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Knowing and Learning with Technology (and on Wheels!): An Introduction to the Special Issue

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This special issue of *Technology, Knowledge and Learning* is dedicated to bicycles and computing. Yes, you read that correctly. The theme of the issue is really and truly bicycles and computing.

How can this be? To quote the current Editor-in Chief, Bruce Sherin, *Technology, Knowledge and Learning* has been and continues to be:

> …interested in uses of technology that push the envelope of what is possible. But, more than that, our core mission is grounded in the belief that novel technologies do not just provide a means of teaching the usual subject matter in a manner that is more effective, entertaining, or efficient. Rather, new technologies hold the potential to radically reshape what is taught and learned. (Sherin 2011, p. 1)

Granted, it seems unlikely that at the time that this journal was founded,[1] the journal's editors had bicycling in mind as the prototypical domain in which that radical change would take place. When this journal began, computational technologies were just beginning to establish new opportunities for learners of all ages to engage with disciplinary content. This charge was led by reconceptualizations of how mathematics would be learned. Leading that charge were Turtle and Cabri Geometries (e.g., Hazzan and Goldenberg 1996; Papert 1996), microworlds (e.g., Hoyles and Healy 1997), and radical new uses of calculation devices (e.g., Ruthven and Chaplin 1997). However, 17 years later, here stands a contingent of regular journal followers and contributors, contributing to an entire issue about bicycles.

Is this the equivalent of a journal's teenaged-years rebellion? My goal, as guest editor of this special issue (and writer of this introduction) is to convince you that it is not. Rather, it is my view, and the view of the executive editors who kindly supported this endeavor, that we are at a point in the development of our societal technology infrastructure where we can take an activity as mundane as bicycling and examine it as a space in which knowing and

[1] As the *International Journal of Computers for Mathematical Learning*.

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learning can be profoundly affected by computation. In fact, if we take that opportunity seriously, we may find out something interesting and worthwhile related to how technology influences and reshapes knowing and learning generally.

1 Why Bicycles?

The original motivation for this special issue came out of a discovery that a number of scholars in Learning Sciences had been independently running research projects that involved innovative uses of digital technology and bikes. These bicycle-related research efforts were happening in disparate locations and not coordinated with one another. In fact, it came as a surprise that there were several of us who had come to the realization that bicycling could be a rich domain for studying technology and learning. We had each thought we were on to something uniquely clever. As our conversations with one another began, we realized that we were clearly each posing quite different questions related to bicycles and technology. However, we all had common rationales for exploring the territory covered by the umbrella of "bicycles". While I cannot fully represent the nuances of each team's perspective in the limited space of an introduction, I will try to at least note some common threads.

1.1 Bicycling is a Familiar and Ubiquitous Activity

Speaking from the perspective of countries that are highly developed and with ample economic resources, knowing how to ride a bicycle is simply taken for granted for every able-bodied individual above a certain age. Learning to ride a bicycle is understood as a childhood milestone, often accompanied by some combination of training wheels, eager and nervous parents or guardians, a ringing bell, and inevitable fall, road rash, and tears. The script of parents staying up all night to assemble or wrap a shiny new bicycle as a surprise gift is a familiar one in popular media.

This reflects a wealth of experience upon which we can all draw upon related to bicycles. If one accepts the core Constructivist assumption that prior, everyday knowledge is absolutely the basis from which our more developed expert understandings emerge (Smith et al. 1993) bicycles and bicycling represent a fund of knowledge worthy of exploration (Moll and Greenberg 1990).[2] In fact this is not a new idea. Among his many experiments and interview tasks, Piaget had actually devised a task to explore children's understanding of physical causality by asking children to draw and explain the mechanisms associated with moving a bicycle. To quote him directly:

> A bicycle is an excellent subject for questions. Every boy has observed its mechanism. All the pieces of this mechanism are visible. And above all, the combined use of drawing and speech enables the child who has been questioned to show all he has understood. (Piaget 1965, p. 197)

In classic style, Piaget identified stages of conceptual development related to understanding of bicycles. These stages go from a synthetic view of bicycle motion in which the whole of the machine is recognized and all recalled (or imagined) parts are somehow implicated in its movement, to one in which central components such as pedals and gears and wheels are

[2] It is likely more familiar and fruitful as an area of conversation for individuals of varied ages and backgrounds than, say, string theory.

recognized but not causally "chained" (Russ et al. 2008) with one another, to finally a cause-and-effect sequence that places actions and components in contact with one another. That latter stage is attained, according to Piaget, at age 8.

As many education researchers and developmental psychologists are well aware, the implied universality of development and specified age boundaries are where Piagetian theory has generated controversy. In my own research group, we have taken the same methodological approach as Piaget—using the task of drawing and explaining how a bicycle moves as a means for eliciting knowledge—to see how people talk about the mechanisms associated with bicycles. Two drawings from that work appear in Fig. 1. Both of these drawings have familiar components, such as wheels, spokes, a seat, and handle-bars. Both also have a bicycle chain connecting the chain ring (big gear) to both tires. One of these pictures was drawn by a 12 year-old boy. The other was drawn by a successful business professional in his sixties.

For typical bicycles, the chain should only connect the chain ring to the back wheel. The front wheel must remain unattached to the chain, as that would impede the ability to steer. Both of these individuals owned their own bicycles, and each had years of experience using them. Yet in drawing and talking about bicycles, they both conveyed similar ideas with respect to what pieces were connected to which other ones in order to make the bicycles move.

The point I am making with these two pictures is that the "both wheels are chained" way of thinking about how a bicycle moves is actually quite sensible. Most people know that the bicycle chain is implicated in its movement. Rotating wheels are among the most visible "moving parts" on a bicycle. Connecting the chains to both wheels is a very reasonable way of explaining how a bike works. It seems highly unlikely that, when presented with a real bicycle, either of these individuals would see the chain connected only to the rear wheel and think the bike was defective. In fact, I observed a number of adults who stated how surprised they were that it was so difficult for them to draw a bicycle.

While the chain configuration in Fig. 1 may be technically incorrect, I view it as suggestive of both an incomplete familiarity, despite years of experience, of a particular object combined with some very responsive generative capabilities we possess with respect to dynamic reasoning (e.g., Sherin et al. 2012). Exploring these generative capabilities and identifying means for eliciting ideas that we can build upon is part of our work as education researchers. Bicycles and bicycling are fine—perhaps even exceptional—candidate objects

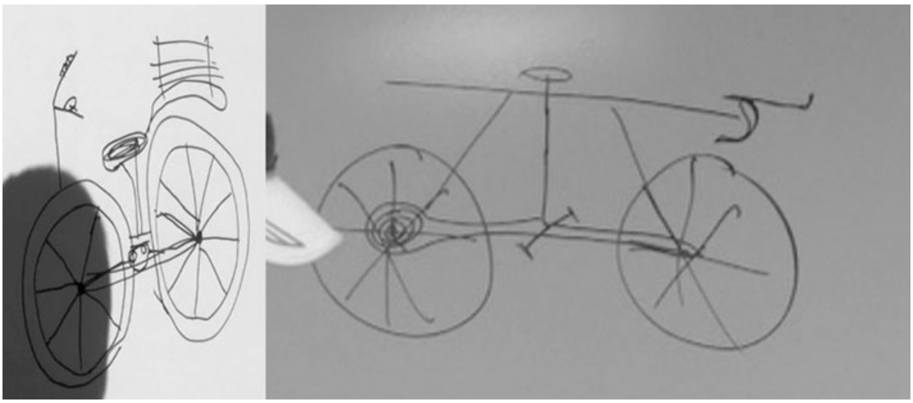

Fig. 1 Drawings of a bicycle prepared by a child and an adult

and domains for eliciting ideas. In fact, Smith et al. (1993) report on some classroom exercises they had run in which education graduate students were asked to bring their bicycle relevant knowledge to bear. In the process of discussing how bicycles worked, the students engaged with and expressed key physics ideas such as support, tension, springiness, and air pressure in rather sophisticated and abstract ways. This quality of discussion and reflection represents the ones we strive to have regularly in schools. Bicycles might just represent a very good seed to make those moments happen.

1.2 Bicycling has and Maintains Its Own Cultures

A second reason for considering bicycles is that they are meaningfully situated in multiple vibrant cultural spheres. For example, bicycles are one of the primary means by which children transport themselves, often independent of adult supervision. Thus, they can enable access to places and spaces that would not be accessible to someone else who must transport themselves exclusively on foot or in a car. If we take seriously the lived experiences of youth, we can and should consider the experiences they have and tools they use with respect to mobility (Leander et al. 2010).

Bicycles are instrumental to a small, but growing body of professional commuters. There are full time jobs, such as couriers and messengers and bike taxis, that all depend on cycling and cyclists. These activities have their own cultural history and community concerns (Fincham 2006). For example, it may be surprising to know that bicycle couriers in Boston have an injury rate three times as high as meat-packers, a career seen as especially dangerous and prone to many injuries (Dennerlein and Meeker 2002). Yet, despite these risks, working as a courier has been documented as an important space for identity construction (Kidder 2006). For these individuals, riding is not simply an act of recreation. It is a way of being.

Bicycling has also a political dimension. Riding a bicycle or advocating use of a bicycle can be a way to "speak" critically against heavy dependence on motorized transportation. For example, there are a number of people who participate in large monthly group events called "Critical Mass" in which hundreds of cyclists of all backgrounds and levels overtake major city streets as a form of protest. These monthly night rides serve to build community and also promote recognition of the needs of cyclists—in terms of more bicycle-friendly infrastructure and policies—within urban spaces that more often than not, privilege automobiles (Furness 2010).

And of course, there is the athletic dimension. Bicycling comprises its own sport and is also part of other sports. For example, beyond high profile long distance bicycle races, like the *Tour de France*, bicycling is a key part of triathlons (Hirsh and Levy 2013) and has appeared in various forms such as cyclocross (which involves physically carrying bicycles over harsh terrain and obstacles) and more recently as snowbiking (which involves using underinflated, fatter tires to write on snowy and icy outdoor trails). The visibility of certain cycling athletes establishes widely recognized cultural figures[3] and generates national and international headlines when such figures are exposed as having used illegal performance enhancing substances.

So, a second reason why cycling could generate interest among learning scientists is that it is affiliated with a number of interesting cultures and communities where phenomena

[3] For example, in a case study described in Lee and DuMont (2010), knowledge of the atypical heart rate of a famous cyclist served an important role in helping students think about what their own athletic performance would be.

related to learning and knowing take a number of interesting and variable forms while sharing bicycles as a common object.

1.3 Bicycling and Technology have had and Continue to Find Points of Intersection

Finally, there have been glimmers of creativity with respect to how bicycles and technology can be combined in novel ways. I had stated earlier that the familiarity with and access to bicycles is common in developed countries with a certain amount of economic resources. That means there are many places where bicycles are still not commonplace. Israeli inventor Izhar Gafni has done something recently that could greatly broaden access to bikes. Recently, Gafni made headlines with his design and patent for a bicycle made out of recyclable cardboard (Bashan and Gafni 2012). In a spirit similar to that which drove the *One Laptop Per Child* movement, the possibility of providing any person in an under-resourced country with transportation is now looking like a real possibility for the future. The current cost estimate, once production processes are optimized, is US $20 per bike. With such an inexpensive bike, people located in small and fairly remote villages could realistically make regular trips to larger cities for food, medicines, school, and work. Given the low cost, theft and damage should be much less pronounced concerns.

Beyond engineering new designs and materials that could democratize access to the bicycle, there are still several other ways technology and bicycles could be practically integrated. For example, Leah Buechley has made public a LilyPad Arduino project she had developed that served as a wearable turn signal for a cyclist (Fig. 2). While there are existing hand signals and specified rules for how cars and bikes should interact on the road, it is a known problem among cyclists that automobile drivers are not always aware nor considerate of the needs and intentions of cyclists (an instance of this will be illustrated in Taylor and Hall 2013). The act of safely turning can be especially problematic. Noted user-centered design advocate Donald Norman (1992) once said that turn signals are the facial

Fig. 2 "Turn signal biking jacket,"© Leah Buechley, used under Creative Commons Attribution license, http://creativecommons.org/licenses/by/2.0/ and with Dr. Buechley's permission

expressions of automobiles. We may not be that far off from putting digital expressions on bikes as well.

Additionally, specialized web services related to cycling have emerged as well. For example, *Strava* is a company that takes advantage of the increased availability of GPS data and the omni-presence of mobile devices to help users upload and share their ride data. This service allows friends and strangers to compare their speeds and distances and even compete. Routes can be recommended and shared, and one lucky individual can lay claim to becoming "king of the mountain" by setting and maintaining the fastest time on a given route. Other services, such as *MapMyRide*, also offer similar features and capabilities. Technology and cycling are intersecting in a way that converts the ephemeral experience of a bicycle ride into a quantifiable and comparable experience. This has particular resonance for some of the new technology-supported practices that are already being adopted by athletic individuals (Lee and Drake 2013).

In my research group, we have been talking about using bicycles as a means of helping students to explore and experience power. By this, we mean that the act of pedaling and moving gears generates power. A properly equipped bicycle could give feedback to students, in a school or in a museum, with respect to how much power they are generating. We were pleased to discover that others have been thinking along these lines as well. For example, a master's student at Stanford University, Stephanie Chang, had actually created such a bike.[4] According to Ms. Chang's website, this energy bike will be making appearances in museums and science centers in the very near future.

So, taken together, conceptualizing technology and bicycles as being related and creating new opportunities for us to move, communicate, and learn both makes sense and is happening already.

2 The Contents of this Special Issue

As stated earlier, this special issue is about bicycles and technology. We bring together reports from different studies that are all linked to the overarching theme. Our individual motivations and inspirations for our respective projects deviated slightly from what I had listed above, and we each frame our work differently. Yet collectively, we shared an interest in the possibilities that exist with bicycles and riding with technology.

This special issue contains three empirical articles. The first, contributed by Hirsh and Levy (2013), involves the development and use of an agent-based model to help young triathletes in Israel to explore aerodynamics and drafting techniques. Hirsh and Levy designed a full learning intervention, "Biking with Particles" and created new metrics from which they could assess efficiency and physical performance at different times during and after the intervention. In their article, they discuss ways in which individuals can differently relate to phenomena that have microscopic, macroscopic, and experiential dimensions. They also raise questions about how motor learning might be understood in the future given the unexpected results that they found.

The second article, contributed by Lee and Drake (2013), involves interviews with adult athletes who participate in distance sports such as running and cycling. In that paper, they describe how individuals came to become active in their respective sports and how technology—in the form of bike computers, heart rate monitors, and GPS devices—came to become part of their athletic practice and routines. One other issue they explore is how the

[4] See http://shc3.wordpress.com/2012/07/12/biketoscale/.

introduction of technology into their sports created tensions with respect to how they conceptualize their athletic activities and the identities that are crafted about themselves as athletic individuals.

Taylor and Hall (2013) contributed the third article. They report on a social design experiment that involved urban youth who had limited options for mobility building and exploring their city with bicycles. The technologies the research team introduced included mapping services, GPS tracking sticks, and GoPro cameras worn by bicycle riders. In that article, Taylor and Hall take seriously the spatial reasoning opportunities afforded by mobility and through examination of spatial artifacts such as maps. Included are some detailed descriptions of how students engaged with and talked about space through various representational and recording technologies. This ultimately culminated in new opportunities for youth to participate in larger community practices that also had implications for the design and planning of transportation routes in their city.

Finally, TKL Executive editor Michael Eisenberg was kind enough to also prepare a thematically related "computational diversion" (Eisenberg 2013). In this issue, he takes inspiration from a poem by Gelett Burgess and considers what would it be like to ride a bicycle with elliptical wheels. On paper, this bicycle would look fine. On the road, the ride is something else entirely. I am very appreciative to Mike for playing with our special issue theme in a way that is creative and interesting. His efforts make it possible for me to confidently state that every article in this issue has the word "bike" in it. As guest editor, I hope that the combination of these papers are interesting, surprising, substantive, and may encourage others to conceptualize and propose bold and unconventional special issues for this journal.

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