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Use of Emerging Technology as Part of the Experiential Learning Process in Ultradistance Cycling: A Phenomenological Study

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USE OF EMERGING TECHNOLOGY AS PART OF THE EXPERIENTIAL LEARNING PROCESS IN ULTRADISTANCE CYCLING: A PHENOMENOLOGICAL STUDY

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ABSTRACT

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Technology is well entrenched as part of our everyday lives and formal learning settings. The role technology plays as part of informal learning of sports and physical activities has not been explored as thoroughly. This study examined the use of technology by ultradistance cyclists as part of their experiential learning process. Data collection was through semi-structured interviews of 10 cyclists who routinely utilized technology in preparing for and participating in ultradistance events. Emerging themes were organized utilizing NVIVO software. While identified themes were similar to the phases of the Kolb (2014) experiential learning model, there was also a strong temporal component. Technology usage themes prior to an event included Abstract Conceptualization, Route Planning, and Training. Technology usage themes during an event included Active Experimentation, Concrete Experience, and Coping with Equipment, Mental, or Physical Challenges. A technology usage theme after an event included Reflective Observations. Participants also expressed preferences in technology characteristics; themes included Record and Display information, Easy to Use, Syncing Between Devices, and Reliability. Kolb and Kolb (2005) identified a number of features that enhanced informal experiential learning spaces in higher education. Technology

could replicate these features to enhance the experiential learning process in ultradistance cycling.

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CHAPTER I

INTRODUCTION

> It was a dark and stormy night; the rain fell in torrents – except at occasional intervals, when it was checked by a violent gust of wind which swept across the country roads (for it is in Brittany that our scene lies), rattling along the hedges, and fiercely agitating the scanty illumination of our head lamps that struggled against the darkness. (Adapted from opening lines of *Paul Clifford*; Lytton, 1830, p. 1)

In 2007, my wife and I attempted the Paris-Brest-Paris (PBP) Randonnée (long-distance bike ride). The PBP is a ride of 1,200 kilometers--starting on the outskirts of Paris and traveling to the Brittany shore and back. At 3 a.m. the first night, we were 200km into the ride and experienced the worst weather recorded in the past 50 years of the event. A café and a warm cup of coffee would have been a perfect respite. In preparation for the ride, we had printed out maps and turn-by-turn directions. Each set of maps was organized into roughly 50-mile segments between controls (checkpoints); they had been resized to fit in a jersey pocket and were glued to cardstock and hand laminated. Using our headlamps and hand-made maps, we could find the next turn and knew the distance to the next control point, but there was no mention of cafés, coffee, or shelter. We could only ride and hope for the best. Now, 10 years later, not only can we have a well-lit, detailed map showing the location of nearby cafés and restaurants on our smartphones but we can also order our coffee enroute so it is ready for pick up. In addition, during the course of the ride, we became separated in the dark and rain. It took us almost an hour to get back together among the thousands of other cyclists on the road and in the rest area. I will never forget that experience!

Participation in PBP required the completion of a series of qualifying distance rides of 200km, 300km, 400km, and 600km. While some of the rides ventured into new territory, navigation was fairly simple. It was also easy to manage our efforts since we knew where and how long climbs would be; this was not the case in France. The profile and maps provided were general with limited information. We knew the elevation of each control but the maps did not show if the road between was flat or if there was several thousand feet of climbing. After our qualifying rides, we could compare our total time with other riders but there were no specifics on how they rode. Some riders would ride fast and take longer rest breaks. Others had slower, steady efforts with very short breaks. The lack of information made it a challenge to determine if we were "on pace." Emerging technology would have addressed many of the challenges we faced and perhaps would have helped get us to the finish line rather than abandoning the PBP after 30 hours and 450km. If we were to repeat the ride now, our experience would be very different.

Ten years later, phones with international plans are cheaper and easier to obtain. Map applications that can give turn-by-turn directions to the nearest café (and in some cases, allow you to place your order in advance) are readily available. We can send a quick "Where are you" text to find each other. This would have saved us both a tremendous amount of physical and mental energy spent searching for each other and aided us with finding the resources we needed along the route. Other smartphone applications (apps) can provide language translation in the palm of your hand. Increased and higher bandwidth coverage makes these apps accessible even on remote French farm roads. Handlebar mounted cycling computers and accessories powered by hub generators can measure heart rate, pedaling cadence, power output, and provide turn-by-turn directions. Algorithms in fitness programs measure performance and recommend recovery between workouts. Websites can show how your efforts compare to your friends and rivals as well as validate record setting attempts. One simply has to look around to see how emerging technology is changing the way we live and learn.

Experiential learning is learning by doing. My wife and I learned a great deal about ultradistance cycling even though we did not complete the PBP. Technology can play a role in the learning process. Simply being able to communicate with each other would have dramatically changed our experience that rainy night on the roads of France. I can only speculate on how that would have changed our performance.

This dissertation explored the use of technology as part of the experiential learning process in ultradistance cycling. By narrowing my focus on this particular style of riding, participants might encounter many of the same challenges and find a common reference in their lived experiences. This dissertation allowed me to examine how individuals cope with these challenges through the use of emerging technology.

Background of the Problem

Lon Haldenman (cited in Burke & Pavelka, 2000), one of the greats in ultradistance cycling, noted, “Long-distance cycling is the most important part of our sport” (p. ix). Throughout the book by Burke and Pavelka (2000), no mention of smartphones, apps, or using a global positioning system (GPS) was found. Now, 17 years later, mobile tracking devices are required at some events (Ultra Marathon Cycling

Association) and a wide variety of apps support and promote athletic endeavors (Middelweerd, Mollee, van der Wal, Brug, & te Velde, S. J., 2014). Heart rate monitors and power meters have dropped in price and increased in mounting and reporting options, allowing use by a greater number of athletes in a wider variety of events.

The development of emerging technology and its adoption by ultradistance cyclists have raised a number of questions related to the experiential learning process. How are ultradistance cyclists using this new technology? Are they using it to plan workouts and rides in order to improve performance? Does the technology make it easier for newcomers to ultradistance cycling? Is emerging technology changing the way athletes train and compete? Does it change how they ride outside of events? Does this use of technology transfer to other aspects of their lives or other athletic endeavors? Does the technology they use in cycling aid in other learning opportunities like traveling to new countries? Answers to these questions within the context of ultradistance cycling could lead to a better understanding of the experiential learning process within the sport as well as exploring the characteristics of emerging technologies important to ultradistance cyclists.

Emerging Technologies

Emerging technologies is a broad term. The focus of this study was limited to smartphones, heart rate monitors, power meters, and wearable training devices as well as programs and applications that interface with these devices. Two of these, wearable technology and smartphone exercise applications, made their first appearance in the 2016 edition of the American College of Sports Medicine (ACSM) Worldwide Survey of Fitness Trends (Thompson, 2015), indicating their emergence as an important trend in fitness. In addition, continued improvement in other technologies facilitates new and emerging uses.

A wide variety of features available in emerging technology (Middelweerd et al., 2014) also gives athletes ready access to a great deal of information about performance. The following sections outline some examples of emerging technologies and the information they presently provide.

Smartphones. In this study, a smartphone is one that supports 3G or 4G data connection to World Wide Web (www) resources, distinguishing it from a "feature phone" that only has text and voice connectivity (Hanson, 2011). A smartphone also supports the installation of apps, which are specialized programs. Additionally, apps utilize enhanced features of the smartphone like data connectivity and GPS functionality to provide a wide variety of information to the user. These applications allow the user to find nearby restaurants (including reviews), navigate an unfamiliar city, receive notices when friends are nearby, and post pictures and reviews of places they visit as well as many other features.

The use of mobile devices has grown dramatically in recent years (Kim, 2013). In 2015, 64% of American adults owned a smartphone--an increase of 29% from 2011 (Pew Research Center, 2015). In addition to increased cell phone *ownership*, there has been an evolution in *connectivity*. The amount of data easily transmitted even in remote locations is increasing (International Telecommunication Union, 2015). This increasing connectivity leads to greater availability and a wider variety of apps with increasing ranges of use.

Training applications. Training applications are apps that have been developed specifically for use in sport activities. A wide variety of training and fitness apps (Middelweerd et al., 2014) are available. In addition to time, speed, and distance a basic handle-bar mounted cycling computer displays, smartphone apps have many more features. A central component that allows many advanced features on smartphones to function is the inclusion of a GPS receiver, enabling users to record the exact route ridden. With the known location, phone applications can pull information on local weather and topography. As a result, ride information can include temperature, wind speed, and elevation gain. When GPS location technology is coupled with increased data access, there is the possibility for real-time tracking in addition to post-ride performance comparisons. This real-time tracking allows not only comparison with a user's own ride but also with other app users who have also ridden that same route. Smartphone exercise apps were noted as an emerging fitness trend in the ACSM Worldwide Survey for 2016 (Thompson, 2015).

Wearable technology. Wearable technology (wearable tech) is defined as "an app-enabled computing device, which accepts input and processes that input, and is worn on, or is otherwise attached to, the body while being used" (Moar, 2017, p. 1). The wearable aspect is a distinction from a carried smartphone or a bike-mounted cycling computer. Many wearable tech items connect with smartphones or other devices via Bluetooth (Piwek, Ellis, Andrews, & Joinson, 2016). Wearable tech includes heart rate monitors, Garmin and Polar fitness devices, and Fitbits and MyZone bands to name just a few. These devices can record and report not only heart rate as a measure of effort but also include metrics such as cadence, stride length, vertical oscillation, and ground contact time. Wearable tech is often used in conjunction with training apps to track performance over time and was also identified as the number one fitness trend for 2016 (Thompson, 2015).

Ultradistance cycling. There are two main governing bodies for ultradistance cycling in the United States: Randonneurs USA (RUSA; 2014) and the Ultra Marathon Cycling Association (UMCA; 2014). The primary difference is competitiveness. The UMCA events are races over time or distance where there is a winner or record holder. While RUSA events are also timed, the objective is to finish. All finishers receive the same recognition as long as they make it in the allotted time. Results are often listed alphabetically rather than in order of finish. However, the utilization of smartphone apps to aid in navigation brings with it the ability to upload and compare performances on a designated course. The ability to upload performances has been embraced by the UMCA (2016) as a means of validating records and competitions. Randonneurs USA currently still relies on checkpoints and checkpoint signatures to validate course completion.

Paris-Brest-Paris was first held in 1891 and predates the Tour de France (RUSA, 2014). It was the first and is considered the most prestigious Grand Randonnée. Since this preeminent event is only held every four years, it can serve as a benchmark when discussing the use of smartphones in ultradistance cycling. The four years between offerings span a significant time frame in the world of technology, allowing a great deal of change to take place. This time span between offerings makes it possible to ask athletes how their preparation, experience, and learning changed from one offering to the next due to technological advances and utilization.

For example, a technology change in bike headlights can alter the ultradistance cycling experience and impact performance. Light-emitting diode (LED) lights became much more widely available between the 2003 and 2007 PBP events (Knisley, 2007). The switch to LED bulbs in lights for cycling allowed not only a wider variety of mounts but also better visibility. Lights with LED bulbs were lighter with longer battery life (Knisley, 2007). The reduced weight made it more convenient to wear and use a helmet-mounted light, allowing riders to read maps and view roadside navigation signs without the need for handheld flashlights or redirecting their bike-mounted lights. Having a head-mounted light source expands the focus of the rider beyond the narrow patch of pavement of road lit by a traditional bike-mounted incandescent light, making it possible to look around and see surroundings and fellow cyclists. Now, LED lights are the norm and many of them are run by hub generators, reducing the need for batteries (William, 2015). Hub generators are also being adapted to charge devices enroute. The use of hub generators removes the battery life limitation on emerging technologies like smartphones and mobile apps, allowing information and measurements they track to be available throughout a multi-day ride. Availability of this information allows riders to reflect on how their performance changed during a ride. Reflecting on their performance, riders can conceptualize different strategies, which can then be tested with the athlete gaining experience with the results of a new strategy. This process of reflecting, conceptualizing, testing, and experiences can be undergone multiple times through the course of an ultradistance ride. A question this paper examined was how emerging technologies help facilitate this process through the information and feedback they provide.

Experiential Learning

At the most basic level, experiential learning can be thought of as "learning by doing" (Tanis, 2012, p. 24). Kolb and Kolb (2010) noted that in experiential learning theory, "The concept of deep learning describes learning that fully integrates the four modes of the experiential learning cycle--experiencing, reflecting, thinking, and acting" (p. 27). The perceived effectiveness of experiential learning can depend on the learner's pre-existing mastery of the subject (Ellis & Kruglanski, 1992). Ellis and Kruglanski (1992) found learners were more confident in their ability to self-instruct when they had more experience in the subject area. Distances and challenges of ultradistance cycling can be prohibitive to entry level cyclists as it is difficult to anticipate what problems (food, mechanical, navigation) a rider will encounter late in a 10-hour ride without first having ridden that 10-hour ride. This concern of the unknown can make it difficult to a cyclist new to ultradistance. Emerging technology might provide a bridge to this knowledge gap, reducing barriers to entry.

A brief explanation of contrasting definitions of experiential learning is necessary to clarify the approach of the research. One view of experiential learning is it "is achieved through reflection upon everyday experiences and is the way most of us do our learning" (Kolb, 2014, p. 1). This view contrasts with an alternative form of experiential learning that is "sponsored by an institution and might be use on training programmes for professionals" (Kolb, 2014, p. 1). The former was used to define experiential learning within this study. While ultradistance cycling is not an "everyday experience" for everyone, it was a common practice for participants in this study. For those participant athletes, this activity was undertaken on their own initiatives and was not an institutional training program. This self-guided, reflective version of experiential learning was the focus of this study—it examined how athletes used emerging technologies during their training (the experience) while reviewing rides (reflecting), planning for future events (thinking), and modifying their riding (acting) to improve their ultradistance cycling performance.

Using Technology in Ultradistance Cycling as a Lived Experience

Experiential learning is learning by doing. Every ultradistance cyclist is unique. Each has different skills, abilities, strengths, and weaknesses. The role technology played in the lived experience explored in this study was different for each person.

Statement of the Problem

In third grade, I had a class that taught us to use an electronic calculator. In the years that followed, my school library bought two computers for student use. By the time I graduated high school, we had a computer lab and there were several courses in programing. Computers were becoming affordable enough to make their way into homes. Smartphones are now more powerful and faster than the best computers of my high school days and can fit in my pocket. Programing has evolved beyond basic courses that were offered to allow fast and easy development of innovative apps for use in everyday life. Some uses of emerging technology in everyday life include ordering and checking out at stores and restaurants (Kimes & Collier, 2014).

Digital technology is a regular part of everyday life including teaching and learning. The prevalence of technology and its use in learning was seen in Bennett, Maton, and Kervin’s (2008) discussion of digital natives. Although only 17% of adults in the United States consider themselves digitally ready to incorporate technology into learning, nearly all have been exposed to the tools or concepts (Horrigan, 2016). Learning is not restricted to schools and classrooms; it occurs in everyday life (Kolb, 2014). Being part of everyday experiences is the essence of experiential learning and it includes not just academic subjects but also mastery of physical skills.

I started off using training wheels when I first began learning how to ride a bike. Those training wheels were essentially a technology assisting me in learning to ride. With those in place, I was able to pedal on my own without the need of supporting hands. Training wheels allow new cyclists to ride and learn at their own pace by experimenting with different speeds and balance until the extra support is no longer needed.

Could emerging technologies fill a similar role in overcoming more complex physical challenges? Technologies provide support and guidance to athletes attempting new endeavors. Support and guidance could range from providing navigation in unfamiliar territory to planning and tracking activities to monitoring effort to gauge progress to sharing accomplishments with friends and rivals. In a more formal sport setting, some of these functions are fulfilled by a coach or training partner. Emerging technologies provide feedback to the individual, allowing him/her to pursue a unique experiential learning opportunity without the need for an instructor, mentor, or coach.

The impact of emerging technology has been seen in cycling sports at the professional level. A classic example is Greg LeMond winning the Tour de France in 1989 on the last day of the race by a mere eight seconds. Emerging technology, in the form of aero-bars, certainly contributed to his victory (McGann & McGann, 2008). Use of aero-bars as well as specialized aerodynamic bikes and helmets is now common in time trials in professional races. More recently, live GPS tracking was incorporated for all riders in the Tour de France (Delaney, 2015), greatly increasing the amount of information available. No longer was the knowledge of riders limited to those in the main groups who could be identified from television coverage--the location of every rider was known throughout the race. It was immediately apparent if an opponent was struggling or dropped from a group. Surprise and misdirection were reduced. It was no longer possible for a potential contender to slip away from his rivals with a group of unknowns. Global positioning system tracking also gave real-time splits. Chasing riders knew exactly how far ahead the leaders were. They knew immediately if they were gaining or losing ground. Power meters and heart rate monitors measured how hard an athlete was working. A coach could encourage a rider to work harder through ear-piece radios, another emerging technology, or back off and rest based on data gathered during training. At the professional level, there was concern technology was having a detrimental effect on the sport (Cossins, 2018).

Increased availability and affordability of emerging technologies have allowed for use in non-professional aspects of cycling. Without a coach or mentor, athletes plan their own training and efforts in order to reach goals they set for themselves. Historically, ultradistance cycling had been an amateur sport involving riding in unfamiliar areas for many hours. Sometimes, the ride lasted several days necessitating food and possibly sleeping along the route. Budgeting time, effort, energy, food, and water became increasingly important as the length of the ride increased. More proficient use of these resources could lead to better performance. Emerging technologies could aid in ride preparation, goal setting, resource management, and performance monitoring (Hutchinson, 2018).

Navigating unfamiliar roads is also a challenge. When I was active in the sport, directions were given on printed sheets with turn-by-turn cues and sometimes a rudimentary map. Now, phone apps can give you turn-by-turn directions. There is no need to be able to read a map.

Heart rate monitors and power meters can give a measurement of effort unbiased by perceptions clouded by exhaustion. These metrics also provide more detailed feedback of effort after the completion of a ride--a ride that felt hard could be given a quantifiable value like average heart rate. Richer post-ride data allow for greater reflection of the event and might lead to additional planning for improving performance. These uses of emerging technologies have the potential to feed into all aspects of the experiential learning process: concrete experience, reflective observation, abstract conceptualization, and active experimentation.

Lee and Drake (2013) discussed the introduction of an “informational layer between the individual’s perception of the activity and their execution of physical movements necessary for the activity” (p. 60). They noted easy availability and immediate feedback of data could create stress and challenges to the participants as well as providing benefits. The finding that feedback created stress in the athletes implied the use of mobile apps on smart phones as well as other emerging technologies could impact not only the sport but the perception of the sport by participants. In addition to the memory of the experience, riders could attach numbers to the experience. Attaching numbers imparts a quantitative aspect to what had previously been a qualitative experience, potentially allowing the measurement of performance improvement as part of the experiential learning process.

Experiential learning is a continuous cycle with each mode feeding the next. As Kolb and Kolb (2010) put it,

> The learning model portrays two dialectically related modes of grasping experience--concrete experience (CE) and abstract conceptualization--and two dialectically related modes of transforming experience--reflective observation and active experimentation. (p. 27)

Physical movement and the perception of this movement is an inherent part of the ultradistance cycling experience. Adoption of emerging technologies creates additional informational layers. If informational layers contribute unevenly to the modes, the balance of the dialectic changes (Korb & Korb, 2010). The change in balance might result in a change in the experiential learning process. It is important to examine the informational layer created by emerging technologies both within the context of more physical modes (concrete experience and active experimentation) as well as more mental modes of abstract conceptualization and reflective observation in order to explore how the model was changed.

Significance of the Study

Bikes are machines; the materials and components that make up these machines are subject to technological advances (Zinn, 2018). Lighter and stronger materials lead to lighter bikes that better translate leg strength into speed. Changes in components and designs lead to an increasing variety of gearing and shifters. An increased number of gears allows for the accommodation of differing cadences and riding styles. Materials and mechanics are changing the bike but there still needs to be a rider to push the pedals. Emerging technologies are providing cyclists with additional tools to monitor and improve their performance. The July 2013 issue of *Technology, Knowledge and Learning* was dedicated entirely to cycling and computing (Lee, 2013). Guides discussed the various aspects of technology to consider when purchasing a bicycle (Shrieves, 2016) as well as information on various fitness-related apps (Middelweerd et al., 2014). While these articles described the "what" of technologies, they did not offer much related to "how" they could be best used. The role of emerging technology in the experiential learning process is not well explored.

Few formal training opportunities are available for amateur ultradistance cyclists. While professional athletes have access to coaches and training programs they have developed, amateur and recreational cyclists do not. They learn by doing. Increased availability of emerging technology allows an increasing number of amateurs to incorporate items like power meters, heart rate monitors, and fitness application into their training. Technologies can provide an external, objective measurement of effort and performance. While not a substitute for a coach, they provide the athlete with feedback. As part of the experiential learning process this feedback allows for *testing* the effectiveness of new training activities.

Many different emerging technologies are available to ultradistance cyclists. Athletes are free to adopt whichever technology works best for them. Often, as in the case of fitness apps (Riegersperger 2017a, 2017b), athletes utilize a combination of technologies to meet their needs. Differing adoption strategies provide an excellent opportunity to examine the role a variety of emerging technologies play in improving athlete participation and performance as well as examining the characteristics of these technologies. Characteristics that facilitate the various modes of experiential learning (experiencing, reflecting, conceptualizing, and testing) could be identified. It might then be possible to extrapolate the importance of these characteristics to emerging technology use in other sports and experiential learning opportunities.

Although a large amount of literature was related to mobile devices and learning, there was less research on the use of these devices as part of the experiential learning process in sports. There has been ongoing debate regarding the role media and technology play in learning (Amirault, 2015; Clark, 1994; Hastings & Tracey, 2005; Kozma, 1994; Westera, 2015). The lack of consensus did not eliminate the need for consideration. Indeed, this indicated an area ripe for study.

Purpose of This Research

The purpose of this study was to explore the use of emerging technologies by ultradistance cyclists as part of their experiential learning stemming from participation. An examination of the use of emerging technologies led to the identification of their characteristics and the role these characteristics played in the ultradistance cycling experiential learning process. The Clark/Kozma debate (Clark, 1994; Kozma, 1994) highlighted the importance of focusing on the characteristics of a technology as a means of identifying their role in learning.

My Personal Background

I participated in my first ultradistance cycling event in 1997. In the 20 or so years since then, I have participated in several dozen ultradistance events. I have found myself gravitating toward the Randonneur style of events. While they are long and hard, there is no pressure to finish as fast as possible since it is not a race. Completing the course in the allotted time is enough of a goal for me.

Two coaching experiences have stuck in my mind related to ultradistance cycling. One was prior to my first 12-hour race--the goal was to ride as many miles as possible within the allotted time. The coach of our collegiate team was very experienced in events like this and much longer so I asked him for advice. He said two things: “Have everything that you’ll need for 100 miles with you when you start” and “Keep with the lead group as long as possible.” I took this to heart and ended up riding 206 miles. The winners did over 250. I felt it was good for my first attempt but I did not enjoy the competitiveness.

My second experience was in 2009 as part of the support crew for a friend who was doing a 1,000 mile race. After three days and 775 miles, she was in a bad spot and we called her coach for advice. The coach was very insistent she could still finish in the 10 hours remaining. After an encouraging talk and giving suggestions on how the crew could keep her going, the coach then asked, “Where are you? How much further does she have?” At that moment, I realized the coach was operating on instinct and giving generic advice without the needed information. Even when fresh, our rider had not averaged over 16 miles per hour. Now exhausted and suffering from extensive saddle sores, she would have to average over 20 to have any chance of finishing. Needless to say, we did not make the time cut. However, it was a testament to her determination that she finished the entire course even though it was 12 hours too late to be official.

These two experiences shaped my opinion of the role and challenges of coaching in ultradistance cycling. In the first case, my coach knew he would not be with me to give updated feedback; therefore, his advice was simple and addressed the biggest challenges. In the second case, our rider would have greatly benefited from earlier feedback. By the time the coach became involved, it was too late. The advice was good but not timely. In both cases, the challenge of coaching was accentuated by the time and distances involved in the sport. Technological changes were dramatic during those 12 years but the coaching approach was the same--give advice and have the athlete follow it until he/she finished. Feedback was delayed, sometimes to the point of becoming irrelevant. Unless the coach was riding along with the athlete, he/she was on his/her own. However, the proliferation of smartphones with sports applications and other wearable technology could provide athletes with immediate feedback throughout training rides and events. I found myself wondering how technology has changed the ultradistance cycling experience of athletes.

I was able to experience this change first hand in 2017 as my wife and I participated in a two-week 1,000 mile ride across Great Britain. While it was a fully supported, non-competitive event, it provided additional insight into technology usage during long distance cycling. Most, if not all, of the group we rode with had navigation devices. For the first several days, my wife and I rode without such a device, relying instead on printed maps and cue sheets to find our way. Once we were able to borrow a Garmin, our ride experience changed dramatically. We no longer had to be constantly focused on the map, slowing down and scrutinizing each road sign we approached. Instead, we could just ride and look at the scenery. It made the experience far more enjoyable. In addition, many of our fellow riders were active on Strava (a social fitness network) and would post pictures and comments on the day's ride each evening. In addition to seeing their efforts each day based on the speed and data on Strava, we could also share in what they saw that we might have missed. This experience provided additional insight and enhanced my curiosity on the use of technology in various long-distance cycling events. Now, as I consider returning to the sport, I wonder how my training and participation would change with the uses of various technology not available 10 or even five years ago.

Theoretical Framework

Kolb (2014) built a model of experiential learning and described a learning styles inventory consisting of four stages: experience, reflection, conventionalization, and test. These experiential learning stages are often seen in the practices of cyclists although not usually explicitly stated or categorized as such. For example, the practice of drafting, riding in another cyclist's slipstream, is a concept well suited to learning through experience (Hirsh & Levy, 2013). While the basics can be diagramed and explained, the process of doing leads to deeper understanding and the ability to apply appropriately in practice. New riders learn to find the "sweet spot" out of the wind when riding in a group. A following rider adjusts his/her position behind the leader (testing) and pedaling becomes easier if one is in the correct position or harder if poorly positioned (experience). Upon approaching a turn with a shift in wind direction, the rider can learn to anticipate a shift in positioning (conventionalizing) that will maintain his/her draft. Looking back on a ride with effective drafting, a cyclist will note a higher average speed than if riding alone into the wind (reflection).

An important aspect of experiential learning is being able to reflect upon an experience in order to plan for future experiences and conceptualize the process (Kolb, 2014). Emerging technologies measure effort and performance during exercise as well as recording this information for reflection after the event (Lee & Drake, 2012;

Middelweerd et al., 2014). This research examined how athletes utilized technology that tracked and measured performance before, during, and after ultradistance cycling events.

Research Questions

As I pursued my degree in Educational Technology, I became more aware of how technology has been used not only in a formal educational setting but also in informal learning situations including training for and participating in various sporting events. Ultradistance cycling requires a substantial time commitment. By necessity, my participation in long-distance events took a back seat while in graduate school. During this time, technology used in the sport continued to advance and change. Now that I can participate once again, I found myself wanting to understand and take advantage of these changes. While I will never be a world-class athlete, I want to improve my cycling experience by riding faster and longer, exploring new places, or simply enjoying the ride more. I believe many others share this desire and that technology plays a role in the cycling experience.

The intent of this study was to examine the use of emerging technology as part of the experiential learning process in training for and participating in ultradistance cycling events. Beyond the learning process, the use of technology has become part of the lived experience of ultradistance cyclists. In examining the role technology has played as part of cyclists' experiences, the following research questions guided this study:

Q1 How are ultradistance cyclists using emerging technology as part of their experiential learning process?

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?

Research Design

Crotty (1998) noted the importance of scaffolding--the selection of four elements of social research that inform research design: epistemology, theoretical perspective, methodology, and methods. This section gives an overview of the choice of the theoretical foundations that informed the intent and direction of this research. The guiding view was that ultradistance cyclists undergo experiential learning to build knowledge of the sport. This experiential learning was unique to each athlete as viewed through a constructivist lens. Emerging tools and applications utilized by the athletes created new technological layers within their experience.

Epistemology

"Constructivism refers both to a learning theory (how people learn) and to an epistemology of learning (what is the nature of knowledge)" (Harasim, 2012, p. 60). A common saying in the ultradistance environment is every athlete is an experiment of one, i.e., what works for one individual might not work for another. To capture and value the experiences of every participant in this study, a constructivist approach was adopted. The focus was on what the participants learned and experienced rather than on the cognitive process (Ormrod, 2012). By adopting a constructivist approach, the views and opinions of each individual were valued. This led not only to a deeper understanding of how an individual partook in experiential learning but also facilitated a broader examination of the process through the inclusion of a variety of experiences in ultradistance cycling.

In addition, "constructionist theory posits that people construct their own understanding and knowledge of the world through experiencing the world, and reflecting on the world" (Harasim, 2012, p. 60). Experiencing and reflecting are two critical elements of the experiential learning process (Kolb & Kolb, 2010). The sport of ultradistance cycling is a very tactile learning experience. As such, it would be very difficult to replicate the experience of being in the saddle for a 10-hour ride in a classroom or workshop setting. Participants developed and constructed their understanding and knowledge of the ultradistance cycling world through their day-long rides. Reflection in the form of "why am I doing this" was not uncommon late in the ride, particularly in bad weather. It was the goal of this research to examine how and why ultradistance cyclists' usage of emerging technology shaped their learning experiences.

Theoretical Perspective

The impact of new computer systems on user experiences has been examined in workplace settings (Scheepers, Scheepers, & Ngwenyam, 2006): "These devices are extending not only the boundaries of the 'office' in space and time, but also the social context within which use occurs" (p. 261). Applying this concept to a sports setting entailed the consideration beyond a gym or training setting and to encompass how emerging technology was utilized in ultradistance cycling experiential learning.

Lee and Drake (2012) utilized the term "technoathlete" to describe "individuals who combine athletic training and performance with the collection and evaluation of personally-relevant data in an effort to better understand their own abilities" (Abstract). In additional research, Lee and Drake (2013) examined the impact an *informational layer* created by technology use has on athletes. They described technoathleticism as "a strand of athletic activity that we see as melding physical training and exercise routines with the practices associated with collection and examination of information taken from data gathering technologies" (p. 24). Within this concept, Lee and Drake (2013) found two broad areas of consideration: Physical Activity Data Logging: Collecting and Inscribing and Relationships with Data: Tensions and Realizations. Taking in conjunction with experiential learning modes described by Kolb and Kolb (2010), these concepts could serve as starting points when exploring the use of emerging technology by ultradistance cyclists. For example, while the main topic of Wood's (2015) article was the development of a data visualization process, the end result was a method of data inscription that provided a means to conceptualize the experience. The increasing numbers and wider diversity of emerging technologies have the potential to create additional technological layers that might influence the experiential learning process.

Nikolaeff (2016) examined the use of technology during a three-week backpacking excursion. In the narrative of the experience, he described utilizing iPhone apps to retrieve maps and access information. This technological layer was integral to the author's experiential learning process. Without the iPhone and related technology, the backpack trip would have been a different learning experience. The current research was an attempt to examine the role of technology in a different setting (ultradistance cycling) across multiple user experiences.

Methodology

To examine the use of emerging technologies in ultradistance cycling, a phenomenological approach was used. "The basic purpose of phenomenology is to reduce individual experiences with a phenomenon to a description of the universal essence" (Creswell, 2013 p. 76). By exploring experiences of ultradistance cyclists, it was possible to develop a description of the role of emerging technology in the experiential learning process and explore the lived experiences of the participants. A phenomenological approach allowed for deep understanding of the athletes' experiences. Among the phenomenological methods aimed at gaining this deeper understanding were surveys and interviews. A survey gave insight into a broad range of emerging technologies like fitness apps (Riegersperger, 2017a) being used by athletes. Interviews narrow the range of participants but allow for more in-depth exploration of individual user experiences. Since the goal of the research was to gain a deep understanding of the experiential learning process in ultradistance cycling, interviews were the primary method of data collection. Initial contact with potential participants was via an online voluntary questionnaire distributed through Facebook and Strava groups and clubs that focus on ultradistance cycling.

Method

Participants in the study were ultradistance cyclists who self-identified as technology users on the questionnaire and who were willing and able to meet for face-to-face interviews. Data collection consisted of 45 minutes to hour-long, semi-structured interviews utilizing open-ended questions. Recordings of the interview were professionally transcribed. Participants were provided with transcripts of their interviews and were encouraged to review and edit to ensure an accurate reflection of their thoughts and opinions. The reviewed transcripts were then added to NVIVO for analysis using an emergent design and a constant comparison protocol.

Transcripts were analyzed using a thematic content approach. During initial coding, important statements were identified. These statements were then grouped together by common concepts. Finally, themes related to learning and technology uses were identified and revised. These themes are presented with exemplar statements by participants in Chapter IV and discussed in Chapter V.

Summary

This chapter provided an overview to the use of emerging technologies in ultradistance cycling as well as gave an introduction to the experiential learning process. Over the past several years, many fitness-related technologies have been developed such as smartphone apps and wearable fitness devices. When used in conjunction with wider cell-phone coverage and higher bandwidth for data transmission, this has allowed for the integration of these technologies in ultradistance cycling training and events. An examination of how athletes used these technologies as part of their experiential learning process could lead to the identification and increased understanding of the characteristics of these technologies that facilitated the process. Chapter II examines this subject in greater depth and provides a review of pertinent literature related to emerging technologies, cycling, experiential learning, and intersections of these subject areas.

Definition of Terms

Bikepacking. Multi-day bike rides where all equipment is carried, usually off-road on a mountain bike.

Emerging technology. For the purpose of this study, emerging technology included software and hardware that was developed or, through affordability and/or modification, became more easily available to ultradistance cyclists in recent years--smartphones, portable GPS units, fitness applications, power meters, and wearable technology like heart rate monitors.

Experiential learning. This is learning by doing. The process includes experiencing, reflecting, thinking, and acting.

Mobile app. A program that runs on a smartphone, often supporting data exchange with the World Wide Web.

Randonneuring. Long-distance unsupported endurance cycling. Although there are time limits for the completion of the specified route, there is no ranked order or "winner." The last finisher receives the same recognition as the first.

Smartphone. In this study, a smartphone is one that supports 3G or 4G data connection to World Wide Web resources. It is distinguished from a feature phone that only has text and voice connectivity. No distinction is drawn between manufacturers or operating systems.

Technology. This paper utilized the broader, social sciences-focused definition described by Luppicini (2005) where technology "refers to the organization of knowledge for the achievement of practical purposes as well as any tool or technique of doing or making, by which capability is extended" (p. 104).

Ultradistance cycling. For the purpose of this study, an ultradistance ride was considered to be 200 kilometers or longer, distinguishing it from "century rides" that are often well supported with food and follow a well-marked course as well as mechanical assistance for riders.

Wearable tech. Technology worn by the athlete; the most common example is a heart rate monitor but also includes devices like a Fitbit that can track steps or monitor sleep patterns.

Assumptions, Limitations, and Delimitations

Assumptions

It was assumed that participants in this study would answer truthfully to the best of their knowledge and based on their personal experiences. Ultradistance cycling is an individual sport; each individual has unique needs, goals, skills, and abilities. The use of technology was unique to each individual. While individual usage was unique, it was assumed that themes of use common to multiple participants would be representative of the broader ultradistance cycling community.

Limitations

This study was limited by the emerging technology used by participants. Since the potential technology available was far greater than the number of participants, some technologies or a combination of technology uses were excluded from the study.

Delimitations

The study was limited to athletes who were available for data collection. Ten respondents to the questionnaire met the ultradistance cycling criteria (two or more rides in excess of 200km), the technology use criteria (use at least one form of technology), and were willing and available to meet for face-to-face interviews.

CHAPTER II

LITERATURE REVIEW

Introduction

The previous chapter gave an introduction to the use of emerging technology as part of the experiential learning process by ultradistance cyclists. This chapter reviews research related to the topics of this paper: (a) emerging technology, (b) experiential learning, and (c) ultradistance cycling. The chapter continues with an examination of the literature related to theoretical frameworks that established the viewpoint of the research including constructivism and the concept of a technological layer. This chapter concludes with an overview of the methodologies employed to inform the subject: qualitative study, phenomenological research, interview in research, and bracketing of my preconceptions.

Review of Research

Emerging Technology

As mentioned in Chapter I and for the purpose of this study, emerging technology included software and hardware that was developed recently or, through affordability or modification, became more easily available to ultradistance cyclists in recent years. These technologies included smartphones, portable GPS units, fitness applications, power meters, and wearable technology like heart rate monitors.

Broadly, new technologies are being adopted in sports, education, recreation, entertainment, business, and many other aspects of our lives. The goal of this study was more focused--examining the role emerging technologies play in the experiential learning process within the sport of ultradistance cycling.

Smartphones. The use of emerging technology, particularly smartphones, has grown dramatically in recent years (Kim, 2013; Middleton, Scheepers, & Tuunainen, 2014; Smith, 2015b). In 2015, 64% of American adults owned a smartphone. This was an increase from 35% in 2011 (Smith, 2015b). Worldwide, there were more than 7 billion mobile cellular subscriptions in 2015--an increase from 738 million in 2000 (International Telecommunication Union, 2015).

In addition to increased cell phone ownership, there has been an evolution in connectivity, increasing the amount of data easily transmitted. According to Cisco (2016), "Global mobile data traffic grew 74 percent in 2015" and "data traffic has grown 4000-fold over the past 10 years" (p. 1). High bandwidth 4G networks are widely available and increasing (OpenSignal, 2016). Worldwide, the proportion of population with access to a 2G network increased from 58% in 2001 to 95% in 2015 (International Telecommunication Union, 2015). The Wi-Fi capabilities of smartphones allow integration of the apps with websites that have additional features (Martin & Zimmerman, 2014). Increased coverage is particularly relevant to the sport of ultradistance cycling since riders cover many miles in a single event. Having reliable coverage that facilitates a steady data exchange allows the use of new technologies throughout a ride.

Mobile devices have a number of inherent strengths and weaknesses (Budiu, 2015) including small screens, portability, interruptible, a single window, touchscreens, and variable connectivity. These devices often include a number of additional features such as GPS, camera, accelerometer, Bluetooth connectivity, and touch identification (Budiu, 2015; Hanson, 2011). Their low cost and the unobtrusive nature of accelerometers in particular have led to a rapid increase in their use in activity monitoring in recent years (op den Akker, Jones, & Hermens, 2014). When tracking a ride, the smartphone differentiates between "ride time" and "total time" by pausing when the rider is stopped. It is no longer necessary to manually hit the stop button while waiting at a red light. Even better, the rider does not need to remember to hit "Go" when the light turns green. Not only does this ensure every mile is tracked but it also allows the rider to focus on traffic at the intersection rather than worrying about his/her device.

Constantiou, Lehrer, and Hess (2014) examined location-based services utilized by smartphone owners including mapping and navigation, point of interest, public transportation planners, fitness applications, city guides, traffic monitors, and radar detectors. They also found context of use was an important consideration for adoption. As the name implies, ultradistance cycling covers long distances, inevitably leading the rider into unfamiliar territory. Smartphones with navigation features along with route and city information provide different opportunities and resources for riders with the possibility of influencing how they prepare for and experience events.

Emerging technologies in education. The role of technology in education has been debated (Clark, 1994; Kozma, 1994) and has sparked the emergence of new pedagogical approaches (Attwell & Hughes, 2010) and models of knowledge construction (De Oliveira et al., 2015). Integrating these emerging technologies into learning brings both challenges and opportunities (Mayes, Natividad, & Spector, 2015). The increased mobility aspect of this new technology is seen in the use of tablet personal computers in physical education (Gubacs-Collins & Juniu, 2009).

Smartphones and mobile apps are technologies with potential to influence learning and knowledge construction. The impact can range from being a source of distraction to being fully integrated into the instructional process. The importance of examining these technology roles was reinforced by Lee and Drake's (2013) belief that

> pursuing such an understanding is actually both important and valuable for education research, and specifically, for educational technology research. This belief is based on the fundamental assumption that new technologies establish new ways of thinking, knowing, and acting, rather than simply enhancing our ability to learn some specified content. (p. 40)

Cummiskey (2011) gave an overview of incorporating smartphone apps into health and physical education. A more methodical approach was provided by Juniu (2011) who emphasized the importance of choosing "your technology to aid your teaching, rather than designing your lesson to fit the available technology" (p. 1). Marshall (2016) described seven apps that could aid in communication by individualizing content and delivery, demonstrating student learning and knowledge, and improving teacher productivity. George and DeCristofaro (2016) concluded, "Smartphone apps promote active learning and the long-term retention of knowledge" (p. 411). Each of these examples illustrated the importance of selecting technology suited to individual goals rather than adapting individual goals to fit the technology. I have encountered this issue in my role as an instructional designer at a community college. Sometimes, there was the desire to adopt a new technology or application that looked cool without a clear idea of how it would be used in a course or what instructional objectives it would meet. A preferred process would be to identify the instructional objectives first and then seek technology to meet those objectives. One goal of this research was to examine how the technology adoption process occurred as part of experiential learning in ultradistance cycling. Did riders adopt a new technology and then create a goal the technology measured or did the athlete seek out specific technology to help meet his/her goals?

For lifelong learning and fitness, apps need to move beyond the classroom setting. As Cummiskey (2011) noted, "The fields of health and physical education are meant to promote healthy, active lifestyles. New technologies are part of this strategy, but only if we embrace them" (p. 26). Moving beyond the classroom by looking at the use of emerging technologies as part of learning in the sport of ultradistance cycling was the goal of this paper.

Emerging technologies in sports. "Physical education programs teach children lifelong skills to keep them healthy" (National Association for Sport and Physical Education & American Heart Association, 2016, p. 3). These skills could build the foundation of sports programs later in life. Just as smartphones and fitness applications are being incorporated into physical education programs (Cummiskey, 2011), many apps are being developed for use in a variety of sports both by coaches (Sportlyzer Academy, 2013) and athletes (Litman et al., 2015). One aspect of lifelong learning could be partaking in experiential learning. One of the aims of this research was to examine the role of emerging technology in the sport of ultradistance cycling and hopefully extrapolate it to other lifelong learning experiences.

One role of a mobile technology user identified by Middleton et al. (2015) was "entertainment seeker" (p. 506). An example of this would be an application like Pandora that plays music or one that provides scores and highlights of sporting events. These types of applications provide entertainment directly. Others facilitate and improve a user's experience in athletic endeavors (Middelweerd et al., 2014). The focus of this paper was on the latter--those that facilitate and improve the activity.

Litman et al. (2015) found a correlation between sport application usage and increased exercise and concluded, "Apps provide multiple features that appear to help users overcome their barriers, the effectiveness of exercise apps can be significantly improved by the utilization of individualized, theory-driven approaches" (p. 12). Another factor that contributes to using smartphones and applications in athletic endeavors is ease of use (Martin, Bernardos, Iglesias, & Casar, 2013). Automatically recognizing an activity to log appropriate data is one way in which advances in technology are making the use easier (Martin et al., 2013). This could reduce the barriers to adoption while simultaneously creating a technological layer to the athletic experience. Emerging technologies with low barriers to adoption are more likely to be incorporated into an athlete's experiential learning process. Factors that have reduced barriers to adoption of smartphones include more widespread and higher bandwidth data connection (International Telecommunication Union, 2015; OpenSignal, 2016).

Some evidence also indicates the riding environment has an influence on bicycling behavior (Ma, Dill, & Mohr, 2014). Applications like MapMyRide and Ride with GPS allow users to map out routes in advance. Street views in Google Maps give a real picture of what the roads are like, creating a preconception that influences ride expectations and thus shapes the experience. In addition to smartphones, which were discussed at length earlier, a number of other emerging technologies are being adopted in the sport of ultradistance cycling: fitness applications, wearable technology, power meters, and portable GPS units.

***Fitness applications*.** Increased availability of smartphones, built-in features, and the wide-spread coverage of high bandwidth connectivity have led to innovative fitness applications (Middleton et al., 2014) that can have a direct impact on the cycling experience. For instance, mobile connectivity was used in crowdsourcing data collection for the development of OpenStreetMap (Smith, 2015a). BikeNet utilizes built-in phone features to develop a system that includes cyclist performance/fitness measurements, environmental/experience mapping, and long-term performance trend analysis (Eisenman et al., 2010). Biketastic utilizes smartphone microphones to collect noise data and map out more enjoyable routes for cyclists (Savage, 2010). While these applications illustrated changes for the commuting style cyclist as well as potential uses in training, they did not include the ultradistance aspect of cycling. As Middleton et al. (2014) put it, “Compared with only a few years ago, mobile users today have an immense, perhaps even daunting range of apps on offer” (p. 506). The *Worldwide Survey of Fitness Trends for 2016* (Thompson, 2015) listed smartphone exercise applications as one of the top 20 trends identified by fitness professionals.

Cyclists often use a combination of fitness application to meet their needs (Riegersperger, 2017b). As Litman et al. (2015) noted, there are thousands of sports-related apps. Some of the most popular cycling-related apps are Strava, RidewithGPS, and Map My Ride (Wynn & Elton-Walters, 2016). By necessity, the focus of this paper was limited to emerging technologies utilized by the participants.

***Wearable technology*.** Wearable technology devices are physically worn by the athletes. This differentiates wearables from technology such as power meters, cycling computers, and smartphones that are carried or mounted on an athlete's bike. Wearable tech often monitors an athlete's physiology with a heart rate monitor or fitness band like a Fitbit. Others provide the athlete with access to information as with smart glasses or even an ordinary watch. The market for healthcare, wearable devices is rapidly growing (Tractica, 2016) and these devices have many uses beyond sports applications (Piwek et al., 2016). Thompson (2015) listed wearable technology as the top emerging trend identified by fitness professionals. A sampling of data available from wearable technology is provided in Figure 1. In addition, some heart rate monitors include an accelerometer that can also measure stride length, ground contact time, cadence, and vertical displacement (Maker, 2016). Bluetooth technology allows the syncing of wearable tech with both smartphones and fitness applications, thus facilitating, among other things, real-time activity monitoring (Bloss, 2015).

As with fitness applications, not all wearable tech provides all the information. One goal of this research was to discover what information ultradistance cyclists recorded and how these data were used in training and performance.

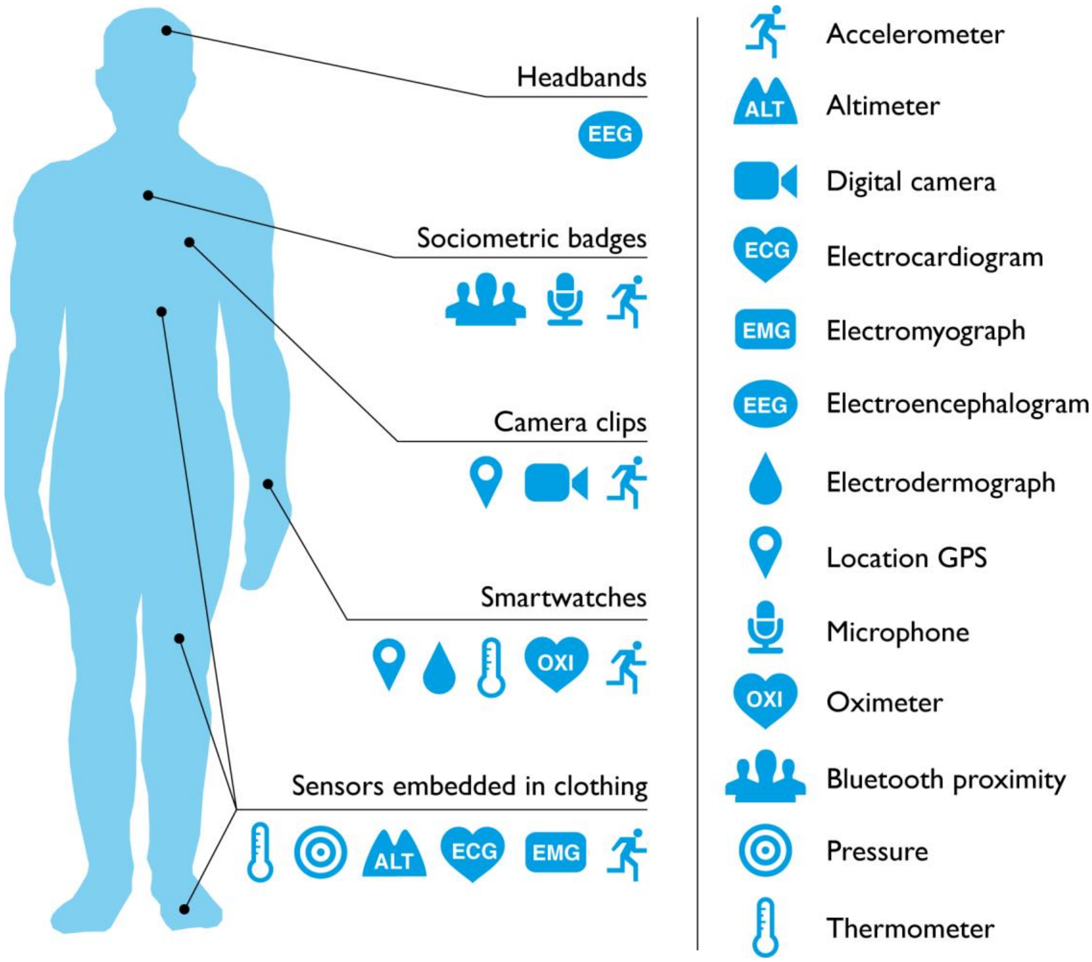

Figure 1. What can consumer wearables do? (Piwek et al., 2016, p. 2)

Power meters. "Bicycle-mounted power meters measure the strain a rider puts on the crank, rear wheel or chain and translate that into watts" (Burke, 2002, p. 77). Use of this technology allows riders to monitor their efforts in training and events (Egger, Meyer, & Hecksteden, 2016). The cost of power meters has been declining in recent years and become more affordable (Rainmaker, 2018). Reliability and accuracy were fairly consistent among various models of power meters (Novak & Dascombe, 2016; Pallarés & Lillo-Bevia, 2018).

Portable global positioning system units. Within the context of this paper, a portable GPS unit is a device attached to a bike that can determine location by measuring signals from three or more satellites (McNeff, 2002). Measuring location over time allows the GPS unit to determine speed and distance and record the route ridden. Many units supplement the GPS-determined elevation with barometric measurements to increase accuracy (Barber, 2014). Advances in technology have resulted in reduced prices for GPS units (Wolpin, 2014), increasing their availability and allowing ultradistance cyclists to use them in their recreational activities.

Experiential Learning

Kolb (2014) built and expanded upon a model of experiential learning and a learning styles inventory that identified four stages of experiential learning: experience, reflection, conventionalization, and test (see Figure 2). These stages can be seen in the development of ultradistance cyclist skills. For example, the practice of drafting is a concept well suited to learning through experience (Hirsh & Levy, 2013). It was also of interest to discover how ultradistance cyclists and their use of emerging technology related to the learning styles Kolb identified: diverging, assimilating, converging, and accommodating.

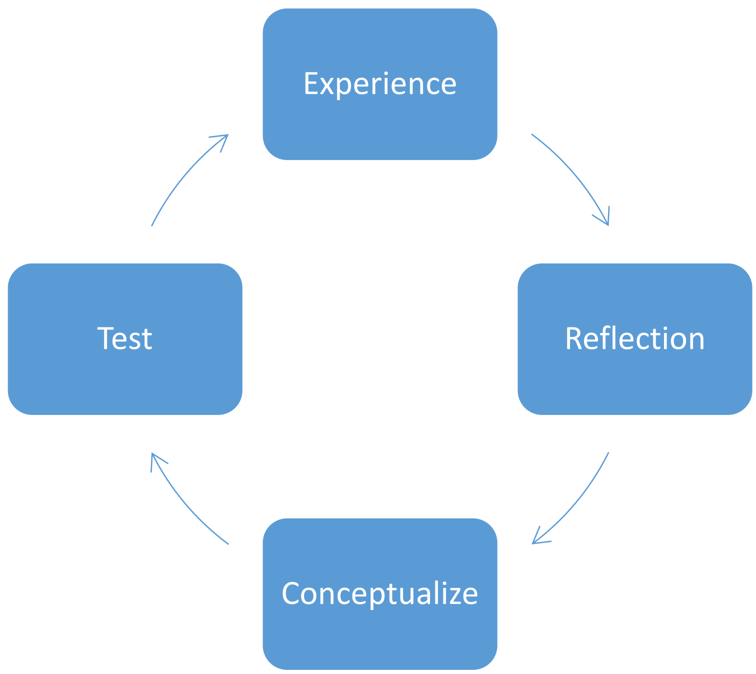

Figure 2. Kolb learning cycle (adapted from McLeod, 2017).

Ruckert et al. (2014) applied Kolb's concept of experiential learning within the context of health professionals utilizing technology to promote active and social learning. Although their research was formal health professional education, characteristics were relevant to the informal setting of ultradistance cycling. One of the exemplars included a specific smartphone app. They found Twitter helped provide a sense of shared experience even though participants were in different locations. Current research might inform how the use of smartphones apps to facilitate sharing experiences was occurring in ultradistance cycling. Ma, Williams, Prejean, Lai, and Ford (2008) also examined the use of technology with teacher candidates with an emphasis on the reflection phase. My research examined technology use by ultradistance cyclists as part of their regular routine; no prior preparation phase was utilized.

An important factor in the experiential learning process is the learner's epistemic authority (Ellis & Kruglanski, 1992), i.e., the more confident learners are in their skills in a certain area, the more likely they are to be confident in learning more of that subject on their own. This would be relevant to the sport of ultradistance cycling since the demands and challenges of 200km (and longer) rides are not the most appealing to novice athletes. It remains to be seen how the use of emerging technologies could facilitate the experiential learning process in ultradistance cycling. Technologies might serve to bridge the epistemic authority gap, giving newer riders the confidence and support to dive into the sport and learn by doing.

Mayes et al. (2015) outlined challenges and opportunities associated with introducing new technologies in formal learning environments; one area of interest they identified was "redefining and refining the role of teachers" (p. 229), noting the need for teachers in becoming familiar with the technology. In the experiential learning environment of ultradistance cycling, the athlete is both the learner and the teacher. For improved learning, epistemic authority would be needed not only in cycling skills but also with emerging technologies being utilized.

As a reminder, this paper utilized the view of experiential learning--learning through everyday experiences rather than a training program sponsored by an institution (Kolb, 2014). Both views emphasize learning by doing. However, the focus of this research was on the informal learning process of individuals rather than a formal, organized training program.

Ultradistance Cycling

The basic definition of ultradistance cycling as used in this paper was any ride over 200km. One style of this type of riding is called a randonnée: "A long ramble in the countryside by foot, ski or bicycle. In common cycling using it means a touring ride of at least a few hours' duration, often somewhat strenuous, at least compared to commuting or running errands around town" (RUSA, 2014, p. 11). The reason for focusing on this style or riding was the need for the athlete to be self-reliant. In turn, this created an opportunity to examine the role emerging technologies played in creating self-reliance and thus part of the experiential learning process.

The growing use of technology in cycling was the topic of a special issue of *Technology, Knowledge and Learning* (Lee, 2013). One of the reasons for this was "cycling has and maintains its own culture" (Lee, 2013, p. 4). This technology includes mobile information systems; when considering mobile information systems, it is important to consider the concept of context (Middleton et al., 2014). Ultradistance cycling provides a unique context for the utilization of mobile information systems wherein mobile apps provide information on distance traveled. Albertus et al. (2005) examined the effect of this type of feedback on pacing in cycling; the sessions were 20km time trials taking less than an hour. Having feedback on distance traveled might have a much different effect on pacing in ultradistance events that travel 1,200km over several days. Smartphones and apps allow for easy visualization of this information (Wood, 2015). Moreover, Lee and Drake (2013) noted the introduction of sensors and computers "injected data into athletic activities by *quantifying* athletic performance, thereby introducing new ways of thinking about and knowing what one's body was doing" (p.

40). Injection of data could facilitate reflection on performance, thus allowing for continuous cycling through the experiential learning process both in the short term, during an event, as well as in the long term over years of participation.

Arguably, the premier event in ultradistance cycling is Paris-Brest-Paris--a 1,200km ride in France that occurs every four years. The four-year interval between events lends itself well to the study of the impact of technology on the experience of users. Four years would be enough time for technology, like smartphones, to move from cutting edge to common practice and greatly change participants' experiences from one edition to the next. For this reason, it would be insightful to use participants' experiences in the PBP as a benchmark for using emerging technology.

Wood (2015) identified several key elements of his personal ultradistance cycling experience including the 2011 PBP: the impact of gradient and wind on effort and feeling of progress as well as checkpoints as opportunities for nutrition and rest. The primary focus of the Wood paper was how information gathered using smartphones and apps could be utilized for data visualization in developing a narrative of the experience. The availability and use of smartphone apps enabled Wood to tell his personal experience in a way that was not possible in the 2007 edition of the PBP. The goal of this paper was to expand this examination beyond the use by a single individual in a single event and consider how emerging technologies were utilized by a variety of cyclists in a broader context as part of their experiential learning process.

Development of the Research Questions

One of the research questions posed by Middleton et al. (2014) was "What business models and value propositions will guide the development of dissolving, devolving mobile artefacts, including the IoT and wearable computing" (p. 507) where IoT was short for "Internet of Things." Participation in ultradistance cycling events as well as the organization and offering of those events were businesses that utilized emerging technology. This concept helped inform the development of the research questions in this study.

Research Question One

Q1 How are ultradistance cyclists using emerging technology as part of their experiential learning process?

This was the primary research question. The focus of the research was on the overlap of ultradistance cycling and the use of emerging technologies.

One aspect of emerging technologies is their role as a mobile information system. Middleton et al. (2014) posted a number of questions related to research on mobile information systems:

- What actions are needed to ensure ongoing development of mobile network coverage and to encourage that the infrastructure needed to support ubiquitous computing and enable the IoT is developed in a timely way?
- How, and by what parties, can persistent digital divides be addressed?
- What actions can be taken to increase accessibility to mobile networks and services for those who are not currently using them?
- What is needed to adopt a 'mobile by default' approach to IS design?
- What business models and value propositions will guide the development of dissolving, devolving mobile artefacts, including the IoT and wearable computing?
- What are the impacts of taken-for-granted mobile access to information and services for individuals and society?
- What are the challenges for organizations when employees and customers are able to bring their own devices and work around existing IS by using consumerised information technology to meet their communication and other needs? (pp. 506-507)

These questions served as the foundation for lines of inquiry during interviews that informed the results of this paper. The interview protocol is provided in Appendix A.

Smartphones have been used to gather data on the cyclist experience during urban rides (Eisenman et al., 2010; Savage, 2010) as well as for mapping ultradistance rides (Wood, 2015). With the array of mobile apps available (Cummiskey, 2011; Middelweerd et al., 2014; Statista, 2016), the potential for use is much greater. Indeed, the use of technology by athletes might change their experience (Lee & Drake, 2013). Exploring this use in ultradistance cycling was the purpose of this question.

Experiential learning involves experience, reflection, conceptualization, and testing modes (Kolb, 2014). Examining the role emerging technologies played in each of these modes also drove this enquiry.

Research Question Two

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?

Mobile information systems is one characteristic of emerging technologies that has a potential influence on the role of experiential learning. It was also the goal of this research to attempt to identify other characteristics of emerging technologies that enabled the experiential learning process. As seen in the classic debate of the role of media in learning (Clark, 1994; Kozma, 1994), the value of a specific technology could be disputed. It could be the characteristics of the technology are of greater import on the learning experience while individual athletes likely have a preferred technology. A goal of this research was to look beyond the brands and models to examine the characteristics that drove the adoption and use of technology in training and performance.

Methods and Methodology

This section gives a brief overview of the literature related to methods and methodologies utilized in this research. Chapter III includes detailed plans for the study and greater details of the methodology employed.

Qualitative Research

"Qualitative researchers are interested in understanding how people interpret their experiences, how they construct their worlds, and what meaning they attribute to their experiences" (Merriam, 2009, p. 5). The purpose of this research was to examine the experiential learning process of ultradistance cyclists using emerging technology. A quantitative approach could be utilized to find out which applications and technologies were being used. This approach could also be used to identify the most popular or in-demand functions and features. However, a quantitative approach would not answer *why* or *how* the athletes used the technologies and the impact this had on their experience. To understand the experience goes beyond simple data collection. As Creswell (2013) noted, "The process of analysis is much more. It also involves organizing the data, conducting a preliminary read-through of the database, coding and organizing themes, representing the data and forming an interpretation of them" (p. 179). For this reason, a qualitative approach was warranted. The goal was to understand the use of emerging technologies by ultradistance cyclists. To gain a better understanding, I utilized phenomenological research methods and my primary data source was interviews with ultradistance cyclists.

Phenomenological Research

"A phenomenological study describes the common meaning for several individuals of their lived experience" (Creswell, 2013, p. 76). In the context of this research, the "lived experience" was the use of emerging technologies in training for and participating in ultradistance cycling events.

Emerging technologies allow athletes to track and record large amounts of information about their performance. In addition, some of these technologies present results and performance metrics in highly visual ways, thus allowing the athlete to engage with the data in ways not previously possible and creating the potential for a far richer training experience. Wood (2015) stated,

> By tapping into the themes that have emotional resonance for participants, good personal visualization design can engage the consumer of the visualization in ways that might be more challenging in a more traditional detached scientific context. (p. 81)

While individual technologies used by athletes varied, the goal of this research was to seek out experiences common in their usage.

Interviews as Research

According to Merriam (2009), "To get at the essence or basic underlying structure of the meaning of an experience, the phenomenological interview is the primary method of data collection" (p. 25). With this in mind, interviews of ultradistance cyclists who utilized emerging technologies were conducted. Interview questions focused on participants' experiences in ultradistance events and the effect emerging technology had on those experiences. The initial potential participant pool was members of the local ultradistance cycling club. Additional screening was by use of emerging technology and participation in multiple ultradistance events over multiple years. An interview protocol is provided in Appendix A.

Qualitative Data Analysis Software

This research study utilized NVIVO software to organize, store, and manipulate the qualitative information obtained in order to facilitate thematic content analysis. It is important to note that

> whilst computer programmes can facilitate data analysis, making the process easier and, arguably, more flexible, accurate and comprehensive, they do not confirm or deny the scientific value or quality of qualitative research, as they are merely instruments, as good or as bad as the researcher using them. (Burnard, Gill, Stewart, Treasure, & Chadwick, 2008, p. 430)

Bracketing

"It is common practice in phenomenological research for researchers to write about their own experiences of the phenomenon" prior to interviewing others (Merriam, 2009, p. 93). In past years, I have participated in ultradistance events--both cycling and running. I am also a regular user of a smartphone and several fitness applications. While conducting this research, it was important that I set aside or was at least aware of preconceptions related to the topic. In particular, I have preferred apps and ways I used them. More importantly, I had my own reasons for using various technologies and applications. For example, I tended to focus on the metrics provided by apps such as time, speed, distance, heart rate, and cadence. I was not as apt to use social or navigation features. I needed to account for these preconceptions, particularly while conducting interviews of participants so as not to potentially bias responses. I did not want to discount a feature or practice simply because it was not the way or reason I used the app. At the same time, a personal narrative of an experience could be a rich source of information as seen in Nikolaeff's (2016) examination of using technology during a long-distance backpacking trek. For this reason, it was important that I remained aware of my questions, comments, and gut responses while reviewing, categorizing, and coding the transcripts, questionnaires, and artifacts as well as when I conducted the interviews. I captured these thoughts as soon as practical after each interview and included this view as a separate data source in the research.

Summary

The purpose of this study was to examine the use of emerging technology in the experiential learning process of ultradistance cyclists. This chapter reviewed research related to this topic, examined the literature supporting the theoretical framework on which this research was based, and concluded with an overview of the methodologies employed to inform the subject. The following chapter examines the methods and methodologies of this research in greater detail.

CHAPTER III

METHODOLOGY

Introduction

The goal of this study was to gain a better understanding of the role of emerging technology in the experiential learning process of ultradistance cyclists. In recent years, there has been an increase in the availability and affordability of emerging technologies like smartphones, fitness applications, heart rate monitors, and power meters. This has allowed more athletes at varied levels to include these technologies in their training. An examination of how these athletes were using the technologies could lead to a greater understanding of the role of technology in experiential learning and ultradistance cycling. To develop this understanding about emerging technology and experiential learning in ultradistance cycling, the researcher explored and described participants' perceptions within the context of the lived experience.

Research Design

The design guided the research through planning and implementation of the study in order to achieve the intended goal of the research (Burns & Grove, 2003). The focus of this research was the use of emergent technologies in the experiential learning process within ultradistance cycling. The cyclist's experience with emergent technology was at the core of this process. This study was exploratory, descriptive and contextual, warranting a qualitative approach that included those characteristics.

Exploratory Research

Exploratory research explores new and little-known areas of study to gain new insight into the phenomenon being studies. This study employed an exploratory research approach to better understand how emergent technologies were integrated into the experiential learning process of ultradistance cycling. By their nature, emergent technologies warrant exploration because they are new. Additionally, as the field of ultradistance cycling evolves and technologies continue to pervade many elements of our social and work lives, little is empirically known about how these technologies are used or the influence they have on the topic. Thus, understanding this phenomenon better builds insight into emergent technology integration into experiential learning.

Descriptive Research

When research is lacking about a phenomenon, description is necessary to establish an understanding of the phenomenon. Qualitative research focuses on exploring "emic" perspectives and ideas of participants; this study followed that precedence by gaining perspectives from ultradistance cyclists. Emic constructs arise from group-specific common knowledge, interpretations, and meanings that exist within a culture (Holloway, 2005), e.g., the culture surrounding ultradistance cycling. Conversely, "etic" constructs originate from generalized observations, categories, and explanations of persons outside of a culture. The researcher often comes from the "etic" perspective; therefore, he/she must be open-minded and prepared to encounter complexity in the situation and interaction with participants. Any familiarity with the research of the culture being studied blurs emic and etic perspectives, thus complicating the role of the researcher. To accurately describe and interpret the emic view as accurately as possible, qualitative research requires systematic collection, organization, and analysis of subjective narrative data. Key statements and resultant themes are identified in these data and organized, leading to larger patterns that explain the phenomenon under study (Holloway, 2005).

Contextual Research

In qualitative research, focusing on participants' perceptions, language, interactions, presented ideas, lifestyles, and values as an integrated whole gives a holistic sense of a topic under study. Knowledge of a particular phenomenon is organized into a collection of linked ideas and used to develop insight. Analysis concentrates on the relationships between elements and concepts and considers the whole is always more than the collection of parts (Burns & Grove, 2003). Thus, the context of the lived experience is critical in phenomenological study because it is unique. Qualitative researchers work to glean an in-depth insight of the phenomenon while creating a picture of participants' values, reality, and social and cultural contexts in which the phenomenon being studied occurs (Holloway, 2005). This study attempted to understand the role of emergent technology in the experiential learning process of ultradistance cycling or within the contextual framework of their lived experience as members of a population with a unique history and culture. The data only made sense in the context and the information found and shared needed be always linked to this context. It was best gathered through qualitative methods.

According to Ramsook (2018), "A qualitative study investigates meanings and personal experiences constructed by individuals in a particular setting" (p. 14). Vagel (2014) noted that when the unit of study for a research project was the experience as influenced by a particular happening, it was appropriate to adopt a phenomenological approach for the investigation. In the current study, the "particular happening" was the lived experience of participants using emergent technologies within the experiential learning process of ultradistance cycling. Furthermore, Merriam (2009) described "the task of the phenomenologist, then, is to depict the essence or basic structure of the experience" (p. 25). Therefore, a qualitative approach was adopted by the current study to depict the essence of emergent technologies in the experiential learning process of ultradistance cyclists with the design based on the descriptions by Groenewald (2004) and Creswell (2013).

Phenomenological Research

In general, qualitative research applies methods that explore how people make meaning of their lived experiences and their views of the world from their perspectives (Creswell, 2013). Philosophers who laid down the foundations of phenomenology as philosophy did not develop guidelines for the discipline of phenomenology. Van Manen (1997) offered a set of guidelines for human science research that has served as the template for research in nursing, law, and the social sciences. Creswell (2013) described seven defining characteristics of a phenomenological study. The first characteristic is the emphasis on the *phenomenon* being studied. In this research, the phenomenon was the introduction and adoption of emerging technologies as part the experiential learning process in ultradistance cycling. It also warranted that qualitative processes take place in natural settings and employ a variety of empirical methods such as interview or personal experience "that describes routine and problematic moments and meanings in individuals' lives" (Denzin & Lincoln, 2004, p. 2). The second feature is a *group of* *individuals* who have experienced the phenomenon. In the case of this study, the group was ultradistance cyclists who were using emerging technology as a part of their experiential learning processes within the sport. Specifics of this group are detailed in the participants' section below. A third characteristic is a *philosophical discussion* of the phenomenon, which includes both subjective and objective experiences and leads to the importance of interviews for data collection. Each participant in this study had both unique as well as collective experiences in training for and participating in the sport of ultradistance cycling. Interviews allowed for a rich expression of ideas, beliefs, and experiences that were vital to describing the phenomenon. The questions asked were thus intended to allow the participant to delve deeply into the topic with the interviewer. The fourth characteristic is the importance of *bracketing* the experiences of the researcher. The influence of prior ultradistance cycling experiences and my use of emerging technology were taken into consideration as described in the previous chapter. My background both allowed for access and closeness to the phenomenon and it hindered my assumptions and personal experiences that needed to be accounted for during analysis. My use of a researcher's journal served as a mechanism for capturing a consciousness about these assumptions. An auditor could also support this process. The fifth characteristic of phenomenological research is *data collection*. In this study, data were collected through interviews, questionnaires, and examination of artifacts. The sixth characteristic is *data analysis*. Coding through open and axial means served as primary analysis processes. In this study, I utilized NVIVO to assist in the organization of meaningful statements and phrases. These narrow meaningful units were then organized into broader categorized and further examined to provide an explanation of the "how," "what," and the "why" of the phenomenon of today's ultradistance cycling experience. The seventh and final feature of phenomenological research is to incorporate the "what," "how," and "why" to describe the *essence* of the experience. The focus of this research was technology utilization by the participants. In the semi-structured interview questions, I asked participants not only what gadgets they utilized, how the technology was used, and the reasons for those used (the why). Taken in conjunction, these interviews allowed me to develop a description of the essence of technology usage by participants in their preparation for and participation in ultradistance cycling events.

These details aligned with van Manen's (2014) broader views about phenomenology. The approach is grounded on basic activities of research including (a) exploring deeply the nature of the lived experience, (b) investigating experience as it is lived and in context, (c) identifying and reflecting on essential themes, (d) phenomenological writing and rewriting, (e) maintaining a strong and oriented relation to the lived experience, and (f) balancing the research by considering parts and the whole. Additional details of how these features will be included in the current research are found in the sections below.

Design Outline

The research design followed the structure suggested by Creswell (2013) for phenomenological studies including the steps of the data analysis spiral (data collection; data managing; reading, memoing; describing, classifying, interpreting; representing, visualizing; and account creation). These steps took the following form in this research:

1. Identification of potential participants.
2. Filter participants.

3. Conduct one to two interviews.
4. Record notes and observations of interviews.
5. Transcribe interviews.
6. Provide transcripts to participants for review.
7. Read transcripts.
8. Record additional personal observations and interpretations.
9. Add transcripts to NVIVO.
10. Code and organize emergent themes (inductive).
11. Update interview protocol (includes refining the participant pool).
12. Repeat steps 3 to 11 for all interviews.
13. Compare to existing model, revise codes, and organize themes (deductive).
14. Analyze, interpret, and summarize data collected and themes identified.

This outline emphasizes the importance of the data analysis spiral. An integral aspect of this process was the review of emerging themes and the modification of interview protocols to further explore these themes. Appendix B contains a table mapping interview questions to the research questions.

Research Questions

To examine the use of emerging technology in experiential learning process in ultradistance cycling, the following research questions guided this study:

Q1 How are ultradistance cyclists using emerging technology as part of their experiential learning process?

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?

These research questions drove the direction of inquiry during data collection through interviews with the intent of developing an understanding of the phenomenon that was explored.

Setting

Ultradistance cycling settings vary greatly. As defined in Chapter I and for the purposes of this study, an ultradistance ride is one that is longer than 200km. Events are often much longer and can be on- or off-road over single or multiple days. Depending on the format, duration might be by fixed time or designated distance. Some events are set as stages where prescribed distances are covered each day with riders starting together each morning. The focus of this study was on the commonalities in the experiential learning process for ultradistance cycling. The process was different depending on the type of ultradistance being ridden. For example, an off-road ultradistance rider might utilize emerging technology differently than an on-road rider. The needs and uses for a multi-day ride might warrant different emerging tech than a ride completed in a single day. While focusing on the commonalities was the focus of this study, contrasting the uses in differing modes of ultradistance cycling could be a potential subject for future research. An overview of some of the types of ultradistance cycling is provided in the following sections.

Randonneuring

A randonnée is "a long ramble in the countryside, by foot or bicycle. In common cycling usage, it means a touring ride, often somewhat strenuous, at least compared to commuting or running errands around town." A formal event like "a brevet would always have time controls" (Randonneurs USA, 2014, p. 4). Having a dedicated support crew for each rider is not required and is the exception in most events. Riders are generally assumed to be self-reliant. While there are time limits for events, there are no awards for first place. Verification that a rider completes the entire course is essentially on the honor system. Participants self-report when they reach checkpoints with tracking cards being signed by bystanders or convenience store merchants. A subcategory of this type of riding is an Audax event in which the entire group rides together at the same pace over the entire course.

The premier randonneuring event is Paris-Brest-Paris. This event is held every four years in late August and covers 1,200km from the outskirts of Paris to the Brittany coast and back. There is a time limit of 90 hours.

The national governing body is Randonneurs USA (2014); it is responsible for certifying courses and events as well as distributing awards. In general, awards are given for reaching various distances over certain time periods. For example, the Super Randonneur medal is given for riding a 200k, 300k, 400k, and a 600k brevet in a single season (RUSA, 2014). This medal is available to anyone who completes the series and no attempt is made to record the "Fastest Super Rondonneur."

Given these characteristics, it is not surprising there is a strong feeling of camaraderie in RUSA events. Riders stick together and help each other when they have trouble with the goal of everyone making the time cut.

Ultra Marathon Cycling Association Events

Ultra Marathon Cycling Association (2014) events are more competitive. Events have a winner and there are record holders of fastest times. Support for riders is usually provided and a dedicated crew for each rider is sometimes required. Events are over a specified distance or time with the winner being the fastest rider. Some examples include 12/24 hour races, fastest state crossing, or courses over a set distance. Due to the competitive nature, verification is more rigorous than RUSA events. Certified officials and referees validate races and record attempts. In some cases. the UMCA (2016) has recently adopted the use of GPS tracking for ride verifications.

Arguably, the premier UMCA event in the United States is the Race Across America (RAAM; 2015). In the case of RAAM, it is not unusual to have a 12-person crew for a single rider. The competitiveness is evident as there is an entire section of the rules dedicated to spying other riders (RAAM, 2015).

Off-Road Ultra Events

Ultradistance cycling events are not just confined to the road (Zletman, 2014). These events can vary from point to point to multi-day stage races. Some riders are fully supported and some riders are on their own as they navigate trails and back roads. Distances can vary from 100 miles to across continents (Zletman, 2014). Some events require a crew while others prohibit any outside assistance. Given the difference in needs and the wide variety of off-road ultra events, the role emerging technologies played in this experience would vary greatly. An example of this type of event is the Colorado Trail Race. Technically, it is not a race since that would not be permitted in the various national forests the route traverses. However, participants can be very competitive and progress is recorded using tracking devices.

Data Collection

The major research activity in a phonological study is to investigate the lived experience of the participants (van Manen, 1997). Study data are systematically gathered to expand the knowledge and discourse of the phenomenon. In the current study, data were gathered systematically through the use of a questionnaire to identify potential participants and then through interviews with individuals who met the cycling and technology use criteria. This study examined the lived experiences of ultradistance cyclists by focusing on the phenomenon of using emerging technology in their training and participation in ultradistance events.

Questionnaire

Initial contact with participants was through an online questionnaire posted to ultradistance-related Facebook and Strava groups (see Appendix C for a copy of the questionnaire and Appendix D for a list of specific groups and membership numbers). A copy of the questionnaire was provided to and approved by the University of Northern Colorado's Institutional Review Board (IRB) prior to distribution (see Appendix E for approval).

Three of the four Strava and Facebooks groups utilized were local to the Colorado central and northern Front Range. The purposeful distribution to these groups was with the intent to target potential participants for face-to-face interviews. Financial constraints limited travel to meet more distant respondents. The remaining Facebook group (Ultradistance Cycling Association) was utilized in an effort to reach participants beyond the Randonneur or bikepacking focus. There was no local equivalent for this group. Distribution to this national group was an attempt to promote inclusivity of a greater variety of ultradistance cycling disciplines while balancing the logistical requirements of face-to-face interviews. Demographic information was requested from all participants as a means to examine how representative the sample was of the broader population.

There were 182 respondents to the questionnaire. Ramsook (2018) noted that for a phenomenological study, “Participants should be selected based on the certainty that participants possess real experiences and intimate knowledge about the phenomenon that is studied” (p. 16). For this reason, two respondents who indicated no ultradistance cycling experience were excluded at this point. Of the remaining respondents, 33 indicated a willingness to meet for an interview. Of the 33 willing participants, 10 were located in central and northern Colorado and were able to meet for face-to-face interviews. Each had completed two or more ultradistance cycling events and had used at least one technology in their training and events. All 10 of these participants were interviewed.

Contact information for additional participants was kept on file in the event additional data collection was required. This would have necessitated an IRB amendment. No new emergent themes were identified in the final three interviews, indicating reasonable saturation.

A copy of the template used in contacting potential participants is provided in Appendix F. In addition to standard contact information, I intentionally included my Randonneur USA membership number so participants, if they chose, could examine my participation in past events. This was done to build rapport with participants and give them access to information about me and my performance; it also provided them with similar knowledge I had acquired about their abilities from the survey. This was done to help minimize the power differential dynamic Creswell (2013) identified as a potential challenge when conducting interviews.

Of the 182 respondents to the questionnaire, 33% (*n* = 61) indicated they had participated in five or more ultradistance cycling events, 36% (*n* = 66) indicated they had used three or more technology items in preparing for or participating in ultradistance cycling events, 29% (*n* = 53) indicated their performance improvement was very or extremely important to them, 11% (*n* = 20) reported regularly working with a coach, 16% (*n* = 30) did not work with a coach, and 18% (*n* = 33) occasionally worked with a coach or had worked with a coach in the past. Table 1 provides additional demographic comparisons.

Table 1

Demographic Information

	Randonneurs Membership	Respondents	Interview participants
n	2749	182	10
Average age	53.9	43.8	46.3
% Male	82	80	60
% Female	18	20	40

Source: Randonneurs USA (2018).

Interview

Data collection was through semi-structured interviews (Merriam, 2009; see Appendix A for the initial interview protocol). Specific questions evolved based on participant responses. Thoughts and reflections on initial questions and modifications are summarized in Appendix G. Interviews were approximately 45 minutes in length. The interviews were conducted in semi-private environments within a public setting to prevent interruption and maintain confidentiality. In the majority of cases, this was an out of the way, two-person table at the participant's favorite local coffee shop.

Interviews were digitally recorded and professionally transcribed. Participants were provided with a copy of the transcript and solicited for corrections, clarifications, and comments prior to coding in order to facilitate member checking and increase reliability (Merriam, 2009). For sample size, Creswell (2013) recommended, "A heterogeneous group is identified that may vary in size from 2 to 4 individuals to 10 to 15" (p. 78). Potential participants were members of various Facebook and Strava groups where a link to the online questionnaire was posted. In addition, at least one participant forwarded the link to another email list that had an ultradistance cycling interest (see Appendix F for the template used to initiate contact).

Participants were identified with a pseudonym I selected and a key was kept in a password-protected file on a hard drive separate from other research material. Recordings were uploaded to a secure site and deleted from the portable device within 24 hours of the interviews.

Participants

Participants in this study were a purposeful sample of ultradistance cyclists who used emerging technology as part of their preparation for and participation in ultradistance cycling events. Initial identification was through an online questionnaire posted to ultradistance cycling focused Facebook and Strava groups. There were 186 respondents to the questionnaire; 81 indicated they had one or more rides of 200km or longer and utilized at least one of the following technologies (Strava, Ride with GPS, MyFitnessPal, MapMyRide, Garmin Connect, heart rate monitor, power meter, a wearable technology like Fitbit, and/or a GPS unit). Of the 81 technology-using ultradistance cyclists, 33 were willing to participate in an interview. All 33 of those potential participants were emailed to verify their willingness to participate and determine if an interview was logistically possible. Of those willing, 23 were not local and were unable to meet face-to-face. The remaining 10 participants took part in 45 minutes to one hour long recorded interviews. The national membership of RUSA (2018) is 82% male and 18% female with an average age of 53.9. The average age of questionnaire respondents was 43.8: 80% of respondents were male and 20% were female. The average age of interview participants was 46.3. Six males and four females were interviewed.

Participation was voluntary and no compensation was provided. Informational consent forms were provided and signed (see Appendix H). The consent form gave notice that this was a research study, the purpose of the research, the procedures that would be followed, identified potential risks and benefits, informed of the voluntary nature of participation as well as the right to withdraw at any point. Participants were informed of the procedures in place to ensure confidentiality. Pseudonyms were used for referencing participants in the findings. Signed copies were retained per institutional policies. Informed consent forms were developed and approved by the IRB at the University of Northern Colorado.

Researcher Stance

I participated in my first ultradistance cycling event in 2000. At the time, I was not even aware of the possibility of smartphones. I was an avid user of Polar heart rate monitors in training and had a cycling computer that measured cadence in addition to speed and distance. I meticulously recorded these metrics (time, distance, heart rate, and cadence) after each ride or run. Having and reviewing this information was part of the experience for me and guided my training. This was particularly true when running marathons. I would carefully monitor my heart rate during the event in an effort to maximize performance. During rides, I found my heart rate varied due to many factors (wind, climbing, road surface) so I would focus on times for five-mile segments. It was too challenging to try to remember each split so I would focus on how far above or below my goal time of 20 minutes per five miles. This changed when Garmin came out with a unit that not only had GPS to measure time, distance, and speed but also included a heart rate monitor. Even better, metrics could be downloaded directly from the device. I could then record and review not just my average heart rate but also how it varied over the course of a run or ride.

For me, using a Garmin device became integral to my sports. If I did not have the GPS and heart rate data, then the run or ride lost some of its importance. I have used Strava, Ride with GPS, Garmin Connect, Endomodo, and My Fitness Pal apps to organize and review information after a run or ride. I have not used smartphone apps during exercise since I have not found a way to sync them with my heart rate monitor. I prefer the simplicity of a worn device and dislike the need to mount a smartphone for constant viewing. If I could get an app to include heart rate information and a reliable mounting system, I could see using it during cycling since the large screen on a smartphone is easier to see and use than the wrist version of a Garmin. I would also appreciate the map and navigation functions of many of these apps. However, these benefits did not outweigh the lack of heart rate data for me. For now, having that information is integral to my ultradistance cycling experience.

Even though I am pursuing a degree in educational technology and am a fairly heavy user of technology in both my professional and private life, I consider myself a cautious adopter. I own and use a smartphone but I do not seek out the latest and greatest apps. I have not rushed out for the newest iPhone as I prefer to see what others are using and how they are using before trying it out myself. I generally believe smartphones and mobile apps use can enhance the ultradistance cycling experience. However, my approach remains the same as the adoption of technology in the classroom: let the need dictate the technology used rather than embracing a new technology and *then* trying to find a use for it.

I expected that during the course of this research I would discover new and different uses of emerging technologies I had not considered before or I did not think was the best way of using them. Thus, it was important for me to reflect on those issues in my research journal as soon after the interviews as possible. It helped capture my own viewpoint on the experience in addition to those of my participants.

Researcher Journal

Researchers need to be aware of their own perspectives and assumptions when engaging in qualitative research (Mertens, 2010). As revealed in the researcher stance, I have a connection to ultradistance cycling and technology and thus have conscious and unconscious assumptions about the phenomenon being studied. It was important to continually be aware how I viewed these topics and how my personal ideas might influence this study. Therefore, it was important to keep a researcher journal to reflect on this study as it progressed. I wrote in my journal as I completed each participant's interview, reviewed documents, and as I analyzed data. I made reference to my researcher journal as I evaluated the findings of this study.

In this phenomenological study, interviews were the primary research instrument in capturing the lived experiences of participants and in the interpretation of those experiences to understand the phenomenon of emergent technologies in the experiential learning process of ultradistance cyclists. As the researcher, my perspective could make an impact on the study so it was important that I reflected on my assumptions, the interviews with participants, and review of the interview transcripts. Qualitative researchers need to be self-reflexive both before and during fieldwork by documenting their motivations, biases, and any changes in direction (Lincoln & Guba, 1985).

Ontological and Epistemology Position

"Ontology is the study of being. It is concerned with the 'what is', with the nature of existence, with the structure of reality as such" (Crotty, 1998, p. 10). In this research, I utilized an interpretivist approach, which "looks for culturally derived and historically interpretations of the social life-world" (Crotty, 1998, p .67). I wanted to understand and interpret the behavior of ultradistance cyclists. Specifically, I wanted to understand and interpret their use of emerging technology in their experiential learning process. I believed it was important to put their uses of technology in the context of what they had used in the past, how technology was changing, and how it was used to meet the challenges specific to the ultradistance cycling sport and culture.

Epistemology refers to the nature of knowledge (Merriam, 2009). From an epistemology stance, I utilized a constructivism viewpoint. Using this viewpoint, "meaning is not discovered it is constructed" (Crotty, 1998, p. 8). Each cyclist developed his/her own view of the role of technology in experiential learning. The meaning of technology was unique to each individual and every view was equally true and valid. From the standpoint of a researcher, I found this process both challenging and informative. The challenge was to ensure my personal views did not impact my acceptance of the participants' views. While I had many uses and views in common with several of the participants, I took care to make note of this while reflecting on each interview. At the same time, exposure to different views opened my eyes to technologies and uses I had not considered. I look forward to returning to the sport of ultradistance cycling and implanting some of those ideas.

Trustworthiness

To ensure a systematic and accountable methodology, the criterion of rigor was applied. In qualitative research design, trustworthiness is essential to ensuring the accuracy, meaningfulness, and effectiveness of a study. Trustworthiness refers to the ability of a study to produce meaningful results (Merriam, 2009). Lincoln and Guba (1985) described four main tenants to establish trustworthiness in a study: credibility, transferability, dependability, and confirmability. Credibility refers to the value of truth of the data collected and the accuracy of the description of the participants experience (Lincoln & Guba, 1985). Member checking was used in this inquiry as a method to rule out misinterpretation of the participant's meaning during the interviews (Lincoln & Guba, 1985; Merriam, 2009), through participants' review and feedback of the transcription and findings to ensure accuracy, and that their voices were appropriately represented. Transferability "is concerned with the extent to which the findings of one study can be applied to other situations" (Merriam, 2009, p. 223). In qualitative inquiry, transferability is possible through "sufficient descriptive data" (Lincoln & Guba, 1985, p. 298) by means of maximum variation and thick, rich description (Merriam, 2009). Dependability refers to the criterion of consistency. This means addressing the question of whether the findings could be repeated if the study was conducted with the same or similar subjects and context (Lincoln & Guba, 1985). Additionally, this study used an audit technique that allowed an external person to review the steps and processes in the study and the raw data to confirm the findings. Confirmability allowed for minimizing the researcher's bias by allowing an auditor to determine if the conclusions and interpretations could be traced to sources and whether they were supported by the study (Erlandson, Harris, Skipper, & Allen, 1993; Mertens, 2010). These practices provided evidence that this study was trustworthy.

Summary

A common saying in ultradistance sports states every athlete is an experiment of one. This saying was seen in the choice of food; some riders relied on bars and gels while others preferred a ham and cheese baguette. The "experiment of one" was also seen in the choice of equipment; the perfect saddle for one rider would rub another raw. I believed individual preference was also true in the phenomenon of using emerging technology in the sport of ultradistance cycling. This went beyond identifying which apps were being used or even which function of apps was preferred. The core of the phenomenon was the role emerging technologies played in shaping the experiential learning process. Each participant would have a different perspective of this role. The interview process attempted to explore these perspectives, which could lead to a better understanding of the essence of ultradistance cycling experiential learning. A better understanding of the essence could also lead to changes in how emerging technology was used by ultradistance cycling athletes, coaches, and event organizers. Moreover, the exploration of the use of emerging technologies in the sport of ultradistance cycling could lead to insights of potential uses beyond the sport and further inform the experiential learning process.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to explore the use of emerging technology as part of the experiential learning process of ultradistance cyclists. Exploration of the topic included an examination of how cyclists utilized technology in preparation for and participation in ultradistance events. In addition, features of technology favored by participants were explored. As introduced in Chapter I, the following research questions guided this study:

Q1 How are ultradistance cyclists using emerging technology as part of their experiential learning process?

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?

Data were gathered through semi-structured interviews over the course of 18 weeks. The 10 participants were cyclists who utilized multiple technologies in their preparation for and participation in ultradistance events.

About the Participants

Phenomenological studies are an examination of the lived experiences of participants (Ramsook, 2018). These experiences were explored as data about the use of technology in the experiential learning process of ultradistance cyclists. To appreciate the lived experience, it wa helpful to have some background on those who lived the experiences. The following short biographies provide some context for the experiences expressed by the interview participants. Appendix I contains a summary table of participant information.

Albert

Albert is a 45-year-old male. He completed his first ultradistance event in 1999--18 years ago. He has since completed over 100 ultradistance cycling events ranging from 200 to 1,200 km in addition to several multi-day solo rides. Technology changes he has experienced included advances in hub generators, lights, GPS units, tires, gearing, and clothing. For the sport of ultradistance cycling, he noted that the improvement (and lower cost) of LED lights has been "a game changer." In conjunction with a hub generator, this has allowed greater flexibility in riding as well as improved safety. He felt the combination was "liberating."

For Albert, technology needed to be easy to use during an event. He tried various combinations and set ups prior to the event but wanted the technology to be hassle free when he was "on the clock." This was evident in the various GPS/USB/hub generator combinations he mentioned. He was willing to forego some technology options if an alternative was more reliable and traded features for ease of use. For example, even though mapping on the Wahoo device lacked street names and did not have a search function, Albert preferred it over the Garmin since the Wahoo was more reliable and easier to use. The Garmin would occasionally route him to non-existent roads. He did not have that issue with the Wahoo.

Comfort was also an important factor in some of the technologies he mentioned. He wanted a gear ratio that allowed him to spin at a high cadence. He also preferred wider tires since they absorbed more of the vibrations of a roughly paved road. This was increasingly important as the ride got longer. His preferred rain jacket had detachable sleeves that allowed him to wear it as a vest as needed to adapt to changing weather conditions on long rides. It also needed to meet randonneur safety requirements.

Albert felt physical comfort was needed to offset the mental challenge of staying focused for long periods of time. This helped fight the tendency to slow down when not paying attention. This focus was assisted by using a GPS for navigation and knowing his speed. Early in his riding career, he used a watch to estimate distances by time ridden. Current technologies provide accurate measurements of distance traveled and can include turn-by-turn directions as well as a map. This greatly reduced the potential for time lost due to going off course and was much less stressful mentally. On the other hand, he found that previewing the ride elevation profile and knowing how much climbing was coming up was NOT helpful.

While avidly using newer technology for lighting (hub and lights) and navigation, he did not place a great deal of importance on frame material. He preferred staying with tried and true steel. For Albert, the geometry of the bike was more important than the frame material.

Albert preferred to ride in a group but did not use technology for “social media” related activities like posting pictures or commenting on others’ rides. He uses Ride with GPS to plan routes and navigation but not for social interactions.

Albert has completed the PBP five times as well as multiple other 1,200km events. He tended to prefer multi-day randonneur-style riding. He has also done long, solo, multi-day rides. While he was very aware of how fast he was riding during an event, it was not in an effort to achieve a faster overall time but was more a focus on reaching overnight checkpoints with sufficient time to rest before riding again the next day.

Barb

Barb is a 45-year-old female who has participated in two ultradistance cycling events. Prior to taking up ultradistance, Barb participated in bike racing shorter distances. Barb's main focus was the Colorado Trail Ride--a self-supported 500+ mile mountain bike ride. It had extreme challenges made more so by weather (rain, cold, and lightning), altitude, and limited access to resupply. Miles ridden each day could vary dramatically due to terrain and weather.

From a tech standpoint, the Garmin InReach was her one critical tool. The "SOS" function allowed a measure of security even in the most remote locations. It also allowed others to track her location. The features combined to give her the feeling of safety and peace of mind to participate in the Colorado Trail Ride. Prior to using the Garmin InReach, she was not willing to go on multi-day rides in remote locations.

Barb also used the Mountain Bike Project Colorado Trail app, which assisted in navigation including finding water sources. She also used Strava but did not consider herself an avid user. When judging effort, she preferred to go by feel without the need of a heart rate monitor or power meter. She did use heart rate during her pre-ultradistance riding and felt very "dialed in" to her efforts.

She also mentioned that an important feature of gear was that it was lightweight. She also noted that packing gear on the bike was an important skill to develop--even a simple trash bag could be a lifesaver.

Due to extreme weather conditions, Barb had a challenging first attempt at the Colorado Trail Race. She was forced to suspend her ride at Silverton because of heavy rain, wind, and lightning. She returned in more favorable conditions to complete the final 80 miles. She is hoping for better weather for her next attempt.

Chad

Chad is a 49-year-old male who has participated in 30 ultradistance cycling events over the past seven years. His experience in ultradistance cycling has evolved over time. He mentioned that when he started ultradistance cycling, he felt a need to “crush the ride.” He wanted to ride every event hard and be a top finisher; this was true even in non-competitive events. He gradually adopted a view where he pushed hard but was now focused on challenging himself rather than beating others. On shorter group rides, he still pushed his effort and went hard. For the ultradistance rides, it became more about the experience than the final placing. This change in attitude was similar to “recovering agon addicts, who, before they joined the free play league, were hooked to the fierce competitiveness of the game” (Kolb & Kolb, 2010, p. 40). While he rode the shorter, faster rides during the week, Chad liked to ride one-day randonneur style rides at a fast pace on the weekends.

Chad’s use of technology reflected this change. He used a heart rate monitor as a measure of his effort. This use was not to avoid overextending himself but to ensure he was going as hard as he had in the past. He used Strava to track and compare volume and thought the “kudos” feature was a nice morale boost. The group features in Strava allowed him to see how his ride volume compared to others. Although he used the heart rate monitor in training and events, he felt very in tune with his fitness and preferred to ride by feel rather than have a prescribed workout. Chad liked to compete with his earlier performances on the same route or distance. While being faster than others was not a focus, he liked to put out a good effort on every ride.

Daniel

Daniel is a 43-year-old male. He has ridden 10 ultradistance events over the past five years. We talked about the challenges of the Colorado Death Ride during the interview. The first year he did the Death Ride, he mentioned the final climb was particularly challenging because of the repeated false summits he encountered. He knew the distance to the finish but not the amount of climbing packed into the last 20 miles. He found this mentally draining at the end of a long ride. Even with this experience, he tended not to look at the elevation profile during a ride. It was sufficient to look at ahead of time in order to mentally be prepared for the challenge.

Daniel used Ride with GPS to map his routes prior to riding. When this info was loaded onto his Wahoo GPS unit, it provided "pretty good" turn-by-turn prompts. He has used several Gamin devices over the years. However, the Wahoo provided better navigation and was easier to set up and use. This was particularly important on longer rides when he felt it was very important to save mental energy. Although he used Strava, he preferred Training Peaks. He was interested in exploring the use of the Total Stress Score in Training Peaks to measure effort and improve performance.

As part of his training, Daniel utilized the Sufferfest app for his indoor trainer workouts. He liked that these workouts provided power and heart rate targets. He felt the "real world" aspect of the video stimulated mental engagement and made the time pass more quickly than a series of efforts on a note card. He planned on adding a power meter on his road bike for the upcoming season.

In addition to The Death Ride, Daniel plans to do others in the Colorado Triple Crown--a series of challenging one-day rides throughout Colorado. Some are supported while others are ridden randonneur style. While times are recorded and there are cut-offs, all finishers receive the same recognition regardless of placing.

Ellen

Ellen is a 49-year-old female who did her first ultradistance cycling event 18 years ago. In addition to long-distance cycling, she also participated in (and has won) triathlons up to and beyond Ironman distances including eight days of back-to-back Ironman distance triathlons.

Ellen tracked and provided physiology for her coach but did not focus on it too much herself unless following a prescribed workout. She is still exploring the potential of her recently acquired Fenix 5 (Sapphire). She is intrigued by the possibility of easier control of music with her Fenix, taking advantage of the communication between tech devices (phone and Fenix). The on-wrist notification of incoming calls or messages is also a convenient feature.

Ellen has had privacy concerns with using Strava. Although she uses it for a specific challenge, she will “go dark” when the challenge concludes. She was uncomfortable with the automatic posting of her routes and was worried someone would be able to know where she would be if they were stalking her. She also did not like the “kudos” feature in Strava when given for a workout she felt was not a worthy effort. However, she did like when her Fenix notified her when she reached a goal.

Ellen noted that on long events, getting feedback on how far she still had to go could be discouraging. This was especially true early in an event. As the finish approached, she liked to know and be able to count down to the end. She also found it a challenge to keep navigation devices charged over long events.

Ellen's main focus was the ultra-distance triathlons including a deca-Ironman where the goal was to complete an Ironman distance triathlon every day for 10 days--a total of 24 miles swimming, 1120 miles biking, and 262 miles running. Ellen saw herself as a potential role model for other women interested in entering the ultradistance sport.

Frank

Frank is a 50-year-old male who did his first ultradistance bike ride 17 years ago. His use of technology in cycling has changed dramatically over the past six years. When he started riding, his only technology was a Timex watch on long bike rides. This changed six years ago when he received a Garmin as a gift. He now trains with power and heart rate on the bike under the direction of a coach. Unlike many other ultradistance cyclists, his main focus after 100 miles on the bike was not to ride a strong second 100 but to have a fast marathon run as part of an Ironman distance triathlon.

Frank has been trying to find the right heart rate monitor. He was struggling with balancing comfort and accuracy. He felt that for optimal performance improvement, it was important to have real-time, accurate measurements of heart rate. He found the chest strap monitors were more accurate but less comfortable. Although he found the wrist-based monitors were more comfortable, the reading could be more erratic. In his experience, the erratic and inaccurate readings were particularly evident early in a bike/run where the heart rate read too high for how he felt. Frank has a strong running background so he has a good feel for monitoring effort during a run. He is using technology to bring this same awareness to his cycling efforts.

Greg

Greg is a 40-year-old male who has participated in 35 ultradistance cycling events in the past two years. In addition to ultracycling, he is an avid bike-commuter. He has tested out new gadgets, devices, and even clothing while commuting before using them on ultradistance rides. Once he has ridden a couple hundred miles with the tested item on his daily commutes, he incorporates it into his ultradistance equipment.

Greg found nutrition to be a limiting factor on his long rides. He has tried a variety of foods but nothing has been ideal. His preference is for “real food” rather than bars and gels. However, time constraints and locations of ultradistance events have made it difficult for him to eat his preferred foods. He has yet to find technology that would solve this challenge. This nutritional challenge is a concern for Greg as he is planning on participating in longer events that are measured in weeks rather than days.

Greg found other riders could be too focused on hitting specific numbers both in training and during an event. He though they would do better if they relaxed, looked around, and enjoyed the ride. He uses Ride with GPS on his phone to assist with navigation. In addition, he uses a Wahoo for current information (distance, speed, etc.) as well as for recording data to look at after the ride.

Greg is interested in doing even longer rides although not necessarily the randonneur-type ride where the clock continues to run until you finish. He wants to do multiple back-to-back days over 200 miles with the possibility of doing some type of transcontinental ride.

Heidi

Heidi is a 56-year -old female who has participated in over 150 ultradistance cycling events since she started 32 years ago. In addition to participating in events, she also coaches ultradistance cyclists. She feels the use of technology is more important in training than during an event. Her stance is athletes need to know how to race by feel rather than be reliant on a device. That being said, she acknowledged technology could be used for targeted training until an athlete got a sense of what various efforts felt like. Of the various measures, she tended to prefer power to gauge effort. However, for some athletes, she has found heart rate works better. In the past, she used power measurements on an indoor trainer as a measure of recovery from injury/surgery. When she hit a target mark, this indicated a fitness level for her planned outdoor ride.

Heidi also felt that while technology could make it easier to measure effort, it could also tempt athletes off a planned workout. This was most obvious with the trainer application Zwift, which simulates a group ride in an indoor setting.

Heidi also thought the ability to communicate was a valuable feature of newer technology. Thinking back on her past competitions, she knows having a cell phone would have changed the dynamics of RAAM for her in 1990. It would have made checking in with race officials much easier as well as streamlined logistics for her support crew.

Ivan

Ivan is a 34-year-old male who has participated in two ultradistance events. This is his second year of ultradistance bike racing. His focus has been on 12-hour races. He will be doing five this year. He targets races that allow aerobars since he feels most comfortable with that geometry and there are enough events available for him to be selective. He tends to train using Power but found focusing on heart rate during races was better since it took into account weather (heat and wind). In the past, he planned out ride routes using Map My Ride but this has led to some less than ideal segments (some unpaved or dead ends) so now he also checks road conditions with Google street view.

Ivan uses a Garmin that connects to Strava and Training Peaks. He is exploring a Training Peaks fitness rating as a way to optimize performance at key races. Being new to the sport, he feels he still has a lot to learn.

Juliet

Juliet is a 54-year-old female who has completed about 20 ultradistance cycling events over the past 15 years. In addition to long distance cycling, she has also completed eight Ironman distance triathlons. She has found too many gadgets to be a distraction. She wants her devices to be simple to use without the need to fiddle to get them to work. She found it nice when Garmin synced with other apps so her data were all in one place.

Juliet likes to listen to music while cycling (and running). When preparing for the PBP in 2003, she carried a CD player in her jersey pocket with several CDs and replacement batteries. She has since upgraded to mp3 players and has used four iPods until they expired. She gets motivation from listening to music, which helps soften hard physical efforts. While she does not have a desire for the additional metrics of newer Garmin wrist-wearable GPS devices, she was intrigued by a recently released model that is also an mp3 player.

Juliet was greatly disappointed when she failed to complete the PBP on two attempts. This disappointment resulted in her not riding her bike at all for several months. The frustration in failing to finish was accentuated as she felt her preparation for both attempts was optimal. This feeling was based on comparing her times in qualifying rides with others who successfully completed the Paris-Brest-Paris.

Her interest in cycling was rekindled with the idea of riding LEJoG-- a ride across Great Britain from Lands' End in the southwest of England to John o'Goats in the northeast of Scotland. This ride is a distance of about 1,000 miles completed over 14 days and fully supported by a professional trip-guiding company.

The Author

For comparison, I am including a similar examination of my experience and participation in ultradistance cycling. I am a 50-year-old male. I did my first ultradistance ride 20 years ago. I have done about two dozen rides of over 200km. Most of these rides have been unsupported. Two of the ultradistance rides were races with the goal to cover the greatest amount of distance over a set time (12 hours). My participation in ultradistance events tapered off during graduate school. In addition to cycling, I also participated in running as well as triathlons, hiking, and backpacking. Over the past several years, my use of technology in training has been more focused on running rather than cycling. I use a wearable Garmin (currently a Fenix 5) and a variety of online and phone applications including Strava, Garmin Connect, My Fitness Pal, and several of the MapMySports. I have used Training Peaks and Ride with GPS in the past.

Although I have not been riding long distances recently, I have remained somewhat active. Mostly I have been doing shorter runs, hiking, and backpacking. I have been exploring the run- and hiking-related features of my Fenix 5. I wear the Fenix 5 nearly constantly. I found one of the most interesting functions to be the tracking of heart rate so resting rate is easy to determine. On the performance side, I am intrigued by the Training Effect score that is given after each run or ride. This is a number from 0 (No Benefit) to 5 (Overreaching). Scores for both Aerobic and Anaerobic Training effect are given; those scores could be useful if/when I begin training seriously again. Although my Fenix 5 is GPS enabled, it is not designed for navigation. For my return to ultradistance cycling, I think I would buy a bike-mounted GPS unit with a large screen and customizable data fields or use my phone with an app that provides navigation cues.

Data Analysis

Although this phenomenological study was primarily focused on a qualitative analysis of the use of technology by ultradistance cyclists as part of their experiential learning processes, it could be helpful to examine some quantitative aspects gleaned from the questionnaire responses. Of immediate note was the difference in average age of the respondents (43.8) compared to the national RUSA (2018) membership (53.9). One possible explanation for this difference could have been the distribution of the questionnaire through social media. A difference in technology comfort was seen in different age groups (Prensky, 2001). This difference in comfort would be reflected in a lower average age of social media user and his/her exposure to the questionnaire. This sampling bias was intentional since the purpose of the study was to examine the use of technology. The distribution method served as in initial filter in favor of technology adopters.

The findings of a study are brought about by data analysis, which is the making of meaning from the data (Merriam, 2009). Data analysis is the process of organizing the data with the goal of addressing the research questions (Merriam, 2009). Using a phenomenological approach, data analysis might be considered a researcher's dialogue with the text (Fleming, Gaidys, & Robb, 2003). Thus, data analysis requires (a) reflecting on essential themes both as they are uncovered and as they are developed, (b) the art of writing and re-writing, (c) establishing a strong relationship with the experience as it was lived, and (d) finding a balance between the parts and the whole of the research context (van Manan, 2014).

To accomplish these steps, the digital audio recordings of the interviews were professionally transcribed. I reviewed each transcript while listening to the audio of the interview. Minor edits were made to the transcript where the professional service, who was unfamiliar with the subject matter, made transcription errors. For example, one transcript contained the word "backpacking" where the participant had said "bikepacking." The transcript as well as a summary of the interview were then sent to the participant for review and approval in order to promote internal validity through member checking (Merriam, 2009). Any corrections or clarifications from the review were noted and incorporated in the transcript prior to the start of data analysis. Transcripts of the interviews were uploaded into NVIVO to support organizing, classifying, and managing of the data.

Coding, the process where the researcher attaches labels to data to explain what is occurring, was conducted utilizing the reviewed and approved transcripts. Emergent themes were identified and utilized to modify future interview questions to examine and more fully explore the concepts and experiences (Creswell, 2013). My observations and personal interpretation of interviews were recorded as interviewer notes and included in the analysis as well as providing additional bracketing context.

Two types of coding were utilized in this analysis: open and axial coding. Open coding was initially used to identify themes relevant to the study while axial coding was employed to connect the developed themes (Merriam, 2009). In this study, phrases, sentences, and entire paragraphs were highlighted and tagged as a node using NVIVO software. This process was repeated a second time to clarify the descriptors of each node. The transcript was then reviewed a third time and common themes were identified and the nodes grouped accordingly. A fourth pass was conducted to further group the nodes by theme and consider if they were relevant to more than one theme. This process was facilitated within the NVIVO software by the creation of nodes and sub-nodes to reflect each theme and supporting statements within that theme.

The interview template and questions were reviewed prior to the next interview with modifications made to enrich responses based on themes identified in the previous interview. This process was based on Creswell's (2013) generic "Data Analysis Spiral" (p. 182) and was repeated in each subsequent interview. After the first interview, this process was modified to include the expansion of a fourth pass to incorporate the review and modification of themes identified in previous interviews. The themes were then examined with the focus being on the "how," "what," and "why" of the essence of the ultradistance cycling experience. This process is outlined in Figure 3, which was based on Creswell's template for coding a phenomenological study. No new themes were identified in the final three interviews, indicating a strong degree of saturation was reached.

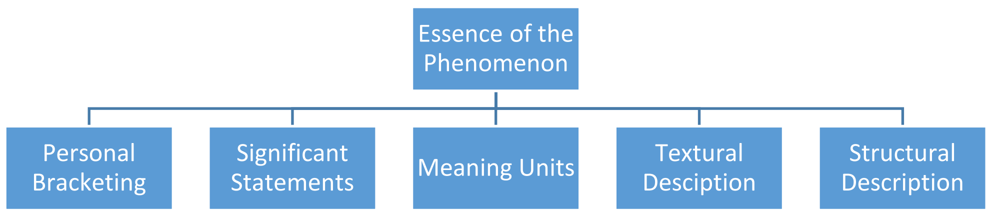

Figure 3. Coding process outline for this study.

As described above, this data spiral process, where summaries of central concerns with salient excerpts and important themes were written and rewritten, established the findings of this study. This phenomenological writing and rewriting was an essential activity in the research process (van Manen, 1997). The section below follows my thoughts as themes were developed, considered, modified, and kept or discarded.

Questionnaire Results

There were 182 respondents to the questionnaire. Gender distribution was similar to national RUSA (2018) membership. The average age of respondents was 10 years younger than the RUSA membership at large. This was likely due to an intentional bias toward technology usage introduced through the distribution method via social media.

Questionnaire responses were utilized to identify potential participants. Thirty-three respondents self-identified as technology users and indicated a willingness to be interviewed. Contact information provided on the questionnaire was utilized to identify respondents where face-to-face interviews were logistically feasible. Ten respondents met this criterion and all 10 were interviewed.

Theme Development and Coding

Initial Thoughts and Coding

I approached thematic coding from the perspective of my two research questions.

Q1 How are ultradistance cyclists using emerging technology as part of their ` experiential learning process?

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?

After open coding, two broad groupings--Technology Use and Technology Characteristics--were organized. Themes were then identified within each grouping. These broad groupings were reviewed, compared, and added to with each subsequent interview.

Technology use themes. Statements by participants were related to how technology was used in the context of ultradistance cycling, why they used technology, what they liked or did not like about technology and mentions of specific technology they used. I first considered the nodes I had identified related to how the participants used technology as part of their training for and participating in ultradistance cycling events. Participants were very prolific in identifying specific technologies they used. My focus was on exploring technology as part of the lived experiences of the ultradistance cyclists. While *what* technology was used was a consideration, the primary focus was on *how* it was used by participants. I examine the characteristics of technology participants identified as being important in a separate section. A list of specific technologies mentioned by participants is included in Appendix J.

Coding based on Kolb's experiential learning model. My initial approach for thematic coding was based on the assumption that participants would utilize a version of Kolb's (2014) model of experiential learning when they were preparing for and participating in ultradistance cycling events. The reason for this approach was I could recall experiencing various aspects of this model when I was learning to ride. I reasoned that if these phases were present in my learning experience, they would also be present in the way others learned. It followed that if using technology to prepare for and participated in ultradistance cycling was an experiential learning process, then the experiences of the participants would be covered by a theme based on one of the phases of the model. The four phases of the Kolb experiential learning model are as follows:

- Abstract Conceptualization
- Active Experimentation
- Concrete Experience
- Reflective Observation

Kolb (2014) based these stages on a two-axis continuum as seen in Figure 4. The Process Continuum reflects how a task is approached and the Perception Continuum reflects how a person thinks or feels about a task. The Process Continuum varies from watching to doing and the Perception Continuum varies from feeling to thinking (McLeod, 2017). I attempted to code identified nodes based on the four phases and on the two continuums. However, there were many statements where the use of a technology was based on *when* it was used rather than how a task was approached or how the participant thought or felt.

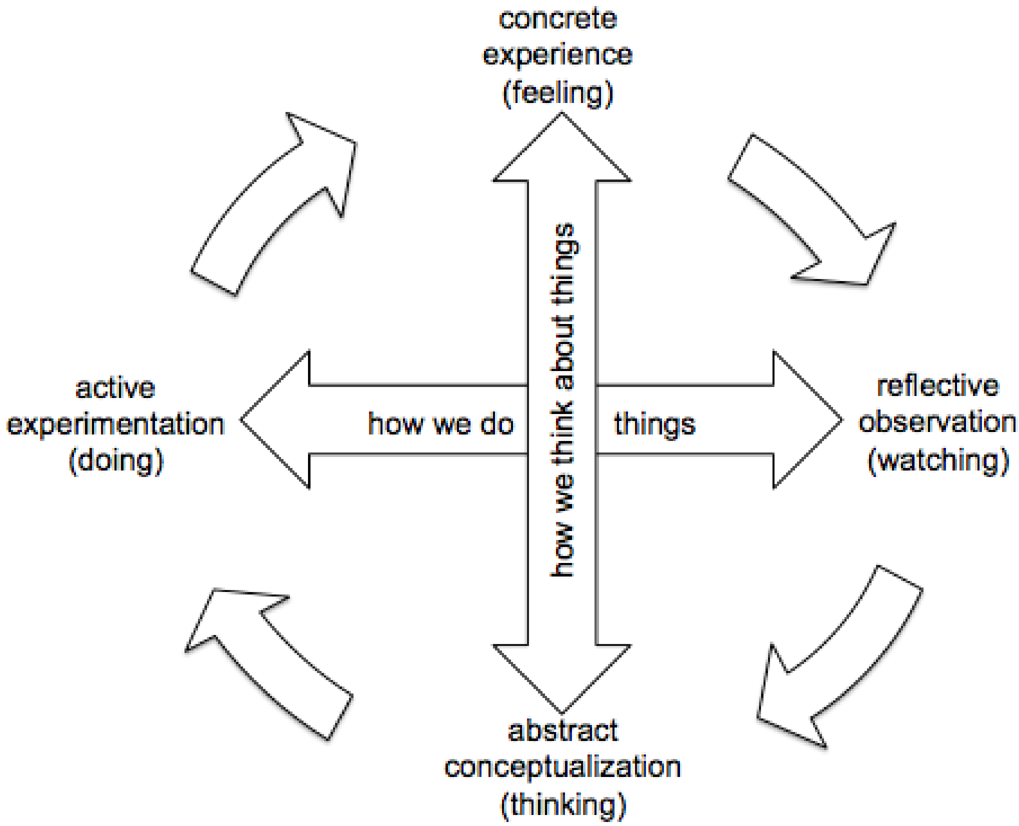

Figure 4. Two-axis continuum (Kolb, 2014).

Revision of the Kolb model themes. The observed uses of technology did not fit neatly into the basic Kolb (2014) categories. For example, several participants utilized various apps and devices to map their routes prior to riding. This seemed to combine both how they approached a ride as well as what they thought about the ride. Also, Abstract Conceptualization did not encompass the utilization of technology in physical preparation or training for an ultradistance event. In addition, the long-time scale of ultradistance cycling allowed participants to utilize technology to analyze, experiment, and overcome challenges encountered during an event. To help explain this process, it was necessary to capture the challenges and coping methods unique to ultradistance cycling as identified by the participants. While coping with challenges could be categorized as a form of Concrete Experience, it was such a common and recurring concept that I felt it warranted a separate theme. Upon reviewing the nodes, the challenges could be broken down further into mental, physical, and mechanical challenges with technology used differently in each category.

It became apparent during the coding process that the use of technology by ultradistance cyclists varied depending on when the use occurred. To help capture these additional concepts, a temporal layer of coding was added, which aided in clarifying participants' usage before, during, or after training and events. The Kolb (2014) model was integrated with the temporal sorting with Abstract Conceptualization occurring prior to an event, Active Experimentation and Concrete Experimentation occurring during an event, and Reflective Observation occurring after an event.

- Prior to an event
  - Abstract Conceptualization
  - Route Planning
  - Training
- During an event
  - Active Experimentation
  - Concrete Experience
  - Coping with Challenges
    - Equipment Challenges

        - Mental Challenges
        - Physical Challenges
- After an event--Reflective observation.

All nodes related to how ultradistance cyclists used technology in preparing for and participating in events were coded on the aforementioned three major themes and 10 subthemes.

Technology characteristic themes. In addition to examining how technology was used, I was also interested in the characteristics of emerging technology that enable participants to use them in their endeavors. It became apparent that to understand the preferences of participants for certain features, it was necessary to capture the unique characteristics of the sport of ultradistance cycling. In addition, it was helpful to identify the types of technology that had the utilized features. With these considerations in mind, the following themes emerged during the interviews:

- Features of Technology
    - Easy to use
    - Sync between devices
    - Reliable
- Features of Ultradistance cycling
- Types of Technology
    - Equipment
    - Technology

One difficulty that emerged during the coding of the nodes was related to the types of technology. In following the constructivist approach, I let each participant include any item he/she considered emerging technology related to ultradistance cycling. Based on the definition developed by Luppicini (2005), I narrowed the nodes categories in the Technology theme as those items involved the collection or organization of information; included were GPS units, cell phones, and training applications. Remaining nodes were categorized as Equipment including such items as lights, clothing, tires, and frame material.

Summary of Thematic Coding Process

After open and axil coding, nodes identified were thematically coded based on the two research questions. First, nodes were coded based on themes modified from Kolb's (2014) experiential learning with a temporal overlay and inclusion of a focus on challenges unique to ultradistance cyclists. Second, identified nodes related to the features of technology were considered and thematically coded into categories based on the features of the technology, the features of ultradistance cycling, and the types of technology utilized by participants.

Findings

Overview of Technology Usage

Participants utilized a wide variety of technology before, during, and after ultradistance cycling events. In addition to themes related to Kolb's (2014) experiential learning model, other categories were identified: Route Planning, Training, and Coping with Challenges.

Use of Technology Prior to an Event

This broad category included all uses of technology by participants prior to an event. The use of technology involved various methods of thinking about an upcoming event. The thinking activities aligned with the Abstract Conceptualization aspect of the Perception Continuum. However, several uses of technology for activities fell on the "doing" end of Kolb's (2014) Process Continuum. To capture these experiences, the categories of Route Planning and Training were included in the thematic coding.

Abstract conceptualization. McLeod (2017) noted Abstract Conceptualization is a reflection that "gives rise to a new idea or a modification of an existing abstract concept" (p. 1). This process was illustrated as Chad reflected on his Fitness/Freshness score generated by Strava and how he considered incorporating this information in his ultradistance cycling.

> Fitness Fresh, yeah. And then try to understand maybe my fatigue level. And I think Training Peaks calls it something else. It's not a Freshness, but it's the same metric and it's your fatigue level based on probably your heart rate or [inaudible], I can't recall. But you can plot that. And the guys that I ride with that race, short races, are extremely in tune with that, and any coaches, too. They're looking at those things. What I'm trying to do more of is trying to understand where I need to be relative to that metric, so that I can do the event comfortably because what I'm noticing is that where I'm trying to go in my head, obviously there's a certain amount of pain with any endurance event, but if I can't ever get past that and transcend it and kind of-- I'll never get where I'm trying to go. If I'm always just thinking, "This is horrible. I'm dying. I hate this," it stops me from getting to where I'm trying to go. And sometimes that happens. And sometimes that happens because I'm worn out and because I've done these group rides a lot the last two weeks and have crazy miles and I went out and did this ride. And I'm like, "This is terrible. I hate this. I'm in hell." But that might be a metric that I didn't mention that I'm trying to understand more and I'm trying to use more as a pre-ride.

This Abstract Conceptualization was also demonstrated as Ivan considered his fitness and different types of rides and when they should occur as developed by the automated Annual Training Plan within the Training Peaks application.

> Yeah. I tinkered with that. So that's pretty cool where it tells you the type of training you should be doing. You say when are your races for the year, and

> what's your A race, what's your B race, what's your C race. And it puts it in and it's like, "Okay, well, do you want to be fit, in this month, January, you should be building." And then as you approach, you should be--it has things like speed, power, cadence, specialties to focus on. But it doesn't say what the training is. Then you can go into their catalog of classes and say, "Oh, it matches this category. I want to do this workout." I see myself getting there at the end of this year or next year. I still don't have the time to mentally focus on it and really get good. Until I feel that my body has to catch up to where my mind is. My mind's got all these grand plans and like, "We should be this and we're an athlete," and my body's like, "Whoa, whoa, whoa. We're getting used to this. Yeah. That's why we made you take a month off.

Route planning. Route planning is another activity that occurs prior to an ultradistance event that is a blend of doing and thinking. As mentioned elsewhere, rides are long distances often on unfamiliar roads. Participants used emerging technology to plan or virtually scout routes in advance. This was often seen in conjunction with Navigation during an event discussed below. Daniel used Ride with GPS for mapping and found it made the ride easier since navigating was one less thing to think about ahead of time.

> I build them up before hand and then will go out and ride these big long loops and stuff. So that way I don't have to--and I do so many group rides with different places that are--one will be in Boulder, one will be in Longmont, or here or there. And I mean you just don't know all those roads by heart and by mind. So to build that route in there. And then just start and say, "I want to ride this route." And it goes, and you don't have to--it's brainless.

In some cases, the route was provided by the organizer prior to the ride. Technology allowed Greg to preview the course and make edits he felt he needed.

> They provided a GP[X] file or whatever format it was so I could [inaudible] have a joint file and then, obviously, my practice before I use one is to go through it turn by turn just to spot the confusing parts or glitches and correct those and make my own version.

Greg went on to say,

> You can add those to your cue sheet. Some cue sheets, whoever creates it will have those. Generally, they don't get added, they don't come with them, but sometimes I will add it. Like another ride, I did last year with the self-created and self-guided rides.
>
> He also used
>
> Strava for maps and that's a useful tool for learning your routes, for seeing shortcuts that you could have taken, to take in the future. Looking at where other people have been thinking, "I didn't know about that, that's interesting." You learn a hell of a lot from Strava. And that's my primary use of it really is just to improve my route making and find new places to ride.

Ivan learned that just using mapping applications might not be sufficient. He blended the technologies he used for route planning:

> But I'll look at Google Maps. And now, because I made the mistake a couple of times, I'll verify in satellite view. But I used to just use the map view, and be like, "Oh, that's a road. Look, I can do this big square around the airport." And you get out there and it's like, "This is a farm road. This doesn't really…" And so now I look at it and I draw a line over it and then I change to satellite. I'm like, "Are those all paved? Okay, those are all paved." There's one road that goes into airport property and there's just a big TSA gate there. And it's not on any maps or anything. It's nice, yeah. A combination of that. I've avoided most of those mistakes

Training. Participants prepared for ultradistance cycling events utilizing a wide variety of emerging technology. This preparation included physical training for riding long distances. In addition to riding outside in preparation, participants also rode indoor trainers, ran, did yoga, and strength trained. Probably the most common use of technology participants noted was for tracking and planning workouts.

Ivan used a training plan within the Training Peaks applications to layout his rides:

> But the way I set up my season is, I'll wait till I'm about 8 weeks out from a race and then put an 8-week training program in, which is kind of nice because then it's like, "You should be doing this today." And then I can make a decision, like, "Well, I can't do that today," or, I will try to look a week out. My fiancé and I run a small business and I used to have to go run a lot of it physically. And so I could look at my calendar with the business and the calendar with the riding, and be like, "Wednesdays are no good, but I have an off day Thursdays. So I'm going to push my off day to Wednesday and move that training day to Thursday." But still try to take a step back because if you do that, sometimes that can domino and hurt you like 6 days later. And you're like, "I have ridden for 10 days straight. What? Why haven't I rested?

Juliet kept her planning and recording more basic. She utilized technology for communicating with her coach.

> He still emailed me, not in a table, graph, or spreadsheet format. It was, "Monday, here's your warm-up, cool-down, and your middle." So there was no table, or graph, or colors, or anything to fill in. I don't know how I recorded my times and my workouts. I'm not even sure. I think I wrote them in a notebook.

In her role as a coach, Heidi noted the need to be prepared to adapt to new technology when developing training plans:

> I'll never forget what Alan Lynn told me. When power was really just coming out in TrainingPeaks and all that kind of stuff, I was like, "I don't know if I like all this." And he's like, "You're going to have to learn to work with all this. And he said, "The power's not end all. Heart rate's not end all. You know that. You have to take all of these things and learn to use them together. Your clients are athletes.

Several participants utilized indoor trainers as part of their preparation for ultradistance cycling events. Indoor trainers are sophisticated stationary bikes (Štrekelj & Kavšek, 2016). A technology that has emerged is the interface of the indoor trainer with computer software. This interface can help create individualized workouts for cyclists. The trainer adjusts resistance to meet specific power goals. This can create short high-power workouts for cyclists who want fast explosive speed or it can be a long-term lower workout that builds endurance. Daniel used software called Sufferfest for his indoor rides:

> Sufferfest has a test protocol that you do. It's another one of your videos. And so it has four different things that you do during that test protocol. And then it will say, "This is the type of rider you are. These are your scores on the four testing protocols. This is what you're good at. This is what you suck at. And if you want to get better at what you suck at, do these videos. If you want to keep doing what you're good at, do these videos." But it will tailor any of the workouts based on your rider profile, as opposed to "Do this video and have fun".

Daniel added:

> But with the technology upgrades that are out there now, you've got smart trainers. And it will do that. The Sufferfest video runs off of a computer or an iPad or something like that. So it will talk to the smart trainer. Or if you have the Wahoo [Volt], it will talk to your trainer too. And you can run it through that to change the resistance or you can just change. If the video says you're going to do this amount effort at this with this cadence, I know what gear I need to be in. So I'll just put it there and snatch it out. Plus it'll show you what your--say your cadence, your heart rate, and your power. And so you just match it. The way I have mine set up is I do my intervals off of power. And so then I just match the power that's required for that interval to what I'm putting out.

Ellen used a similar program. She did not feel it gave a true representation of effort:

> I did a test a couple of weeks ago, and it was a 3-minute test, and then there was a 20-minute test in the space of an hour. And had I been doing that outside, I would have expected during that test period that I would be going 18 to 20 miles an hour, and my heart rate would have been around 160. There I was going, oh, I think, like 11 miles an hour, and my heart rate was maybe 140.

Heidi, who coached athletes as well as participated in ultradistance cycling herself, appreciated the fact that efforts could be specified and measured on trainers: "TrainerRoad is good because you can put in--I have a client that uses TrainerRoad, but mostly he simulates things. But he puts in my workouts."

There were mixed feelings about the Zwift application, which creates a virtual ride environment where a cyclist can ride *with* others from around the world. This could create a competitive atmosphere. According to Daniel, this could be great for some riders:

> Zwift is--it's like a video game. So you log in, you start riding, you select a course. There's not a whole lot of courses that I'm aware of that you can select to ride. And then whoever else is online, they show you in the same environment. And so then, based on how fast you're pedaling and how fast your trainer's going--how fast your wheel is spinning, whatever--it will show you based off of what they're doing. So it's like an interactive online game. You can do interval training on Zwift as well. But most people just tend to get on there for a ride, and ride with people online.

Ivan found it helped pass the time for long indoor sessions--a challenge unique to training for ultradistance cycling:

> Yeah. It gives you an avatar with a road, if you don't want to watch a movie while you're riding. I like having it on the laptop and then I'll watch movies. And then, kind of at the end of a nice long 6-hour session, for the elevation it calculates, it's pretty good real world, like, "Hey, you would have gone 100 miles" or "You would have gone 82 miles.

However, Heidi saw it as a potential hindrance to specific training plans:

> Try to tell them not go to sign up on Zwift or all these things. They're like, make them go blow their programs. That you have virtual friends, or your real friends, but it's virtual-looking. I mean, there are races. It is the future. I don't think it's the future forever because I think people will wrap back around and start going, "Well, now [I'm over-]trained." I'm like, "Yes, just like those Tuesday, Thursday night rides [laughter]." So a few years ago, I would tell clients, "No, you can't do spin classes unless you sit in the back, and you fake out the teacher, and you got your little program there. You can't do that Tuesdays, Thursdays evening a month ride.

Although I classified this theme as Training, this word was not how Greg described what he did:

> I don't even call what I do training. I don't like calling my rides training even though they really are. Every time I ride 200k, it's training for a longer ride but that's not what I call it. I just call it riding my bike. Again, probably, I could become a better athlete if I trained to data but I don't consider myself an athlete.

Use of Technology During an Event

This broad category included all uses of technology by participants during an event. In addition to using technology as part of their Active Experimentation in the event and enhancing their Concrete Experience, participants utilized technology to Cope with Challenges specific to ultradistance cycling.

Active experimentation. In active experimentation, the cyclist applies what is learned from technology and applies it in ultradistance cycling. For example, Chad paid attention to his heart rate and power during a ride and related it to previous efforts:

> And those metrics to me, are very important and I'm aware of them, and I'm looking at them. On the ultra-endurance stuff, and this is like an ego thing, I think, but I'm far more concerned with heart rate than I am with power. The reason that is because, over the years, I've noticed that your power will just [dive] which over the course of the endurance of that. So it's just like I'll fall off a cliff at some point, and I'm just maintaining just the bare, bare minimum to be able to move forward. And I'll kind of watch it a little bit, but what I find is it's almost like a negative reinforcement. It's not the energy that I want to have because I'm concerned that it's not high enough. And I'm like, "I would be [inaudible], I'm not putting up enough power, I need to step it up." These things are always something that creates a feedback loop in my head which I don't like to have. And I find that if I concentrated more on heart rate and inducing adrenaline where I am relative to the other riders, or the speed that I'm going, or the time that I'm making relative to past rides, that I can kind of stay in a much more positive or mental space. And I kind of know where I need to be heart rate wise, or where I want to be heart rate wise for the most part over the course of the day where I'm not burning too many matches. But I'm also not kind of taking the ride off or have to ride off.

Ivan experimented with adjusting effort in response to ride conditions:

> I know what my heart rate zone 2 is, that matches up with what my power zone 2 should be. But my second race was out in North Carolina in August and the heat index was like 120 by noon. And my heart was beating so fast and I was so exhausted and I was trying to figure out what was going on because I thought I was--I'd checked my power numbers in between laps and like, "Okay, well, you're holding power where you should be but you're killing yourself. You're not going to last the whole race." So I said, "Okay, no more watching power. Watch your

> heart. Put your heart where it should be, even if it feels too easy." And that got me through the rest of the race.

Taking it a step further, he was curious about LEOMO technology as a method to improve performance:

> They're a company up in Boulder and they make sensors. They're trying to partner up with--who's the guys that do the--Re-Tool. So they're selling a sensor kit that's on your elbow, on your shoulder, on your knee, your hip and your toe. And it reads all the angles into a head unit. So it's like, "Well, your power dropped 20 minutes into the ride, but you shifted your hips forward 5 degrees. Why is that?" That kind of level of detail. It might be overkill, but if I had a coach, I think they would be interested in that.

Greg used active experimentation on shorter rides to refine his choice of technology and other equipment for longer rides:

> All through the winter, you're riding at night, and that's where you test your setup, so it works great. It was easy to transition to that, because everything's been tested on commutes, and if it fails on a commute, it's no big deal, you can always walk home or get a ride home. It's perfect testing and proving ground for night riding.

Greg went on to say,

> I mean, there's been several times where I've not been using it correctly, and I've realized that while I've been testing it on a commute. Every aspect of my [cycling] is tested on commutes. Every new pedal I buy, every new pair of shorts--shorts and clothes, especially. Wear them on commutes for hundreds of miles or out before you take them on a long ride. That way, if you're a bit uncomfortable, the commute doesn't matter.

Concrete experience. At the heart of the experiential learning process is encountering a new situation. This theme captured the new experiences of participants involving emerging technology. Juliet first encountered using GPS for navigation during a bike ride in 2017. It was a key piece of technology she recommended for new ultradistance cyclists: “Absolutely get the GPS because you just pay attention to the surroundings, to the ride, instead of looking at the map in every single turn. That was a huge freedom."

Daniel also found the use of a new GPS enabled cycling computer changed his cycling experience: "I had a better computer on my bike, and that allowed me a better show the course and how much more distance I had exactly and I could where the next turn was coming." Barb selected the primary technology she used during a ride based on what she was trying to accomplish: "If I want to track, I'll use Strava. Yeah. But if I want to navigate, I'll use MTB Project, but I can also use this to navigate [indicating her inReach satellite device]."

Albert found the combination of LED lights and Dynamo hub power generators to be technology that changed his ultradistance riding experience" "Dynamo, that's been another game changer. That's so much better. So I don't even mess with batteries anymore." He went on to say:

> If you're doing 1,200[km] or however you're going--the light management with Dynamo, you just throw it out the window because you have your light anytime you want it, for as long as you want it. And it's really kind of a liberating sort of feeling when you first get one it's like, "Wow, I don't have to worry about anything" and so I use it.

For Barb, the purchase of a SPOT satellite tracking device was technology that enabled her to take part in ultradistance cycling:

> That's why I say it was the game changer for me. Because I have wanted to bike pack for years. I have had a healthy obsession with this for a long time. And I would ask my boyfriend, for two or three years, I was asking him like, "Come do this with me. We got to do this." We love to ride mountain bikes, we love to hike, and this is the best of both worlds. And he was like, "Mehh." So once I got this and had the ability to communicate then I was out of here because I could go off by myself and spend overnights and have that safety factor.

In addition to being able to send out a help message, a SPOT also posts location information that can be viewed on a website. Frank used this function: “You could go to the Spot website and it would [bling?]. It would show an aerial [map view]. I can see where the car was sitting with the Spot [laughter] almost and say, "Oh, they're at the Safeway.” He passed along this information to others who were not aware of the possibilities:

> But the nice thing was [we] had a SPOT. And what happened was is they ended up tracking us. And whenever they'd talk to us, they'd be like, "Have you seen Bob? Have you seen Joe?" We're like, "Oh, yeah. We passed him an hour ago," or "Yeah. They went by us a couple--a day ago." And they had a better feel where everybody was in relation to our SPOT and where Leslie was with the exception of the first two guys, I guess. So they were actually using us and we were actually brought that race kind of like into the computer age and started using technology. And now I think they might use SPOT or something else.

Frank found this tracking ability so useful he has explored using the Track My Phone app to fulfil this function in other situations:

> We didn't try to do the SPOT because that would have been more difficult because then, you got to go through another--two or three different ways to do it and there's places in Florida that just don't have any coverage, which is hard to believe. So as long as we had a phone that she actually had a good feel. You can get in, zoom in close enough on Track My Phone. And she could be at an intersection and go, "Okay. He's on the right road" or "It's going this way." He needs to get back on course. And so that was huge. I don't know if anybody else was doing that, though.

Coping with challenges. Many of the Concrete Experiences involved ultradistance cyclists utilizing technology to overcome challenges they encountered during training or events. Challenges were loosely categorized as mental, equipment, or physical.

Mental challenges. Newer cycling computers and GPS units have multiple screens that allow the rider to customize what information is displayed. This not only gives an increased sense of control but also could minimize information that could be demoralizing. Daniel demonstrated:

> No, I didn't have the profile. I can pull it up. I can change screens and then pull it up on there because that's one of the screens that it will do. But those long distance things, I tend not to want to look at that [laughter]. Because if you're suffering going uphill and you're like--what I see is coming up, I can see that but I don't want to know that it's going to stair-step six times when you're doing 200 miles.

The ability to customize created an additional challenge for Albert:

> Actually, in 2007 when we did PBP, I had my computer in kilometers. And I think that screwed me up because I wasn't used to it. I'm thinking, "Oh, 17, I'm doing great!" No, 17 kilometers an hour, you're not doing great. Since then I've switched so many of my computers to kilometers that I'm used to it and it's not a--I don't know that that ever entered into it [laughter]. I think I was just slow. But mentally, those kinds of things can kind of mess with you, especially when you're super tired.

For Ellen, being able to measure progress, even if slow, was important: "It might have been the second day, that it was viciously windy, and I think I was going about 5 miles an hour for several hours and just using the bike computer to see, 'Okay. It's really windy, but I'm making progress' was kind of important." Ellen also played music as a mental distraction: "Because occasionally, I'd dance. I had headphones, so I had music on the whole time."

Juliet also listened to music; she used a bulky CD player since she entered the sport before there were iPods and cell phones with mp3 players: "I did ride with music sometimes which was new to me. And I had a CD player and four or five CDs that I would wrap in plastic and put them in the back of my jersey, and I would change them as needed. But I had an entire CD player." She went on to say,

> I just remember also having some change in my CD bag and worried that the change was going to scratch the bottom of the CD, and I wouldn't be able to play.

> And I carried extra batteries in case my CD player would--because I was riding for 10 hours, 12 hours at a time.

Although music provided a distraction, technology also provided focus for Ellen:

> In the middle of the night, it's really important to see what my speed is because you don't have any clue how fast you're going at night. And so if I could see it, I could kind of keep myself from slacking off too much while thinking I wasn't slacking off.

Equipment challenges. Adoption of emerging technology was a mixed blessing. Every additional piece of equipment brought with it an additional potential source of failure that could evolve into a ride-ending challenge. Light, GPS units, and cell phones need to remain charged to be useful. Previous themes illustrated the utility of these technologies but keeping them charged was a challenge. Ellen explained her thinking on this topic:

> They're thinking of ways to charge the Garmin while they're riding. Right? And so I think that's probably the biggest issue, is if I'm doing a race that's a multi-day race, none of the stuff I have is going to last that long. So I either have to downgrade to older technology, or I have to come up with some swapping mechanism or charging while I'm going.

And how she met this challenge in some events:

> So for Ireland, I had a bike computer that lasts for six months or whatever, so that wasn't an issue. But my little iPod suddenly lasts for 12 hours. So I had three of them. And whenever one would die, I'd pass it off to the car, and they'd charge it and give me another one. And so I'd have to keep rotating it through. Now that I've got this Garmin thing, I think it lasts for 18 hours. So when I do a longer race--I just did this race in the fall, and I had to have his bike computer as well. And so I used mine until it died, and then I switched to his. And then he charged the other one, and so I had the ability to switch back and forth.

Albert used a Dynamo, which is a generator built into the hub of a wheel. Power is generated by the wheel spinning. Slightly more resistance slows the rider down a bit but it creates a reusable source of power:

> So what I do is I plug it in all day--I charge it all day when I ride and then when it gets dark out, because your light and charging don't work at the same time for most pieces of equipment, I just unplug the Garmin or the GPS, Wahoo in this case.

He also noted the "Luxos has a little cache battery, so the hub charges a battery, which then charges your whatever."

Greg also used a hub generator:

> I have a dynamo USB charger which is sufficient to keep one device charged. Keep your phone charged [or] your GPS charged during daylight hours. In the nighttime, when the lights drawing more power, you don't get the charge from the device but most the riding was in daylight hours so it's not really a problem. I also carry an external battery sometimes if I need to.

Chad adopted a different approach: "I carry battery packs. I don't know how much they store but I have some reviews, different holes, small battery packs that I carry anything. During the ride, I'll try to charge up some of my electronics."

Physical challenges. Long events place demands on the body. These demands can pose challenges to completing ultradistance cycling events. Participants utilized technology to meet those challenges. The challenge of navigation, the act of physically getting to your intended destination, was often an issue for the participants. The physical aspect was often discussed in conjunction with the mental challenge. Route mapping was discussed in an earlier section. This section focuses on the use of technology to overcome the challenge of navigation during an event.

Daniel uses a GPS unit on his rides:

> Once you build it in Ride with GPS and say that's a route that you want to do sometime in the future. It automatically sends it to the Wahoo. And then all you do is turn on your Wahoo and select it from your list of routes. And then it will give you turn-by-turn directions.

He went on to say,

> It gives an audible. You can turn on. There's LED lights across the top. And so the lights will come on indicating which direction you turn. And then it beeps faster and louder and the lights go faster as you approach the turns. And plus it'll tell you on the screen.

Ellen talked about upgrading from her old cycling computer: “I have a Garmin cycling computer which I didn't have then, which gives me my heart rate, and it gives me my location, and it does all of those kinds of fancy things.”

Frank also upgraded his cycling computer:

> That's what we use. For Dirty Kanza, we will use the bike computer. The 520, or whatever it is, with the map function. So that it has--it tells you the--it's a must-have for navigation, because it will tell you, as long as you've got it set up right [laughter]. It'll tell you when to turn within a few hundred feet. So you know. You don't actually have to slow down. And look at your map. And go, "Nope. It's not that one, it's that one." You can kind of--It'll give you an arrow. It'll say, "Turn left on County Road 44." And you're like, "Okay. Cool. That's coming up. There's County Road. Oh. Good. Phew." And it just keeps you moving. You don't have to slow down. You don't have to speed up. You don't have to stop and think about it. So the bike computer has been huge for that kind of thing.

Greg used a Wahoo brand rather than the Garmin GPS device. He also noted that many cell phones have GPS built in and can be used for navigation:

> The Wahoo, I do sometimes use for navigation as well. It's not quite as good as the phone because the screens a lot smaller and it just doesn't have a vocal cue, so the cues are purely visual, but it is really reliable navigation and I figure since I've got it I might as well have it. And then I've got two different independent navigation devices which further reduces mistakes and errors.

Juliet lamented the lack of having a GPS for navigation during one of her rides:

> Technology was extremely important in that ride. And we were at a disadvantage because we had maps. And it was very enjoying riding with other people. We relied on their technology, their GPS, for all the twisty turns that were required for one day of riding that would have been five pages of directions. And I think, had we not been able to keep up, be a part of the group, use other people's technology, because we didn't have it, I don't think it would have been as much fun.

This emerging technology is now very common in ultradistance cycling events as Albert pointed out: “You're in the group and a turn comes up and you hear a collective beep from their GPS units.” Technology solutions for navigation were not just for riding on streets. Barb used a navigation app called the MTB during her Colorado Trail race. “Just the MTB Project map and it shows you--you can hit a button, it'll show you exactly where you are.” She found the information the app provided was very up to date: “It's pretty darn accurate, actually. And that's why I use the map on that as opposed to my inReach to navigate.”

Physical safety was also a consideration where emerging technology played a role. Greg noted the development of an on-bike camera could be useful in that respect: “The cameras on the go, GoPros--look if you ride a lot in dangerous, trafficky situations, and your camera works in the dark, I'd say it's well worth doing.” Similarly, Albert observed hub generators and LED lights needed far less power than older technology, which allowed use not just at night: “That daytime running light? It's a nice feature. You just leave it on all the time and that's a really good safety feature.” He went on to say, “A lot of people just leave their primary light on all the time because it's a safety feature.”

Use of Technology After an Event

After an event, participant use of technology was much more watching than doing but generally balanced between thinking and feeling. However, in some cases, the thinking transitioned into making plans for the next event. Reflective Observation summarized the predominant use of technology with some instances of Abstract Conceptualization. This overlap captured the circular nature of Kolb’s (2014) experiential learning model.

Reflective observation. Reflective Observation is the process wherein a learner looks back on his/her experience and ponders any inconstancies between what was expected and the actual experience. Technology plays a role in this reflection as a reminder of what was planned and what really happened during a ride. This has a greater impact in ultradistance events because of the long time periods involved and occasional lack of sleep. Several participants noted multi-day rides tended to blur together. During the interviews while reflecting on particularly long or strenuous events, they would say something along the lines of “day two or three. I’m not sure which.” Technology helped jog their memory and aided in the reflective process.

Chad used this process to gauge his effort and how it compared to other riders on the same route. He looked at his heart rate and power meter recorded and displayed on the Strava:

> Yeah, after the ride. And it's really more of a--I ride everyday, and so it's really more of kind of like a glance, like I'm kind of looking really quickly. I suppose I'm trying to calibrate in my head where I think I am, and if I--based on that and also how I feel. And if I felt strong and if I can look at those metrics and say, "Okay, I have this much in anaerobic, and this much at threshold, and this much." And I can kind of say, "Okay, well that was a good solid effort." What I also do, which I don't think is, well I don't know, I mean since it hadn't been a struggle. I'll look and I'll see how all my segment are comparing to what I've done in the past and say, "Okay, this was-- I have nothing in the top three for anything that I've done here compared to historically."

When asked about his hardest effort on a ride, he also referred back to Strava. He knew it was one of three long events but not which one in particular: “Just go back historically and look for summer because you look and see what month you did the big, gigantic rides, and it'll be one of those three.”

Ivan used the Training Peaks app in a similar fashion. He tracked his improvement over time based on the metrics of his rides:

> I'm still trying to suss out how they all play with each other and how that works. Right now I feel like I'm just trying to collect as much as possible. And then if I look at it on a 6 month time span, I will see a gradual improvement and some rise. When my power meter is working, when I want to watch that more day-to-day specifically, TrainingPeaks, starting to learn how to use that.

He also reflects that sometimes there were conflicting interpretations of the information the technology provided:

> I think it's super fascinating because the technology is getting there to where it can provide all these data points to you. And that is great. Where the sport is struggling and where the tech industry for the sport is struggling, is how to interpret the data. Like, I'm in TrainingPeaks. I have these numbers. I know they're good because they say they're good and I've read, "Oh, this is how it's calculated." But I've also read people in the community who are like, "Don't use TrainingPeaks. This is my belief and this is how I train and this is where my rationale comes from." And it all jives and it all makes sense. I had a rude awakening when I was like, "Well, my heart rate should be here for this power. Does my heart beat faster than other people? Does it beat slower than other people?" And it was like, "Well, are you using Coggan's zones or are you using Friel's zone?" And I'm like, "What?" And it turns out, I think it was Coggan's, and it was like, "Those fit my physiology and Friel's don't." And I'm like, "Well, is Friel wrong?" So I have no problems with the technology in our industry. I have problems with what the technology is based on. Like, who really knows what they're talking about? All athletics is that way. Go down the rabbit hole and start talking about nutrition, and that's just like so many passionate, passionate viewpoints on what the right way [inaudible] are. And it's a very personal thing. It's equally parts helpful, equally parts frustrating. But technology on the bike, in a nutshell. But I don't think I'd be into the sport as much as I am if it wasn't there.

Daniel used both Training Peaks and Strava:

> I upload all of my rides to Strava of course and then I also use Training Peaks. So I do both of those programs to kind of look at how you did compared to where you've ridden at…area before and then with Strava as well. You can compare your ride to the other people that you rode with too. And watch that so that you can see like, "Hey this is where I was riding faster than one, two or three or XYZ." And watch that build and then Training Peaks will break down how your heart rate did, where's your high, where's your low, what it was compared to the overall ride, how much energy you expended, what was the training stress that was involved in that ride. Kind of help you say, "I need to go take this amount of time to recover and stuff."

Albert reflected that the technology did not have to be complex to be useful: “But having the technology there to…you need to really watch the clock. If it's just your wristwatch or whatever. Plan for when you're going to be at your overnight spot. Are you on track or not.” He also noted not every ride was a pleasant experience to reflect on: “Some rides you just don't even want to look back at.”

Reflecting on past numbers could also play a role in setting goals as Greg discovered:

> But last year, for example, I realized towards the end of November, I'd get 10,000 for the year if I just upped it a bit. So I did that in December, I rode it for more miles just so I could get 10,000 miles. I think that's the first time I've ever done something like that and I wouldn't have been upset if I hadn't but it was a little extra thing to go for in December.

Not every participant was enamored with the use of technology as part of the reflective process. Juliet preferred post-ride chatting in a pub after a long ride over pictures and comments posted on Strava or Facebook:

> People posted the profiles and their completion every day, "I did so and so miles at this speed." And I could care less when people post that. That does nothing for me. I find it annoying. It's not that I don't care about the person, I'd rather hear firsthand, "I had a good ride." I don't feel the need to share every workout, and here's the GPS of what I did. I don't read it. As a friend, or as a training partner, or as someone that I know, I don't read it.

Juliet went on to say,

> I think we talked about the general impression of the ride. Was it a hard day? Was it an easy day? Did I enjoy the people I was with? What hill was exceptionally hard? And whether or not I could make it up the hill. And we did look at when we had a 17, 18 percent climb, what speed we went, and how long we could maintain that [laughter], and how low that number could go. And I knew that I could ride four or five miles per hour for a certain amount of time. But when it got to three or four miles per hour, I'd have to get off my bike. So when things got extreme then I looked at those numbers.

Chad liked the Kudo feature of Strava:

> It has everything I need on it and also there's this social aspect that I'm very involved in. It's how I know what my friends are doing, and how I keep up with them, and how I share rides. And also, I think there's a positive energy on Strava where if I go do something, [inaudible] kudoing or saying, "Great job." It's almost never negative. And I really like that. I like being able to say it when [hushy?] friends do ride, I like saying, "Great job. That's fantastic."

Ellen had a different opinion:

> I've got my stuff hooked up to Strava, and I'm doing this little mile jog, and I get, "Kudos. Great job on that 17-minute mile run that you did." Right? And I'm like, "I could take Kudos when I go do like…" we did the Manitou Incline the first week of the year. And that was tough, and that was super fun, challenging. Pausing, and breathing, and looking back, and worrying you're going to fall down, and all that kind of stuff, I'll take Kudos for that. I am not going to take Kudos for a, "I went and jogged a mile."

She went on to say, “I'll take Kudos for things that are worth Kudos, but I don't like…it kind of irritates me that I'm like, ‘So you really think I'm that out of shape that going for a mile run today was a big, 'Good job, girl'?"

Summary of Technology Usage

Figure 5 provides a visual overview of themes and their relationship.

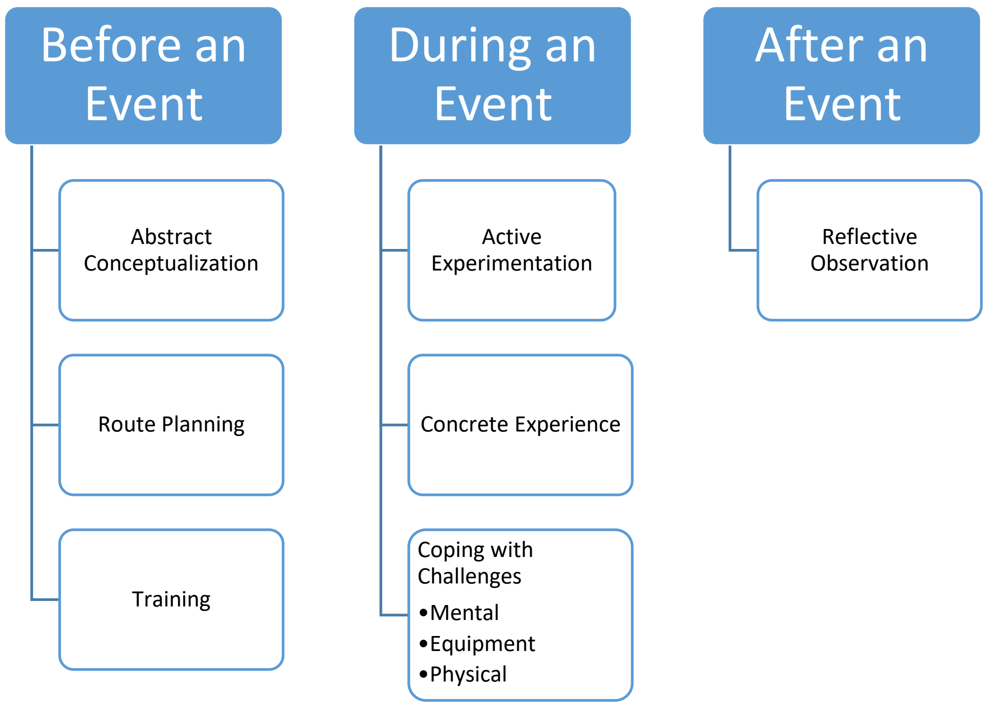

Figure 5. Visual summary of technology usage themes.

Characteristics of Technology

In addition to exploring how ultradistance cyclists used technology in preparing for and participating in events, I also wanted to examine the features participants identified as making the technology useful.

Features of technology. A number of themes related to features of technology were developed. These features were identified by participants as being important to preparing for and participating in ultradistance cycling events. A prominent feature in many of the technologies utilized was the ability to Record and Display Information.

Additional features that factored into participants' selection of technology were Easy to Use, the ability to Sync Between Devices and Applications, and Reliability.

Record and display information. Participants wanted to know where there were and how they were doing during ultradistance cycling events. Individual usage changed over time. Albert, Frank, and Heidi specifically mentioned relying on a simple watch during their early participation in ultradistance events. This use evolved to include the use of GPS devices that also tracked heart rate, power output, and even provided turn-by-turn directions. Most devices allowed users to customize their display. Daniel's use was typical: "When I'm riding I have speed, distance, time so elapsed time not clock time but elapsed riding time, elevation, gain, climbing grade, and then heart rate on there."

Easy to use. Ultradistance events last many hours or even days. At some point, riders become tired but still need to utilize the technology. Participants did not want to have to spend precious mental energy trying to get a device to work. Features helpful for nighttime riding were common in ultradistance events. When combined with a cell phone, voice prompts were given. As Albert put it,

> [The Wahoo] ELEMNT was just so easy to work with and set up… If I know someone who is just getting a GPS, I tell them to get the Wahoo because it's so user-friendly to start out. When you just touch the screen, the backlight would come on.
>
> Ride with GPS, the basic is free, you just sign up. But if you get the premium you can get a routing capability that will work off your phone and its got voice prompts and everything, it's actually pretty darn nice as long as you have a cell signal.

Daniel found the process to upload a route and have directions to follow was very easy with helpful prompts and cues during a ride:

> Much more easier to upload routes, especially when you're doing long-distance stuff, you can't memorize 4,000 turns, but if you can put that into your computer,

> then you don't have to have a map in your pocket and pull it out, or a [cue]-sheet. You just put it on your computer. And the Wahoo is much easier, the user interface is a whole lot easier to load those maps.
>
> It gives an audible [notice]. You can turn on. There's LED lights across the top. And so the lights will come on indicating which direction you turn. And then it beeps faster and louder and the lights go faster as you approach the turns. And plus it'll tell you on the screen.

Juliet summed up her choice of technology based on ease of use:

> The larger and the easier it is for me to use a piece of equipment is more important for me than the functions because if it's difficult to fiddle around with, I'm not going to use it. Ease of use, ease of looking at the mileage, and toggling through, and especially keeping track of when you're on 120 miles, as opposed to 123, where on the map.

Sync between devices. Every participant used multiples technologies. During the course of the interviews, it became apparent no device or gadget would do everything a cyclist would want. It also became evident that an important theme was the ability to transfer and sync information between devices and applications. Data transfer utilized different media including hard wire connections between devices, phone data transfer, WiFi internet, Bluetooth, and ANT+ (wireless technology that allows your monitoring devices to talk to each other).

Albert started by creating a route on his computer: “I build my route in there and I just save it in Ride with GPS. On the Wahoo, on the head itself, you turn it on and you go to Routes and you just hit Sync and it uses your Wi-Fi, so you got to set that up.”

Daniel followed a similar process:

> Build the route in Map My Ride, which is an online computer program, and then you have that app on your phone, and then the Wahoo [Volt] talks to your phone very easily and so you just…you put one thing on your phone and it sends the route to your computer head unit and then it's loaded.

Ellen recently switched to a Garmin wrist-worn device that tracked all of her activities. She previously synced her various devices to a web-based app to have all of her workout information in a single place:

> I had a Garmin running watch that I was using just for running. So before, I had my Garmin bike computer that would upload as soon as I finished a ride to TrainingPeaks or Final Surge. And then I had my running watch that was a Garmin that would do the same thing. And so I had all the little bits. This is the first kind of unified thing.

Greater support of syncing between devices was also a determining factor in Frank's latest technology purchase: "It syncs better with Garmin Connect, it syncs better with picking up other…like a PowerTap, like a CycleOps, PowerTap on automatic hub, that kind of stuff." Although, I suspect some of it might have been driven by device envy. Frank went on to say,

> I mean, I went from, I had a little thing that I had to put into my computers, so it would download that way, and then someone at work has the new 935 at the time and he's like, "Oh, dude, I don't have how to do that, it just goes straight in and into Bluetooth" and then I'm like, "What the hell is that?" I'm like, "Come on."

Reliability. It was important to participants that devices be reliable. Lack of reliability of a current device was often the driving force in the search for and adoption of a newer technology. This was the case for Daniel:

> I've had three Garmins or four Garmins now, and I get about two years of use out of them, and they start to be very finicky about, you know, the heart rate won't work all the time, or the map gets very hard to load maps onto it, so that's kind of what prompted me to change.

In addition, it needed to be reliable for the entire ride as Chad pointed out:

> It depends on what I'm doing. My favorite is the 520 because it has a good combination of metrics and battery life. And so you can get maybe 15 or 16 hours out of it. Maybe 15. And then it also gives you a pretty good display, pretty good mapping capability, basic, but pretty good. The 500 will go to maybe 18, 19 hours sometimes of battery life. And so if I'm doing maybe a longer, one of those Triple Crown things, I might keep that as a backup. And I'll run too. I

> hardly use the 810 anymore. It has the best mapping capability but I find that the battery life isn't really sufficient, I mean, it's 8 hours or something like that maybe.

Even on shorter rides, Juliet found the lack of reliability was an issue: “I did not have a computer that worked. It was a little bit annoying.”

Features of ultradistance cycling. To better put the features of technology into context, I collected the nodes concerning features of ultradistance cycling into a theme. Unlike the Challenge theme examined above, the Feature theme was broad in nature rather than specific as illustrated in the earlier theme. This theme also helped emphasize those aspects of ultradistance cycling that were important and relevant to their use of technology.

Distance. It was no surprise that distance was an identified theme in the sport of ultradistance cycling. As noted earlier, the criterion for ultradistance for this paper was a ride over 200km. In email correspondence prior to the interviews, as well as with potential participants who were not interviewed, several comments indicated this distance was too low of a threshold when discussing “ultra.” Most events the participants identified as ultra were 360 to 750 miles in length.

The long distances contributed to the solitude of riding those events. Daniel noted this about the Colorado Death Ride:

> Because it's such a long distance, and really, we have like 20 or 30 people that are crazy enough to try to do that in one day, and so it's not a huge group but over the course of 16 hours, you just get spread out enough to where you're not really riding with anybody.

Night riding. Closely related to the long distances of events was the feature of night riding. This led to different strategies of using technology to cope with the darkness. Ellen needed to be able to see her cycling computer” “The bike computer I had didn't have a backlight, so I would put just a little headlamp on my helmet so I could see the bike computer." Greg shifted his technology usage during night hours:

> I have a dynamo USB charger which is sufficient to keep one device charged. Keep your phone charged [or] your GPS charged during daylight hours. In the nighttime, when the lights drawing more power, you don't get the charge from the device but most the riding was in daylight hours so it's not really a problem.

Types of technology. In reviewing the various specific technologies identified by participants, two subcategories were created. One was Equipment that, while necessary for the ride, did not play a role in the learning process. The other subcategory was the more techy technology involved in the recording, storage, review manipulation, or display of information. Information related technologies was classified as Gadgets for the purposes of thematic coding in this paper.

Equipment. Participants utilized a wide variety of equipment for ultradistance cycling. While a bike was an obvious piece of equipment, participants noted the unique aspects of ultradistance cycling often called for specialized frame geometry and material. Riding at night required lights and power source. While the advent of LED lights made the use of batteries for long rides more feasible, hub generators were also used. Other equipment noted by participants included clothing, fenders, saddles, aerobars, gearing, pedals, wheels, and tires. The determination by participants of which equipment to adopt and utilize during event was often an experiential learning process that can be considered a subset the learning process of preparing for and participating in the sport of ultradistance cycling.

Gadgets. As noted earlier, this theme focused on those items participants used to record, store, review, manipulate, or display information. The most commonly mentioned item was GPS units, which have emerged as a replacement for the more traditional cycling computer. In addition to tracking and displaying time and distance, GPS units also provide navigation and display heart rate and power information if linked to sensors. Many of those functions could also be duplicated on a cycling specific cell phone application. Newly emerging applications for indoor training are being used in place of stationary trainers or spin bikes. These applications create personalized workouts for ultradistance cyclists that can be used at any time. Figure 6 provides a visual representation of the themes related to features of emerging technology used by ultradistance cyclists.

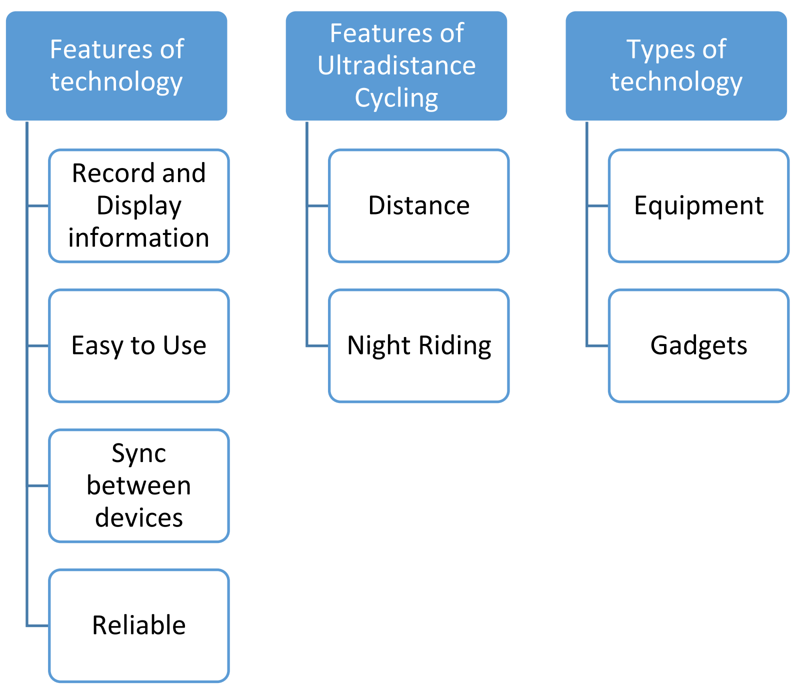

Figure 6. Visual summary of characteristics themes.

Conclusions

Through interviews, participants shared their experiences in preparing for and participating in ultradistance cycling events. Themes that emerged were strongly related to the phases of the Kolb (2014) experiential learning model with the addition of a temporal component. In addition, characteristics that facilitated the use of technology by participants as part of their experience were identified and categorized. Implications of these themes on the use of technology by ultradistance cyclists as part of their experiential learning processes are explored in the following chapter.

CHAPTER V

CONCLUSIONS

Summary

The purpose of this study was to examine the use of technology by ultradistance cyclist as part of their experiential learning process in preparing for and participating in events. Data were collected through semi-structured interviews from 10 ultradistance cyclists. Transcripts of the interviews were coded and themes were identified. The following research questions guided this study:

Q1 How are ultradistance cyclists using emerging technology as part of their experiential learning process?

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?

Kolb's (2014) model of experiential learning served as the theoretical framework for the exploration of the use of technology in preparing for and participating in ultradistance cycling events.

Discussion

In the Kolb (2014) model of experiential learning, all four stages--Abstract Conceptualization, Active Experimentation, Concrete Experience, and Reflective Observation--needed to occur for learning to happen (McLeod, 2017). In exploring the use of technology in ultradistance cycling, it was useful to include a temporal aspect when thematically classifying the lived experiences of the participants. The use of technology differed based on when the participant was using it. In addition to the Perception and Processing continuums established in the Kolb model, the use of technology was also classified by when it was used: before, during, or after an event. The use of technology facilitated the blending and reordering of phases in the Kolb model.

As developed by Kolb (2014), experiential learning is a circular process. Each stage follows and leads to the next. In this model, a Concrete Experience that challenges a person's current view is followed by Reflective Observation on the experience. The Observation leads to Abstract Conceptualization about the experience and how to adapt to it. These concepts of adapting are tested through Active Experimentation which, in turn lead to a new Concrete Experience.

As seen in the interviews with the participants, technology played a role in each of the experiential learning phases and even facilitated a blending process where multiple phases were experienced at the same time.

Technology and Experiential Learning Before an Event

While Kolb's (2014) experiential learning model is a cycle and does not have a beginning or an end, it was helpful to consider the use of technology relative to a particular event. With this in mind, I began by examining the use of technology as part of the lived experiences of participants prior to an event. During the coding process, I identified technology utilization themes that occurred prior to events: Route Planning, Training, and Abstract Conceptualization.

Route planning. Participants often noted their use of technology in planning out routes they were going to ride. Details of this use included building turn-by-turn directions, verifying the route was actually ridable, and checking for places where they could resupply or get additional food and drink. Building a digital route also provided the rider with an idea of what the ride would be like, providing information for Abstract Conceptualization. Applications like Ride with GPS also displayed a profile of the ride. The profile let the rider know ahead of time if there was a substantial climb on the route.

All of these activities involving technology took place prior to the Concrete Experience of riding the route. A strong element of Active Experimentation existed with planning the route. Daniel, Greg, and Ivan used Map My Ride and Ride with GPS to develop routes. They shifted roads they planned on riding to get the distance they wanted. With the addition of satellite images from Google maps, they could Reflect on what the anticipated route would feel like. In some cases, they planned the route so they had a downhill finish, knowing they might be tired and wanted to be able to look forward to an easier section of riding at the end. On hotter days, they planned rides in the mountains where it was cooler or checked for additional water (or ice cream!) stops. Ready accessibility of information through technology facilitated this ability to blend Active Experimentation with Reflective Observation.

Training. Technology also played a role in participants' training prior to an event. Gadgets recorded workouts and synced this information with applications. Applications compiled workout information and made it easily accessible to participants. Some applications also utilized this information to develop a fitness measurement. Some participants utilized the fitness measurement to determine the effort for upcoming rides. Effort might be a target heart rate or even which group to ride with during an event. While riders were concerned with the accuracy of wrist-based heart rate monitors, they agreed they were more comfortable and convenient than chest straps. The added comfort and convenience of this emerging technology allowed participants to wear heart rate monitors beyond just their workouts and training. Full day heart rate monitoring allowed some participants to track their stress levels as calculated by applications that were synced with the wearable tech. A wrist-based heart rate monitor also measured and tracked resting heart rate. A rise in resting heart rate might be an indication of overtraining (Burke & Pavelka, 2000; Friel, 1998). By utilizing this technology, a participant was able to identify potential overtraining and avoid loss of fitness.

Applications, in conjunction with indoor trainers or stationary bikes, allow participants to customize workouts in preparation for an event. Fitness tests on these indoor bikes could identify areas where riders are performing poorly and recommend workouts to address the weakness.

On a fundamental level, the training examples of the participants were Concrete Experiences. Heidi utilized technology to help gauge her fitness recovery from injury. Prior to riding outside, she would ride on a stationary trainer. When she was able to sustain her target of 200 watts indoors, she felt she was ready to venture outside on a ride. Feedback provided by the technology was an important part of her recovery process. The trainer allowed her to take smaller, more manageable steps toward recovery. In terms of the Kolb (2014) model, use of the trainer facilitated multiple reinterpretations of the riding experience as fitness was gradually rebuilt. Without the technology, her first ride outside would have been overwhelming.

Abstract conceptualization. Both route planning and training influenced Abstract Conceptualization. Measurements of fitness gave participants who used that technology a numerical value. This measurement assisted in the analysis of performance as well as provided a consistent reference for generalizations and conclusions. If a fitness value was the same in two prior events, participants could expect similar performances. If the results were different, other explanations could be explored. These explanations could be reflected in the route or changes made in training prior to the event.

In anticipating an upcoming ride that was part of a Super Randonneur series, participants could attempt to conceptualize new challenges like riding at night or what they needed to eat. Measurements and insights on fitness gained during training would allow setting a target effort level for a ride based on terrain and route profiles. If a rider found that riding at a heart rate of 140 beats per minute left them struggling at the end of the 200km brevet, a more moderate effort would be called for during the 300km ride.

Technology provided assistance to participants in the area of Abstract Conceptualization. This was seen in Albert's consideration of riding an SR, a 600km ride with 10,000 meters of climbing. Albert had heard about an SR but it seemed abstract and overwhelming. Then, after a summer where he rode well in several difficult events, he thought he might attempt an SR. His first step was to map out a ride based on familiar climbs. He found he had to add more and more rides to meet the climbing distance. This helped him put the ride into perspective so he would be mentally prepared when he attempted the ride on an official route that was not familiar. He was successful in completing the SR.

Ivan also utilized technology when setting goals for future events. Using Strava, he explored the training volume of other participants leading up to an event. He then looked how this volume compared to their previous performances at the event. Next, he set his goals based on how his training volume compared to theirs. Technology allowed him to add greater details when conceptualizing an upcoming event.

Technology and Experiential Learning During an Event

At the most basic level, an ultradistance event is a concrete experience within the experiential learning process. However, due to the nature of ultradistance cycling, a lot could happen during an event. Multiple new experiences or situations were encountered as well as the need to reinterpret previous experiences. Each of these experiences provided the participant an opportunity to actively experiment with technology. During the data collection process in the interviews, participants were able to speak of the many concrete experiences they had during ultradistance cycling events. Quite often, experiences that sparked memories and discussions were ones where the participant had encountered a barrier and needed to overcome it to complete the event as well the role of technology in this process.

For example, in conjunction with route mapping prior to riding, similar technology was used to assist navigating during an event. Before the widespread adoption of GPS in ultradistance cycling events, paper maps and cue sheets were used to navigate a route. Riders would mount the maps and sheets in specialized holders on their handlebars or keep them in a jersey pocket. In either case, riders needed to refer to this information repeatedly throughout the event including at night. A wrong turn could result in extra miles ridden, missed check points, or possibly even a failed ride. The constant need to check directions and watch for turns was mentally draining. This drain was magnified in the dark when maps were hard to read and street signs and turn indicators were more difficult to spot. Lack of sleep and exhaustion from riding all day compounded the issue. Using GPS technology for navigation gave riders one less thing to think about, thus reducing cognitive load and freeing participants' minds for other activities.

This experience was seen in Juliet in her return to ultradistance cycling when she utilized GPS for navigating across Great Britain. Barb also used the MTB project app for navigation; this not only provided her with navigation directions but also with resupply information. Without this technology, she needed to be much more cognizant of the upcoming route and be more meticulous in her planning. Technology allowed Barb to think and plan for other challenges like the weather. Without the constant mental stress of navigating, Juliet was able to once again enjoy long distance cycling.

Ormrod (2012) noted, "Anxiety interferes with an individual's attention to a task. And because worrisome thoughts take up a certain amount of working memory capacity, anxiety also interferes with effective cognitive processing" (p. 453). Increasing cell phone coverage as well as satellite-based emergency beacons addressed this burden by allowing participants to stay connected no matter how remote the ride took them. Ellen learned this the hard way during a training ride. She crashed while training on her mountain bike. She had her cell phone with her but not her SPOT satellite device. Although she was not injured, the bike was damaged and unrideable. This resulted in a very long walk. She now matches the tech she carries for communication with where she will be riding. The SPOT has expanded her potential training routes. Without the SPOT, she rode much more carefully and was not able to do the type of training she wanted. With the SPOT, she was more relaxed, which led to a better training effort. She also felt that being more relaxed allowed her be more focused on the trail and made it less likely for a crash to happen in the first place.

Another example of apps to enhance safety was seen in a recent example involving a member of a professional cycling team (Middlebrook, 2018). In this case, the cyclist's wife became worried when he was overdue returning from a ride. She posted her concerns to social media and friends were able to track down where the cyclist's Strava feed stopped. Search and rescue were able to locate the rider based on this information. He was found injured but alive at the bottom of a ravine. There was no doubt that having the location information from Strava was vital in speeding up the search.

Several participants noted that technology allowed their spouse or significant other to be able to contact or track them during long training rides. Ellen and Frank utilized the "Where's my iPhone" app in training and events--this app is designed to help find a missing iPhone. Ellen and Frank adapted it to be able to know where riders were during an event. This app also allowed the support crew to know when their rider was approaching or if the rider had gone off route; it allowed the crew to be prepared to give support and let the rider focus on riding rather than navigating.

Having a communication safety net allowed riders to worry less about keeping energy in reserve by knowing they could call for help if they pushed themselves too far. This technological safety net could enhance learning potential by easing worry even if it was never used--just being available reduced anxiety. This was most explicitly seen in Barb's acquisition of an InReach satellite communication device. She would not have entered the sport of bikepacking without the device. Even though she has never used her

InReach, just having it with her has allowed her to attempt ultradistance rides and have the associated concrete experiences.

Communication also allowed more informed decisions. During Barb's ride in the Colorado Trail Race, she encountered bad weather. Apps she used for navigation with her cell phone also provided her with information about upcoming weather. With this information, she knew if the rain was a passing storm or a long-term downpour that would give her miserable riding conditions for the next several days. Using this information, she was better able to conceptualize upcoming challenges rather than being locked into the current concrete experience. This facilitated her ability to actively experiment with methods to meet the challenge. While her solution of utilizing a plastic trash bag as light weight protection from the elements was not a high-tech solution, information that led to that choice was rooted in the use of technology.

Communication during a ride also provided a social interaction aspect. Posting a picture of an interesting feature or creature encountered during a ride created a sense of community. Many tracking and training apps including Ride with GPS and Strava supported pictures as well as text comments on a ride. Posting and sharing pictures and getting feedback from others on the posts was a means of validating the rider's experience. Not only did these pictures provide riders an opportunity to look beyond the bike, it also enhanced the reflective process by offering visual cue of relevant landmarks or events during a ride. Juliet noted this during her multi-day ride in England, Wales, and Scotland. After each day, many of the group she was riding with would meet in a pub and reminisce about the day. This reflection often involved sharing pictures taken during the day and sometimes comparing efforts recorded on Strava. These evening reflections led to plans to ride with individuals who shared common interests and abilities on the days following. Technology enhanced this reflective and planning process by providing a common point of reference. For example, if Juliet and a fellow rider both stopped to take a picture of the same cathedral during the ride, they knew they shared an interest and both would probably target similar features to stop and experience. This created a small learning community.

Juliet was also able to utilize a GPS device for navigation during this ride. She found this had an intense impact on her riding experience. With the use of the device, she was no longer beholden to paper maps for navigation. This allowed her to look around at the countryside rather than being focused on the road and watching for signs. She was able to see people, places, and things she wanted to photograph. Time saved with easier navigation with the device allowed her to stop more often than she would have otherwise. When comparing this tour with her ride in PBP 10 years earlier, it was a vastly different experience. She felt she had recaptured her love of cycling that had diminished. Technology was an important aspect regarding her change in attitude. It minimized her need to focus on the parts of riding she did not enjoy like navigating and instead experience those aspects she did enjoy like exploring new places and meeting new people.

Perceptions of efforts changed during long events (Borg, Ljunggren, & Ceci, 1985; Hutchinson, 2018). To address this challenge, many of the participants utilized heart rate monitors or power meters to gauge their efforts. One interesting observation was while several participants utilized power during training, most preferred to use heart rate during events. This observation aligned with findings from previous research where power was a better indicator of exercise intensity and heart rate was a better indicator of whole-body stress (Jeukendrup & Van Diemen, 1998), indicating participants' primary focus during events was whole body stress rather than exercise intensity.

In other cases, participants did not use physiology measurement but went by speed and distance. Often the reason for this was participants felt they knew their body well enough to know what effort they could maintain. They would ride the speed that would allow them to cover the goal distance in the time they had allocated. This view was evident in the riding styles of Albert and Heidi. Albert was particularly adept at knowing the speed needed to meet his goal. He noted his most challenging rides were those where weather conditions resulted in slower riding and less time for sleep. His selection of technology reflected this focus. He emphasized technology that improved safety and comfort. He wanted to be able to be on his bike for as long as he needed to without needing to worry. For this reason, he placed a greater emphasis on an excellent lighting system for night riding rather than devices to measure power or heart rate.

Heidi had a slightly different approach. She had a strong background in physiology and used power and heart rate in training. She had also raced bikes semi-professionally. She thought it was important to not be overly reliant on technology in case it failed. She also noted that in a race, it did not matter what the devices said. Sometimes you had to push beyond and not be limited by a number on a screen; otherwise, you never really know your limits.

Technology and Experiential Learning After an Event

Technology was used as part of the Reflective Observation phase of experiential learning. Phone apps and GPS units not only helped navigate during an event, they also recorded the route ridden and, with paired devices, recorded physiology information during an event. Reviewing this information allowed riders to examine inconsistences with their expectation and experiences. For example, when Juliet rode PBP in 2003, she felt extremely well prepared. This feeling was based on her completion times from qualifying brevet rides. She did not have any long-term physiology data on her riding performance at that time. When she failed to complete PBP, she was at a loss to explain what went wrong.

Brevet completion is recorded on the Randonneurs USA website (2014). Information displayed includes distance of the event and the time for each member completing it. Members can look back and find the times for rides they did 15 years ago and figure out average speed. Newer technology has more information, enhancing the reflective process. It is possible to compare rides on those routes on Strava or other applications. These technologies include not only the time and distance covered but also elevation gain. Averaging 15mph on a 200km with 5,000 feet of climbing is much different than holding the same speed on a flat route. Application might also include heart rate information. A flat ride at 15mph where the average heart rate is 150 is compared to a ride on the same route at the same speed where the heart rate is 125. This information allows the rider to reflect on the experience to explore the reasons for the difference. Reflecting on the experience might lead to a realization that riding in a group and taking advantage of drafting could result in the same average speed with much less effort. This could lead to planning to try to ride with a group at the next event.

Regarding Juliet's experience mentioned above, if she were to attempt to qualify for PBP again, she would have a wealth of data on which to reflect after each ride. Now she could look at not just finishing times for a 200k brevet but she could also look at what a fellow rider's heart rate was on a ride. If that rider's heart rate was 20 beats per minute slower than Juliet's while they were riding together, then it might hint at a difference in fitness that would be accentuated on longer rides. Ivan had similar experiences. He realized he was struggling as indicated by a higher heart rate during events where it was hot and humid. To adapt to this challenge, he opted to ride by heart rate rather than aiming for a goal speed or distance at his next event where it was hot. He now looks at expected temperatures as well as terrain for upcoming events.

Goal setting is an important part of learning and behavior change (Kolb & Boyatzis, 1970). Technology can provide information to assist in setting goals. In preparing for events, Ivan looked at past results and how his riding volumes compared to others. He then adjusted his goals accordingly. If he was only riding half the distance of the winner of the previous event, he aimed for a lower distance.

Technology gave participants information on completed events. Participants utilized this information to revise training plans and update goals for upcoming events. Having this information enhanced the reflective observation phase.

Characteristics of Technology that Impacted Experiential Learning

A number of themes were related to the characteristics of technology the ultradistance cyclists used. Among these characteristics was the technology was easy to use. The participants were typical of athletes who used multiple devices (Riegersperger, 2017a) in their training and even participation. While the use of multiple devices might be a burden, being able to sync and share information between gadgets and applications greatly reduced the amount of work and understanding needed by the rider. The ability to sync between devices was often the determining factor regarding which GPS device the participants chose to use. In general, participants found it easy to get information from a Garmin device and shared it with other applications. For navigating, many preferred a Wahoo since it was easier to get maps and route information onto that type of device.

Related to ease of use was reliability. Being able to get information on and off a portable device was of little use if it failed during an event. This was particularly important in ultradistance events. The longer the event, the more time there was for a device to fail. This includes the need for devices to maintain a charge for the duration of an event. Many of the more common devices were fine for shorter events but the batteries did not last for the 16, 24, or even 90 hours needed.

The need for long-term power was the driving factor in Albert's use of a hub generator to power not only his lights at night but also his GPS and other devices during the day. The switch for his light gave him the flexibility of where he would stop at night during multi-day events. Previously, he had been tied to a specific resupply point where he could replace the batteries in his lights. This flexibility gave him greater control over his riding experience. If he was feeling good, he could push on and ride further. If he was feeling poorly, he could ride longer into the night to meet his goal without worrying about a failing light. The ability to charge from his hub generator also gave him greater flexibility on which device to use. He no longer had to select the navigation device with the best battery life, he could choose the one with features he preferred. This gave him greater control of what devices he used in his learning experience.

An aspect of reliably that was mentioned by several participants was having an accurate measurement of effort. Two criteria commonly used for measuring effort were heart rate and power. Chad monitored his heart rate to keep himself "on the bubble"--going at a hard effort that he could maintain the entire ride. Seeing a low heart rate reminded him that he needed to go harder. If he was riding in a group, he would move to the front and push the pace. Ellen looked to heart rate for reassurance that she was putting in a good effort. If she was riding into the wind or uphill, seeing a low speed could be discouraging. However, if she also saw her heart rate was high despite the low speed, she knew she was doing the best she could under the circumstances. With the additional information available from the emerging technology of readily available heart rate monitoring, both Chad and Ellen better gauged their efforts and had improved learning experiences from their rides.

Both chest straps and wrist-based sensors were used by participants to monitor heart rate. The general feeling was chest straps were more accurate but not as convenient or comfortable as wrist-based. The beliefs of participants reflected findings in existing research (Case, Burwick, Volpp, & Patel, 2015; El-Amrawy & Nounou, 2015; Terbizan, Dolezal, & Albano, 2009; Wang et al., 2017).

The participants had a variety of opinions on the necessity of tracking heart rate. Some participants explored a wide variety of heart rate sensor options in the search for balance, comfort, and accuracy. Frank in particular seemed to struggle in finding the right sensor. His coach gave him specific heart range goals for workouts but all of the sensors he had used were too erratic.

Other participants did not use a heart rate sensor at all. The non-users explained they had a good feel for effort and did not need nor want to have a specific number attached to the feeling. Even though they might not currently use a heart rate sensor, the non-users had used them in the past. For the most part, they felt they were well enough in tune with their bodies that they did not need to have a monitor to gauge their efforts.

In general, participants felt power meters were more accurate measurements of effort. Daniel, Ellen, Frank, Greg, and Ivan were meticulous in their use of power to measure effort when training using the Sufferfest or other applications. However, they did not use power meters during events. This disconnect could be related to the greater expense of power meters but was most likely related to ease of use. Unlike heart rate monitors that are easily transferable, power meters are part of the hub, crank arm, or pedal. It was much more difficult to transfer a power meter from one bike to another and every participant owned and rode multiple bikes.

The underlying theme that ran through the characteristics of technology was participants did not want to worry about it. They just wanted the technology to work. Ultradistance cycling events are demanding enough without an added worry about technology. From a learning standpoint, it seemed participants were making an effort to reduce their cognitive load. Not having to thing about navigating, recording information, or setting up a device freed their minds to think about other challenges with the event. Albert explicitly stated this about his use of hub generators and LED lights where he noted the combinations had fundamentally changed his ultradistance cycling experience. Juliet’s attitude toward cycling changed with the simplicity of using GPS for navigation as she rode across England, Wales, and Scotland. Being able to explore the countryside rather than being focused on maps and road signs rekindled her love of the sport. Her mind was free to look for memorable spots for pictures rather than worrying about getting lost or left behind.

Another feature of technology related to learning was many of the devices preferred by participants allowed the customization of data fields. Riders could display as much or as little information as they wanted, choose which information to prioritize, and arrange the fields by personal preference. This allowed the user to control his/her learning environment. Albert, Chad, Daniel, Ellen, Frank, and Ivan all customized the data fields displayed on their GPS devices. Each was able to prioritize the information they needed for the ride. Having this information available allowed them to continually monitor progress toward their goals.

Technology as a Means to Enhance Learning Spaces

Technology was an integral part of the riding experience of the participants in this study. Kolb and Kolb (2005) noted several aspects that enhanced learning spaces in higher education. It was interesting to examine how each aspect could be enhanced through technology.

One aspect Kolb and Kolb (2005) identified was "respect for learners and their experience" (p. 207). The "kudos" riders could give each other using the Strava app was a way to provide "cheers." While Ellen scoffed at receiving a kudo for a basic workout, she and Chad both appreciated when a goal was achieved or a hard effort was noted by others or even automatically by Strava. This was a way technology could facilitate showing respect for riders and their experiences. It created a feeling that riders were part of a learning community and enhanced the learning space associated with ultradistance cycling.

Kolb and Kolb (2005) noted, "To learn experientially learners must first of all own and value their experience" (p. 207). All of the participants made use of technology to track their riding utilizing Strava, Training Peaks, Final Surge, or Garmin Connect. Not only did these applications sync with GPS devices to make it easy to record workout, they provided a variety of reports of previous rides. These tracking and reporting technologies made it easy for athletes to own and value their previous experiences.

These applications were as public or private as the athlete desired. Most also included a means to set and track personal goals including automated congratulations based on individual performance. It was also noteworthy that while there was a "kudo" option in Strava and the equivalent in other application, none of them included a negative or derogatory quick comment feature. This served to help create and maintain the equivalent of a "hospital space for learning" Kolb and Kolb (2005) listed as another aspect for enhancing learning spaces. These applications also included space where participants could add notes or even pictures from rides, serving as a space for acting and reflecting.

Emerging technology also supported improved communication not only through the aforementioned training applications but also other social media tools. These tools were readily accessible through cell phones and available network coverage. During the ride across Great Britain, Juliet posted pictures and sent text messages nearly every day. The organizers of the ride created a Facebook page where she and others posted pictures capturing images and experiences from along the route. Communication facilitated by technology allowed easy and casual exchange of ideas. This was equivalent to Kolb and Kolb's (2005) "making space for conversational learning" (p. 207), another factor that enhanced learning spaces. Technology can be viewed through the lens Kolb and Kolb created for examining characteristics that enhanced experiential learning in higher education. This allowed users to better decide what technology to utilize as well as when and how to use it.

Constraints

This study was limited to the experiences the participant had had with technology. There were far more gadgets, applications, and software than were utilized in this study. New technologies continue to emerge. One of the recently developed Garmin fitness watches measures blood oxygen in a manner similar to heart rate monitoring. This added physiological information has the potential to further refine training specificity. By necessity, focus was limited to existing technologies available and utilized by participants at the time the study was conducted.

Implications

The findings in this study have the following implications for the use of technology as part of the experiential learning process for participants in ultradistance cycling.

A key aspect of the Kolb (2014) experiential learning model is the establishment of learning styles based on learner preferences on the Process and Perception continuums. If technology facilitates the blending of the continuums upon which the learning styles are based, it follows that technology would also allow for learning styles that are different from those established in the model.

Comparisons could be drawn between technology use by ultradistance cyclists and factors Kolb and Kolb (2005) identified that enhanced experiential learning spaces in higher education.

1. Long distance cycling is both physically and mentally fatiguing. Technology that is easy to use has a reduced impact on mental fatigue. This should be a factor when participants are deciding which technology to use in preparing for and participating in ultradistance cycling events.
2. Cyclists use a wide variety of technology. Being able to sync between multiple devices, software, and applications can assist in the experiential learning process by allowing participants to select their preferred technology without the loss of information, thereby controlling their learning environment.

Suggestions for Future Research

Technology is in a constant state of flux. As new gadgets and equipment continue to be developed and utilized by ultradistance cyclists, it is likely this exact study could be repeated yearly with different technologies being identified each time. Are the themes identified in this study constant or a snapshot that is dependent on the features and availability of current technology? Although participants reflected on their earlier uses of technology, much of the discussion was focused on what they were currently doing. Participants were at a variety of experience levels in ultradistance cycling but each had his/her own preferences. Does a cyclist's use of technology change as he/she becomes more experienced in ultradistance cycling? Future research could explore additional aspects of technology usage as part of the experiential learning process.

Long Term Individual Case Study

This study used a phenomenological approach to explore the utilization of emerging technologies by multiple individuals in preparing for and participating in ultradistance cycling events. This facilitated the identification of common themes. Although interview questions included consideration of past usage, the main focus was on current utilization as part of the process.

An alternative approach would be to focus on technology usage by an individual and how it evolved over time. This approach would be particularly relevant in the sport of randonneuring and participation in the Paris-Brest-Paris event that is only held every four years. Four years is a long time in terms of technology development. Gadgets and equipment available from the last offering in 2015 and the next one in 2019 will be quite different. The availability overlaps with the learning cycle of a participant. Even if the same technology is used, it is likely a rider would develop different approaches to using it over four years. By focusing on a single user, greater focus could be made on these choices and evolution of usage.

Another possibility would be to compare how first time PBP riders utilized technology compared to riders with multiple finishes. Related to this area would be to compare technology usage related to age. Do young riders who are “digital natives” utilize technology differently than “digital immigrants” (Prensky, 2001) in preparing for and participating in ultradistance events?

Equipment Adoption

As mentioned earlier, the determination by participants of which equipment to adopt and utilize during events was often an experiential learning process that could be considered a subset in the broader learning process of preparing for and participating in the sport of ultradistance cycling. By restricting the focus of a study on the process of adoption, it would be possible explore the deciding criteria in greater depth.

Coaching Versus Self-Directed

Several participants mentioned working with a coach in preparation for ultradistance cycling events. It would be insightful to explore how coached and non-coached athletes utilized technology. While it is unlikely an app would replace a coach any time in the near future by examining the difference in usage, it might be possible to discover shortcomings in current technology where coaching skills fill gaps left by gadgets and equipment.

Related to this topic would be a study focus on coaches' use of technology with their athletes. How does emerging technology impact feedback and communication? Technology allows for real time remote monitoring of physiology metrics like heart rate, power, body mechanics, and even blood oxygen levels. How would having this information impact coaching during a long-distance event?

Other Groups and Demographics

A number of international cyclists responded to my questionnaire. This led me to realize my study was focused on cyclists within the United States. Different ages, genders and cultures utilize technology differently (Jackson et al., 2008; Prensky, 2001). It would be insightful to examine how the lived experience of utilizing technology as part of ultradistance cycling varies in different cultures.

Artifact Analysis

This study focused on data collection through interviews. It became evident during interviews that emerging technologies could also produce a wide array of artifacts. Artifacts created by ultradistance cyclists included not only race and ride reports posted to social media but also items generated automatically by emerging technology.

Examples of automatically generated artifacts included Stava's Fitness/Freshness graph, Garmin Connect's challenge performances, lifetime stats in Ride with GPS, and Training Peaks' fitness measurements. Examination of these artifacts could lead to additional insights on the use of technologies to improve performance.

Conclusion

My last significant participation in the sport of ultradistance cycling was the summer before I started graduate school. I have continued to ride since then but it has been a much more casual affair. As I prepared my proposal and conducted my research, I began to notice not just how the technology has changed but also how it could be used differently. This realization came into focus last summer when I went on an extended bike tour. This was a two-week ride that covered about 1,000 miles with guides and support vehicles. Even though it was different from the randonneur style of riding I had done previously, the technology used by my fellow riders was eye opening. I had prepared as I had for my brevet rides. I printed out the maps and cue sheets the ride organizer had provided. The maps included profiles of each day's ride so I knew to include a fair amount of climbing in my training prior to the event. I was ready for the various hills along the route. The difficulty came in navigating. Every other rider had a GPS device. I was constantly having to look at the sheets to know where to go. The directions were well written--maybe too well since there was sometimes an entire paragraph describing the next turn. I had to stop often to read what was coming up and which landmarks to watch for. It was a struggle.

This changed three days into the event. A fellow rider had a spare GPS they loaned me. It took another two days for me to get comfortable using it. After that, the ride was completely different. I no longer worried about getting lost. I knew there would be an indicator if I missed a turn. This allowed me to relax and enjoy the ride. Having talked about technology with the participants in this research, I realized I did not actually need the GPS device. I could have used any one of a number of applications on my phone to navigate.

During the ride, I also gained a new appreciation for Strava. Most evenings, we would dine with other riders and chat about the day. Those that used Strava exchanged contact information and “friended” each other. After that, each evening also included checking out pictures others had posted as well as looking how we compared on various segments. For me, it was not about being faster than others climbing up a particular hill but finding others who rode at a similar pace. This made for more comfortable riding during the second week of the event.

Learning about the availability of applications and videos for riding on an indoor trainer is another item that has the potential to dramatically change my cycling experience. I had followed training videos before; they were on VHS tape I had played on a TV and were fairly generic. Now there are videos that can address my personal weaknesses on the bike. I can see that being a big change in my winter training if I ever get serious about cycling again. In fact, even without a home trainer, I look at the stationary bikes at the gym in a new light. I have been gravitating toward Expresso Bikes--stationary trainers linked to the Internet with a built-in video monitor. The monitor shows a video of the route’s terrain with pedal resistance increasing and decreasing to match climbs and descents. Power and heart rate are displayed. Ride information is uploaded to Strava. Previous performance on a route is displayed as an avatar pacer who I can race against if I want to improve my best time. This could make even what was intended to be a casual ride into a hard workout.

Even though there is controversy about the accuracy of wrist-based heart rate sensors, I personally like the one I have started using--a Garmin Fenix 5. Since it is essentially a watch, I wear it almost all the time. This allows me to track my casual cycling. If I had to put on a chest strap, I would not bother. The full time wearing also records and calculates my average resting heart rate as well as my sleep quantity and quality. I find I use this to gauge my fitness. I am curious how it will change when I start riding more again. The Fenix 5 also provides aerobic and anaerobic training effects for my runs and rides as well as calculates my VO2 max. While I am skeptical of the accuracy of the VO2 max measurement, I think it is consistent and is a good indicator of gain or loss of fitness.

A wide variety of new technology is available in cycling. From what I have learned in this research, I will be more conscious of what and how I use that technology. In one respect, it was somewhat humbling to compare indications of my current fitness to measurements from several years ago. By patching together data from various devices I have used, I have managed to establish a fairly complete fitness history for the past 10 years. It will be interesting to see how the trend lines change as I return to the sport with a more intentional use of technology.

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APPENDIX A

INTERVIEW PROTOCOL

Interview Protocol: The use of emerging technology as part of the experiential learning process in ultradistance cycling: a phenomenological study.

Time of interview:

Date:

Interviewer:

Interviewee:

Overview

Interviews will be semi-structured. It is expected to take thirty to forty five minute to cover the below questions in sufficient detail and allow for greater discussion of emergent topics.

Prior to the interview, the researcher will provide the interviewee with a copy of this form as well as the consent form.

Before the interview starts, the researcher will review the consent form and procedures with the participant and obtain required signatures.

Questions: (reduced to 5-7 for each interview)

- (An icebreaker question/exercise): Take a few minutes to think of a defining ultradistance cycling (UDC) experience. Tell me about it.
- What makes for a memorable UDC experience?
- How do you prepare for an UDC event? What do you do after?
- Tell me about your first UDC event?
- What was most challenging? How has that challenge changed?
- Tell me about your most recent UDC event?
- What are some cycling technologies that you use?
- How has your technology use changed from your first event to your latest?
- How has the use of technology changed the most challenging aspect of UDC?
- What technology would you hate to lose during an event? Why?
- What do you find most beneficial use of technology during an UDC event?
- What do you find most challenging when using technology during an UDC event?
- How has using technology changed the way you approach, complete and review an UDC event?
- What is the latest/greatest tech that you are using? What makes it so?
- Do you use any of the technology from cycling outside the sport? How?
- If you would recommend one item to an UDC novice what would it be? Why?
- What do you feel is the most overrated aspect of emerging technology

APPENDIX B

INTERVIEW AND RESEARCH QUESTION MAPPING

Interview and Research Question Mapping

The 45 minute interview period allowed approximately seven questions.

Research question	Initial interview questions	Thoughts and observations
Introductory and transitional questions	➢ Take a few minutes to think of a defining ultradistance cycling (UDC) experience. Tell me about it. ➢ What makes for a memorable UDC experience? ➢ How do you prepare for an UDC event? What do you do after? ➢ Tell me about your first UDC event? ➢ What was most challenging? How has that challenge changed? ➢ Tell me about your most recent UDC event?	➢ Asking about the participants "quintessential event" served well as a conversation started. It provided a concrete reference for follow-up questions. ➢ Asking "what was the most challenging aspect of this event" worked well to elicit vivid responses. ➢ Asking what technology they used in their earlier events allowed the follow to ask "how has their use of technology changed".
Q1 How are ultradistance cyclists using emerging technology as part of their experiential learning process?	➢ What are some cycling technologies that you use? ➢ How has your technology use changed from your first event to your latest? ➢ How has the use of technology changed the most challenging aspect of UDC? ➢ What technology would you hate to lose during an event? Why? ➢ What do you find most challenging when using technology during an UDC event? ➢ How has using technology changed the way you approach, complete and review an UDC event?	➢ Using the term "gadget" tended to elicit additional responses when combined with asking about technologies. ➢ I asked what participants have seen others using or what they would like to have/use and why.

Q2 What are the characteristics of emerging technologies used by ultradistance cyclists as part of their experiential learning process?	➢ What do you find most beneficial use of technology during an UDC event? ➢ What is the latest/greatest tech that you are using? What makes it so?	➢ When they mentioned adopting or switching technology they used I would ask why. ➢ I would ask: For your earliest UD ride, if you could bring one technology into the past to use, what would it be? ➢ In order to elicit responses related to future use, I began asking what items did participants wish they had and why. This helped to clarify likes and dislikes of current technologies.

APPENDIX C

QUESTIONNAIRE

Technology and ultra-distance cycling experiential learning

Start of Block: Participation Consent

Q17 CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH UNIVERSITY OF NORTHERN COLORADO Project Title: The use of emerging technology as part of the experiential learning process in ultradistance cycling
Researchers: William Tankovich, Educational Technology
e-mail: tank4118@bears.unco.edu Research Adviser: Dr. Mia Williams
e-mail: mia.williams@unco.edu
Phone: (970) 351-2414

The goal of this questionnaire is to serve as a participant filter for in-depth follow-up interviews. The purpose of the research is to examine the use of emerging technologies by ultradistance cyclists as part of their experiential learning process. The questionnaire should take approximately 7 minutes to complete.

The foreseeable risks to you as a participant are minimal to nonexistent. A primary concern would the potential for stress caused negative self-reflection due to that nature of the questions. Completion of every question is optional. Feel free to utilize this option if you find any question too probing or personal. All responses will be anonymous unless you choose to self-identify for a followup interview. While every effort will be taken to maintain the confidential nature of this questionnaire and your responses, there is always the risk of accidental disclosure of information.

The primary benefit to participants will be the potential for self-reflection on the use of the use of emerging technology in training for and the participation in ultradistance cycling events. No direct compensation will be provided. Final results of the study will be made available which may be of use in future curriculum development.

Participation in this questionnaire is voluntary. You can opt out of participation at any time by simply closing the survey window. If you have completed the survey or have decided not to participate, please ignore any follow-up emails you receive. Be assured these emails will stop at the end of my data collection period (September 15, 2017) if not earlier.

By completing the questionnaire you give permission for your participation. You may print off and keep this page for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910.

End of Block: Participation Consent

Start of Block: Default Question Block

Q13 There as been a proliferation of fitness technologies in the past several years. These technologies include cheaper and more accessible heart rate monitors and powermeters, inexpensive GPS units and a wide variety of fitness applications (both for computers and smartphones).

I took a break from ultradistance cycling as I attended graduate school. Now that I am returning to the sport I am intrigued by the availablity and use of these new technologies. This curiosity, in turn, has shapted my dissertation topic. The goal of this study is to examine the use of emerging technologies in ultradistance cycling events.

For the purpose of this study I am considering an ultradistance cycling event to be an unsupported or self-supported ride over 200km. My primary focus is *how* and *why* you are using the technology that you are using.

While it is impossible to examine every use and reason it is my hope that I can collect as many of your experiences as possible. This initial questionnaire is to attempt to narrow the number of potential participant while capturing as many diverse experiences as can be reasonably managed. If this sounds like something you would like to be a part of, please continue.

Thank you for your participation in my study.

Bill Tankovich (RUSA # 2936)

Q1 How many ultradistance cycling events have you participated in (approximately)?

____

Q12 When (what year) did you participate in your first ultradistance cycling event (approximately)?

____

Q2 How important is it to you to improve your ultradistance cycling performance?

- ○ Extremely important (1)
- ○ Very important (2)
- ○ Moderately important (3)
- ○ Slightly important (4)
- ○ Not at all important (5)

Q4 How many of the following technologies do you currently or have previously used in training FOR or DURING ultradistance cycling events: smartphone, fitness application (including but not limited to: Strava, Ride with GPS, MyFitnessPal, MapMyRide, Garmin Connect), heart rate monitor, power meter, wearable technology (Fitbit), GPS (Garmin):

- ○ None (1)
- ○ 1 or 2 (2)
- ○ 3 or more (3)

Q3 How frequently do you work with a coach or trainer?

- ◯ I have never worked with a coach or trainer (1)
- ◯ I don't currently but plan to in the future (2)
- ◯ I don't currently but have in the past (3)
- ◯ I occasionally work with a coach or trainer but not on a regular basis (4)
- ◯ I regularly work with a coach or trainer (5)

Q14 Would you be willing to meet for a follow-up 45-minute interview to discuss technology in ultradistance cycling in greater depth?
(This would be in the Colorado Front Range area. The interview will be recorded and you will be provided with a copy of the transcript)

- ◯ Yes (1)
- ◯ Maybe (2)
- ◯ No (3)

Display This Question:

If Would you be willing to meet for a follow-up 45-minute interview to discuss technology in ultradi... != No

Q15 If you are willing and able to participate in a follow-up interview please supply your contact information
(All information will be kept private and confidential)

- First name (1) ____
- Last Name (2) ____
- email (3) ____
- Phone number (4) ____

End of Block: Default Question Block

Start of Block: Demographics Base/Universal

Q6 What is your year of birth?

____

Q11 What is your sex?

- Male (1)
- Female (2)

Q7 What is the highest level of school you have completed or the highest degree you have received?

- Less than high school degree (1)
- High school graduate (high school diploma or equivalent including GED) (2)
- Some college but no degree (3)
- Associate degree in college (2-year) (4)
- Bachelor's degree in college (4-year) (5)
- Master's degree (6)
- Doctoral degree (7)
- Professional degree (JD, MD) (8)

Q10 Choose one or more races that you consider yourself to be:

- [ ] White (1)
- [ ] Black or African American (2)
- [ ] American Indian or Alaska Native (3)
- [ ] Asian (4)
- [ ] Native Hawaiian or Pacific Islander (5)
- [ ] Other (6) ____

End of Block: Demographics Base/Universal

APPENDIX D

QUESTIONNAIRE DISTRIBUTION

Questionnaire Distribution

Group/Organization/Posting site	List type	Membership (as of September 2017)
Ultradistance Cycling Association	Facebook group	3817
Rocky Mountain cycling	Strava group	88
Rocky Mountain Cycling Club	Facebook group	718
Colorado Trail Race	Facebook group	1012

APPENDIX E

INSTITUTIONAL REVIEW BOARD APPROVAL

UNIVERSITY OF
NORTHERN COLORADO

Institutional Review Board

DATE:	August 11, 2017
TO:	William Tankovich, ABD
FROM:	University of Northern Colorado (UNCO) IRB
PROJECT TITLE:	[991390-2] Smartphone use in ultradistance cycling: a phenomenological study
SUBMISSION TYPE:	Amendment/Modification
ACTION:	APPROVAL/VERIFICATION OF EXEMPT STATUS
DECISION DATE:	August 11, 2017
EXPIRATION DATE:	August 10, 2021

Thank you for your submission of Amendment/Modification materials for this project. The University of Northern Colorado (UNCO) IRB approves this project and verifies its status as EXEMPT according to federal IRB regulations.

We will retain a copy of this correspondence within our records for a duration of 4 years.

If you have any questions, please contact Sherry May at 970-351-1910 or Sherry.May@unco.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within University of Northern Colorado (UNCO) IRB's records.

APPENDIX F

CONTACT TEMPLATE

Contact Template

Dear Ultradistance Cycling Enthusiast,

My name is Bill Tankovich. I am a graduate student at the University of Northern Colorado pursuing a doctoral degree in Educational Technology. The topic of my dissertation concerns the use of emerging technologies (GPS units, smartphones and fitness applications like Strava) in the sport of ultradistance cycling. I would greatly appreciate a chance to chat with you about technology and ultradistance cycling. If this is something that you are interested in, send me an email at tank4118@bears.unco.edu. All correspondence will remain strictly confidential.

Thank you for your interest and help.

Sincerely

William (Bill) Tankovich – RUSA# 2936
Research Advisor: Dr. Mia Williams

Department of Educational Technology
University of Northern Colorado

APPENDIX G

INTERVIEW PROTOCOL EVOLUTION

Interview Protocol Evolution

Technology vs equipment vs gadgets

During the first interview it became apparent that there can be different interpretations of what constitutes "technology". Albert was keen to talk about frame geometry and material as well as clothing. Those items are certainly important in ultradistance cycling. Several other participants also mention those and other items that didn't fit my preconception of technology. While the participants would utilize a version of experiential learning in determine which, for example, rain jacket they like, the technology was the subject of the learning rather than part of the process. It was the process that I wanted to focus on while still giving participants the freedom to discuss items they felt important. In following interviews, I started using the term "gadget". This seemed to elicit more focused responses about technology that were more directly related to the participants' learning process.

Use of technology by others

After the first 3 interview I also started asking about what technology participants saw others using. This would also include asking if there was any technology they wanted but didn't have. I did this to help clarify their reasons for preferring certain technologies and characteristics of that technology. Related to this topic was the question asking what they would recommend for someone new to the sport of ultradistance cycling.

APPENDIX H

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH

CONSENT FORM FOR HUMAN PARTICIPANTS IN RESEARCH

UNIVERSITY OF NORTHERN COLORADO

Project Title: The use of emerging technology as part of the experiential learning process in ultradistance cycling: a phenomenological study

Researcher: William Tankovich, School of Educational Technology

e-mail: tank4118@bears.unco.edu

Research Advisor: Dr. Mia Williams e-mail: mia.williams@unco.edu

Phone: (970) 351-2414

My goal in this research is to gain a better understanding how the use of smartphone apps is changing the ultradistance cycling experience. This may serve to better inform the use of this technology in the sport.

Data will be collected through forty five minute interviews of athletes, coaches, event organizers, spouses and significant others involved in the sport of ultradistance cycling. Questions will be semi-structured with a base of 7 questions and the option to pursue relevant topics in greater detail. Interviews will be digitally recorded for later transcription and coding.

Recordings will be in digital format. They will be transferred to a password protected hard drive and deleted from the portable device within 24 hours of the interview. The digital recorder will remain in the possession of researcher until the files are transferred and the portable versions deleted. As the data is transcribed and coded, participants will be identified by alias to protect their identity and reduce the association of thoughts and opinions with specific individuals. Participants will be provided with transcripts and allowed to clarify or update opinions expressed prior to coding.

The foreseeable risks to you as a participant are minimal to nonexistent. A primary concern would the potential for stress caused negative self-reflection due to that nature of the questions (ie reliving past rides that were unpleasant). However, the primary focus of this study is to gain a better understanding of the ultradistance cycling experience. There will be no effort to judge or evaluate previous performances. There is also the chance that there would be an accidental disclosure of information (interview content and participant ID).

The primary benefit to participants will be the potential for self-reflection on the use of smartphone apps in ultradistance cycling. No direct compensation will be provided. Final results of the study will be made available which may be of use in plan future participant and preparation for ultradistance cycling events.

Participation is voluntary. You may decide not to participate in this study and if you begin participation you may still decide to stop and withdraw at any time. Your decision will be respected and will not result in loss of benefits to which you are otherwise entitled.

Having read the above and having had an opportunity to ask any questions, please sign below if you would like to participate in this research. A copy of this form will be given to you to retain for future reference. If you have any concerns about your selection or treatment as a research participant, please contact Sherry May, IRB Administrator, Office of Sponsored Programs, Kepner Hall, University of Northern Colorado Greeley, CO 80639; 970-351-1910.

Participant Name (printed) ________________________________

Participant Signature ________________________________

Date ________________________________

Researcher Signature ________________________________

APPENDIX I

SUMMARY OF PARTICIPANT INFORMATION

Summary of Participant Information

Participant	Gender	Age	Years UD	Number of events	Number of tech	Desire to improve	Works with coach
Albert	Male	44	18	Over 100	3 or more	Moderately important	Occasionally
Barb	Female	44	1	2	1 or 2	Moderately important	Not currently
Chad	Male	49	7	30	3 or more	Very important	Not currently
Daniel	Male	43	5	10	3 or more	Extremely important	Not currently
Ellen	Female	49	18	25	3 or more	Moderately important	Regularly
Frank	Male	50	17	10	3 or more	Very important	Regularly
Greg	Male	40	2	35	3 or more	Very important	Never
Heidi	Female	56	30	Over 150	3 or more	Extremely important	Not currently
Ivan	Male	34	1	2	3 or more	Extremely important	Not currently
Juliet	Female	54	15	15-20	1 or 2	Not important at all	Not currently

APPENDIX J

LIST OF TECHNOLOGIES IDENTIFIED BY PARTICIPANTS

List of Technologies Identified by Participants

- Equipment,
  - Clothing,
  - Frame material,
  - Frame geometry,
  - Hub generator,
  - Lighting systems,
  - Tires,
- Gadgets,
  - Cell phones,
  - GPS devices,
    - Garmin,
      - Wrist based,
      - Headset,
    - Wahoo,
      - Element,
  - Heart rate monitors,
    - Chest strap,
    - Wrist based,
  - Indoor trainer/stationary bike and associated software,
    - Sufferfest
  - Phone and computer applications and software,
    - Ride with GPS,
    - Map my Ride,
    - Strava,
    - Training Peaks,
    - Final Surge,
    - Other Mapping apps,
    - Other Navigation apps,
  - Power meters,
  - Satellite communication,
    - SPOT, and
    - InReach.