there was clearly an increase in activity. On seeing this, Justin was quick to respond that "Moving around in Mr. Brush's room on chairs did it".

Following this, conversation about lunch followed. At the time of the school year when this conversation was recorded, it had been snowing and the local air quality was subpar, so many

students stayed inside and opted to go from the downstairs lunchroom back upstairs to their classroom to play computer games on the classroom computers. As they saw a relatively low level of activity for lunch (in comparison to what they would expect for outdoor lunchtimes from previous reviews of their data), Kai quickly suggested that it could be when Justin had gone inside to play computer games. To verify, Milani added that they could “check the floors for that time” to see if there is evidence that Justin did go upstairs back to the classroom. This is an awareness of the technology’s capability that Milani had based on her experience of wearing an activity tracker herself and discovering that only upward movement would register as a change in floors, and thus should appear in the data as well if they were at all uncertain. Her extended use and greater familiarity with the device from having used it since day one of the school year enabled her to make this useful suggestion.

While this was just one excerpt, it captures how the importation of certain ways of doing things with data and tracking devices from QS into the classroom was fruitful. It leveraged the memories of previous days’ fairly standard set of activities that were distributed among the students in the class, and it also positioned the students as more knowledgeable experts. Students could share what they knew about how the technologies would read student movement. They could also share in strategies for reconstructing the events that generated the data. As the students continued to use the devices, these competences became more critical in supporting more personalized investigations as illustrated in the next section.

### **A sample personally relevant project: Comparing sports**

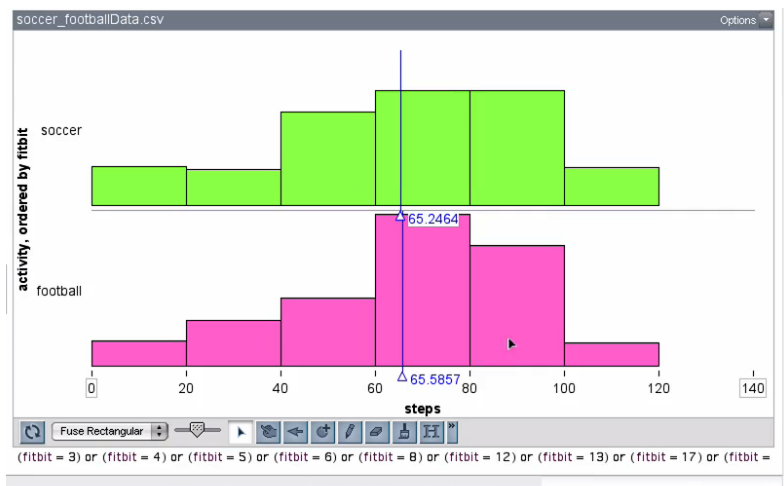
During one of the aforementioned data sharing activities, we observed an incident several weeks after students had all begun using and taking home their activity trackers. One student in the class was discussing what he was noticing about his previous day's data in front of the class. One thing that struck him and others who asked him questions about his data, was that his morning recess and lunchtime recess activity levels were quite different from each other in terms of the height of the step count bars and also the color of the bars (indicating the level of intensity of physical activity). This was even more puzzling because the amount of total free playtime between the two recesses was comparable. The sharing student revealed that at lunchtime, he had been playing football. In the morning recess, he had played basketball. This discovery subsequently led to many students who liked playing football most during recess boasting loudly to the rest of the class that football was indeed the toughest and most demanding sport on the playground.

This boasting began to antagonize some of the other students in the class, and in particular, the students who preferred to play soccer at recess. The soccer students felt that soccer was the most demanding, as it had students running around to move and pass the ball while football involved a fair amount of time standing in set formations before play began. However, given how vocal the football players were in class, the soccer students felt they needed to not just state their opinion but back it up with data. When given the opportunity a few weeks later to conceptualize and execute their own custom project they decided to compare activity levels, as measured in steps, between football and soccer.



The three students involved in this project, Geoff, Lauren, and Neill, convinced the class that in order to test their hypothesis that soccer might be even more demanding than football, they needed everyone in the class to play football for 20 minutes on one day and play soccer for 20 minutes on another. (Since everyone was already regularly wearing their activity trackers during the school day, this simply involved having students participate in the two sports and letting the data recorded transfer automatically.) Geoff, Lauren, and Neill would go back to the classroom on another day and get the data from each of the students in the class for the time periods when each sport was played and then make a comparison.

Following the two sport data collection days, the three students obtained step per minute data for everyone in their class and proceeded to create some data displays to help the figure out what the data were showing. The net result of their data collection is shown in Figure 9.2.



*Figure 9.2* Data display prepared by Geoff, Lauren, and Neill comparing numbers of steps taken per minute while playing soccer or football.

Upon visual appraisal, the group decided that the shapes of the two distributions were surprisingly comparable with one another. There were not major differences to be found by looking at the shape of the data. Both histograms had some peaks around a center region in the distribution and tapered along each side. The fact that so much overlapped with respect to overall shape and also relative horizontal position meant that they had to do some additional work to determine if there was indeed a difference.

Geoff, Lauren, and Neill then became interested in how the means for the two sport conditions compared, and found that soccer had an average of 65.2 steps per minute and football had 65.6 steps per minute. While this could have been taken as showing that football involved more activity than soccer, Geoff (the most vocal member of the small student group) quickly argued that such a small difference, even if considered to be at the level of a difference of an entire step, was not meaningful.

Geoff: It's really not much of a difference, it looks like a difference at first but when you really look at it, it is not much of a difference it looks like a step, but it is not even a step.

In making these remarks, it is worth noticing that Geoff demonstrated some sophistication with respect to how to look at and interpret differences in two sets of data. While these data were not subject to statistical significance tests, Geoff was able to think in terms of what the numbers were referring to in the data display. Specifically, steps only exist in and were recorded by the activity tracking devices in whole number increments, so the fact that the step was only a half was suspect. When translated to the activity that generated it, this was an artifact of the

procedure that produced the decimal value. This is a clear contrast to more formulaic mathematical problem solving approaches documented in the literature (e.g., Schoenfeld, 1988). Furthermore, Geoff also proceeded to explain how it would still be fairly inconsequential if it was considered to be a whole step in a subsequent videorecorded comment:

Geoff: Once you think about it and look at these you think 1 step, who cares if it takes one more step. One step is not even going to burn  $\frac{1}{4}$  of a calorie, it won't even make you more fit so you might as well do one or the other because they are practically the same. If it took 100 more steps then possibly you would choose one (game) or another, but if it takes  $\frac{1}{2}$  a step... then it doesn't matter there is not anything extra. The game is fun, but which one of these you think is fun is the one you should be playing because they have the exact same amount of steps taken.

In this second excerpt, Geoff's familiarity with the devices and his several days of experience with seeing how slowly the calorie counts changed relative to time and amount of effort helped to inform him about how several steps were needed for calories. If the concern was to increase activity levels (and thus burn more calories), there was no meaningful practical difference between the two, leading him to conclude that someone who was trying to decide which sport to play should make their decision based on which sport they thought was more fun as both football and soccer "have the exact same amount of steps taken".

Taken together, this example serves to illustrate how the importing some ways of working with data and devices from QS appeared to support students in engaging with and interpreting data in

ways that, as we had intended, leveraged prior everyday knowledge about activities and was based on topics and questions of personal interest. By providing students with devices to use and keep for an extended period of time, they were able to become much more familiar with the devices that they were using and how different values and modes could inform their interpretation of recorded values. By introducing frequent data reviews, students were able to jointly engage in the interpretation of the data that were provided and also to begin to make claims that could then be tested experimentally. The claims were based also in their own everyday school experiences. And although these experiences were already familiar ones, there was still enough for students to meaningfully investigate and explore.

### **IMPORTING ATHLETES' DATA USE ROUTINES INTO SCHOOL RECESS**

There are other ways that examination of other, non-classroom based communities has helped us generate possible designs for educational purposes. For example, in a study on how adult athletes who participated in long distance running (e.g., marathons) or cycling (Lee & Drake, 2013a) used activity-tracking technologies, we discovered how heavily competition drove their technology use. We observed competition as taking two distinct forms. First, it could be competitions against other people involved in the same activity. In our study, we learned about how using tracking technologies with web platforms and maintaining a blog of running activity could serve as an important motivator for runners who shared information with their friends and casually competed with one another. Some runners even made custom transformations on their own personal records to see how they stood relative to community milestones, like qualifying times associated with high profile races or their standing against different age groups. This emphasis on competition has become so common with activity tracking many off-the-shelf

devices have embraced this kind of social competition and provide features that allow a user to share their physical activity metrics with friends in a friendly competition. Dedicated services provide this as well. For example, the online bicycle ride tracking service, Strava, designates “King” or “Queen” of the mountain for the rider who has the fastest recorded time on various user generated routes. The desire to attain this status has in some cases, driven individuals to extreme behavior (Pidd, 2013).

Beyond competing with others, we also discovered that the use of self-quantification and activity tracking technologies among athletes also was often accompanied by a form of virtual competition with one’s *past self*. Because speeds, distances, cadences, etc. are measured and recorded, cyclists and runners will often try to set new personal best times or do as well (or better) than they had done in a previous season. Self-quantification provided enough specific information pertaining to one’s self to enable a number of approachable ways for individuals to self-improve. Some users of athletic tracking technology had even commented that they would be “lost” without their devices as they would not be able to make self-comparisons.

Together, these two forms of competition served as motivators for continued participation in sport and also reinforced the desire to track data. They also encouraged reflection about typicality, deviation, and trends. Having noticed that, my team became interested in exploring how these two kinds of competition could be imported into the classroom.

In importing competition, it is important to recognize that classroom activities often strive to maintain equity norms among students and a number of learning activities emphasize

collaboration and cooperation. There are certainly good reasons for these emphases, as collaboration and peer support are highly influential in student success. However, there are still several ways to bring competition into schools in a way that is productive and helpful for targeted learning goals. Below, we describe one example of such an effort.

### **Quantified Recess**

The two manifestations of competition that we had observed had been competition with others and competition with self. With the goal of importing those into a school setting, we designed and implemented an activity with students that we refer to as Quantified Recess (Lee & Drake, 2013b). The basic premise of Quantified Recess was that pairs of students were competing with other teams to achieve the highest score based on their physical activity levels during recess by the end of the week. In addition, their scores were not simply their final measured activity level, but rather were determined based on each individual's change over time. That means that not only were student groups were competing with each other, but also they were competing with their past selves. The final score that each group would receive for a week's worth of the activity was a composite of each person's relative increase in activity level from the first day to the last. This was done to both level the playing field (so that students who were already very athletic did not have an inherent advantage) and to also provide each student with a sense that they could find ways to individually increase their activity levels.

However, our larger learning goals had been to engage students with issues of measurement, quantification, and central tendency. With that in mind, we opted to have students' scores be computed by looking at the measure of center for each minute of activity on each day for a given

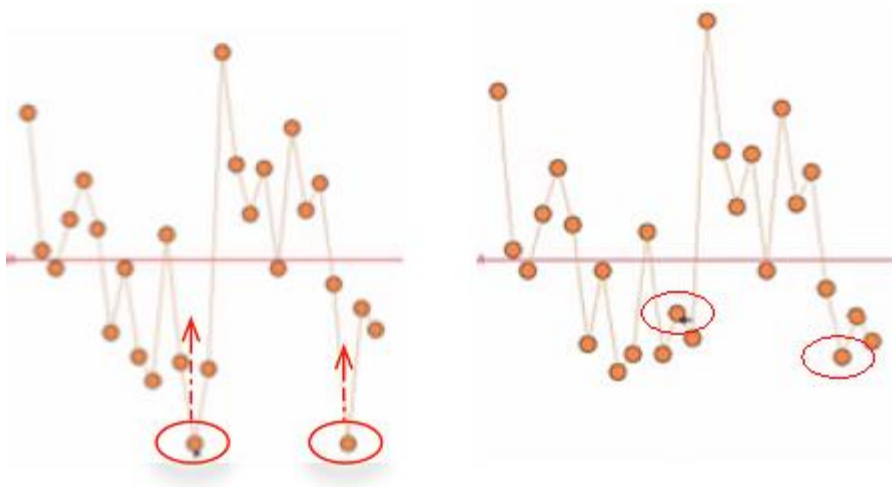
student and having them look at that value for change over time. Furthermore, each student in a competing pair was to be scored on a different measure of center; one student's score for the week would be determined by taking the difference in mean minute activity level from start to finish and the other student would be scored based on the median minute activity level from start to finish. It was up to the students to determine at the beginning of the week which measure of center would be best assigned to which student. Throughout the week of the activity, the pairs of students would meet together and review their scores from the current day, and then jointly discuss and test strategies for how they could change their measured activity levels each day.

So, for example, during a 20 minute recess at the beginning of the week, if one student in a pair had a mean number of steps per minute of 54 and the other student had a median number of steps per minute of 36, then they would each devise strategies to increase their respective measure by week's end. Say that the first student increased her mean number of steps to 72 and the second student increased his median number of steps to 58, then the first student's score would be determined by taking the difference from her first and last days means and the second student's score would be determined by taking the difference from her first and last days medians. That would result in the first student contributing 18 points (72-54) and the second student contributing 22 points (58-36). The combined score for the pair would be 40 (18+22) and that would be compared against other teams to determine which team had the highest score.

We conducted two iterations of Quantified Recess and were pleased to see that one of our original pedagogical intentions had been realized: as students strategized and worked to increase their scores, they engaged in thoughtful discussions about how different values influence

different measures of center. For example, two students engaged in a thoughtful discussion about whether and how rest breaks affected the scores each student would receive. One student in this pairing, Emma (the median), was not as athletic as her partner, Chris (mean). Emma needed breaks as she would get winded, but Chris felt they would be detrimental to their team's performance. In reviewing Emma's data that had been recorded through use of data visualization software, Chris commented:

C: Well you started and you were up and down up and down [on your plot] and that's why your number was so much lower because your numbers were up and down. But if you were more consistent-



*Figure 9.3.* Emma's minute-by-minute recess data before (left) and after (right) Chris moved her lowest points higher. The red line representing her median does not change.

To demonstrate this, Chris moved two of Emma's lowest points on her data plot to show how consistency would have improved Emma's score. In essence, he was moving the outliers so they would be closer to the center. However, when he did this, moving them did not change the



median value. He moved the low points (the breaks in Emma's recess) so that they were relatively higher, but none were changed to a value greater than the median, and thus the median did not change (see Figure 9.3). As the conversation continued, with a researcher (V) probing for more information, the following transaction took place.

C: So if this was up here they were not at zero at all, so if they were raised up...

V: And you moved all those right? Has the [red] line changed?

C: No.

E: You need to change the ones that were *around the middle*.

During this brief excerpt, Emma was animated and appeared to have made a sudden, new realization about her median score. Having those low points in her plot did not negatively affect her score since she was contributing a median value to her team. This is because the median exhibits little to no sensitivity in the presence of a single outlier. Unless data points that were closer to the median changed (the points were located "around the middle"), she did not feel there was a reason for her to be concerned about taking breaks. In fact, she even went on to describe how she felt that breaks were potentially beneficial as they may allow her to get more steps in at other times. Chris, realizing his error, saw that in looking at his score that was computed by looking at the mean, was sensitive to breaks (i.e., outlier values). This ultimately led him to be more comfortable with Emma's desire (and need) to take breaks in the competition. After the competition had ended and all the groups were sharing and discussing strategy with one another, Chris and Emma had enthusiastically shared what they had learned about breaks with the rest of the group. Given this reception from the two students and the degree to which the

collected data were discussed in terms of how they mapped onto physical activities, we as designers were pleased about what had transpired and are currently motivated to explore further how the two kinds of competition identified among athletes could be productively imported into a designed learning activity.

## **REFLECTION**

The core message of this chapter is that as designers of new learning experiences, and in particular designers of experiences that will somehow integrate computational technology and human bodies in new ways, we should be attentive to the opportunities that may reside and be untapped within other established communities and activity groups that may not bear strong superficial resemblance to the specific context we are considering. That is, by looking elsewhere in the world at what people are doing, why, and with what tools and norms, we can then identify specific design solutions for a different space. This is not a new idea, in that the field of ‘biomimicry’ has been championing it for some time (e.g., Benyus, 1997). However, in education, my sense has been that we do not yet do this enough.

This is not a deficiency in how educators approach the work of design. Serious consideration of how we do design in educational research is only a few decades old, and practice and routines are still maturing. What is clear is that design has been productive for a number of educational research goals. New models are still being developed and explored (e.g., design-based implementation research, which looks at larger educational systems as partners in design (Penuel, Fishman, Cheng, & Sabelli, 2011)). What I encourage is that we add to our repertoire routines for importing ideas from other spaces. I like to imagine that some compelling design work in

education will come not just from iteration and continual evaluation of how well a design meets a learning goal, but from the creative composition that comes about when some of the ways that people do things in one sociotechnical space are creatively brought into another. Ideally, that would mean that educational design teams would not simply have expertise in the areas of immediate concern to education, psychology, and curriculum. Instead, it would follow a model that is being popularized in design training programs that bring interdisciplinary experts together, including those who are versed at understanding human behavior and interaction in non-educational settings. Then, through dedicated brainstorm sessions, creative alignments could be established aspects of the source and target domain. When the idea is integrated into the new setting, then the work of evaluating the degree to which a particular hybridized design configuration meets learning goals and how future iterations could bring about improvement could be done. This offers the potential of helping educators to create bold new solutions that may ultimately meet the goals intrinsic to the work of educational design.

I also envision this way of doing design work as one that deliberately commits educational design teams' time, resources, and personnel to understanding how work and thinking is done in non-educational spaces and bringing that back to the rest of the team. While we could look to the reports written by sociologists and anthropologists as the source material from which we work, I maintain that there is still an extra something brought to the table from firsthand accounts and observations and a joint orientation toward bringing something over from that observation into a new educational experience.

An idea like this one would likely be welcome among educators. We already have approaches in place that encourage looking across contexts. However, the core continuities in these examples tend to be focused on following the specific learners across contexts. That is certainly one productive direction, but different from what I am advocating. Instead, I am advocating for descriptive and design-informative efforts that intentionally look further afield and may not share the same population or the community goals because I have confidence that we still have much to learn from the innovations that appear on their own in different pockets of human activity. A model for this might be to take work documenting adult hobbyists who are involved in model rocketry (Azevedo, 2011) and have those who are involved in understanding what drives and sustains participation in those activities and import some of those discoveries into creating engaging experiences in classrooms or museums. Doing so could help us identify novel design solutions and also help us to refine our understandings of learning-related phenomena, even if they are not named as such by those who are involved in them, across a wide range of settings and spaces.

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