# I've Got This: Fostering Topic and Technology-related Emotional Engagement and Queer History Knowledge with a Mobile App

**Jason M. Harley, Ph.D.** University of Alberta
*Corresponding author
Assistant Professor, University of Alberta, Educational Psychology
*Email:* jharley1@ulaberta.ca; *Phone:* (780) 492-9170
*Mail*: 6-102 Education North, Dept. of Educational Psychology, University of Alberta, Edmonton, Alberta, T6G 2G5, Canada

**Yang Liu, Ph.D.** University of Alberta
Postdoctoral fellow, University of Alberta, Educational Psychology
*Email:* ly6@ualberta.ca
*Mail*: 6-102 Education North, Dept. of Educational Psychology, University of Alberta, Edmonton, Alberta, T6G 2G5, Canada

**Tony Byunghoon Ahn** University of Alberta
Masters student, University of Alberta, Educational Psychology
*Email:* byunghoo@ualberta.ca
*Mail*: 6-102 Education North, Dept. of Educational Psychology, University of Alberta, Edmonton, Alberta, T6G 2G5, Canada

**Susanne P. Lajoie, Ph.D**. McGill University
Full Professor and Tier 1 Canada Research Chair, McGill University, Department of Educational and Counselling Psychology
*Email: susanne.lajoie@mcgill.ca*
*Mail:* 3700 McTavish Street 614, Montréal, QC, CAN, H3A 1Y2

**Andre Grace, Ph.D.** University of Alberta
Full Professor and Tier 1 Canada Research Chair, University of Alberta, Educational Psychology
*Email:* agrace@ualberta.ca
*Mail*: 6-102 Education North, Dept. of Educational Psychology, University of Alberta, Edmonton, Alberta, T6G 2G5, Canada

**Chayse Haldane** University of Alberta
Ph.D. student, University of Alberta, Educational Psychology
*Email:* chaldane@ualberta.ca
*Mail*: 6-102 Education North, Dept. of Educational Psychology, University of Alberta, Edmonton, Alberta, T6G 2G5, Canada

**Andrea Whittaker** University of Alberta
Masters student, University of Alberta, Computing Science
*Email:* amwhitta@ualberta.ca
*Mail*: 2-32 Athabasca Hall, Dept. of Computing Sciences, University of Alberta, Edmonton, Alberta, Canada T6G 2E8

**Brea McLaughlin** University of Alberta
Ph.D. student, University of Alberta, Educational Psychology

*Email:* bmclaugh@ualberta.ca
*Mail*: 6-102 Education North, Dept. of Educational Psychology, University of Alberta, Edmonton, Alberta, T6G 2G5, Canada

**Abstract:** Little research has been conducted to differentiate between multiple, and frequently simultaneously available, discrete object foci in academic achievement situations that emotions can be generated from, including technology and academic topics. Using R. Pekrun's control-value theory of achievement emotions and M. Sharples and colleagues' Mobile Learning Theory, we examined whether appraisals of control over technology and task value predicted emotions directed toward using a mobile app (technology-related emotions) and queer history content (topic emotions). In turn, we examined whether technology-related and topic emotions predicted objective and subjective knowledge outcomes. The main results of this study that examined 57 undergraduate students at a Canadian University were the following: (1) Learners reported high mean levels of technological control over the app. (2) Relatively high mean levels of task value. (3) High mean levels of enjoyment and low mean levels of boredom across both technology-related and topic emotions. (4) Learners' appraisals of task value contributed to multiple regression models that statistically significantly predicted all emotions; appraisals of control over technology contributed to the multiple regression model (along with task value) that statistically significantly predicted technology-related enjoyment. And (5) technology-related enjoyment and topic boredom contributed to multiple regression models that statistically significantly predicted perceived success of learning. Findings and implications are discussed from a critical-analytical perspective.

**Key words:** Mobile app; emotion; affect; mobile learning; control; value; LGBTQ

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**Highlights**

1. (1) Little research examining multiple sources of emotion in achievement activities.
2. (2) High levels of enjoyment, low levels of boredom across tech and topic emotions.
3. (3) Task value predicted tech and topic enjoyment and boredom.
4. (4) Tech control contributed to the model that predicted tech-related enjoyment.
5. (5) Tech-related enjoyment and topic boredom predicted perceived success of learning.

# I've Got This: Fostering Topic and Technology-related Emotional Engagement and Queer History Knowledge with a Mobile App

Mobile apps take advantage of the ubiquity of mobile phones and provide opportunities for both formal and informal learning (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014; Wu, Lee, Chang, & Liang , 2013). Moreover, research has found evidence that students learn better with mobile apps than low (e.g., digital book) or no-tech control conditions (Chang, Hou, Pan, Sung, & Chang, 2015; Chiang, Yang, & Hwang, 2014; Efstathiou, Kyza, & Georgiou, 2018; Li, Zhang, Sundar, & Duh, 2013; Yoon, Anderson, Lin, & Elinich, 2017). While the field of mobile apps is rapidly evolving, research examining emotions during interactions with this technology is limited (Harley, Poitras, Jarrell, Duffy, & Lajoie, 2016; Harley, Lajoie, Tressel, & Jarrell, in press). Given the importance of emotions in supporting achievement by (for example) fostering motivation and focusing attention on achievement-related activities (Pekrun, Elliot, & Maier, 2009; Pekrun & Perry, 2014), research on emotions represents a critical direction for educational mobile apps.

Emotions can arise in response to attending to a myriad of different object foci (e.g., features) in academic achievement situations (Pekrun & Perry, 2014; Harley et al., 2016a, in press; Harley, Pekrun, Taxer, & Gross, 2019). Despite research highlighting the influence that technology, teachers, and peers can have on emotions (Maymon, Hall, Goetz, & Chiarella, 2018; Taxer & Frenzel, 2018), the majority of research on emotions conducted in educational and educational technology contexts focuses on the achievement situation, generally. In doing so, research fails to differentiate between multiple and frequently simultaneously available object foci in academic achievement situations (Harley et al., 2016a, in press). When students learn in technology-rich environments it is especially important to assess both the emotions experienced as a result of the learning material (topic emotions; emotions about planets; Broughton, Sinatra, & Nussbaum, 2013) and from using technology itself (technology-related emotions; Butz, Stupnisky,  Harley et al., 2016a, in press; Maymon et al., 2018; Daniels & Stupnisky, 2012).

Without differentiating the emotions that students experience in response to technology, it is challenging to improve educational technologies or appreciate their role in helping support emotional engagement.

This paper contributes to addressing this gap by comparing the predictive relationships of appraisals of control over technology and task value on both topic and technology-related emotions. According to the CVT and associated research, task value and control are key proximal antecedents to emotions and therefore represent critical psychological mechanisms to investigate in association with emotions (Pekrun & Perry, 2014). Following the causal structure of the CVT, we also examined the predictive relationship of topic and technology-related emotions on objective and subjective knowledge outcome measures. In doing so, this article is the first, to our knowledge, to examine the predictive relationships between appraisal mechanisms, emotions, and objective and subjective knowledge outcomes for emotions generated in response to two different object foci (technology vs. topic) and with a mobile app. This article is also the first to integrate a prominent mobile-learning theory into a quantitative study on emotions. In the following section, we describe our theoretical frameworks and how they jointly helped guide the design of our study and the generation of our research questions and hypotheses which are presented immediately afterwards.

**Commented [TA1]:** I think for a while we used the terms "m-learning" theory and "m-theory" interchangeably. A quick search shows that this article only used the label "m-theory" once here – which is good. Because I think we should stick to calling it "m-learning" theory instead of "m-theory" as it brings confusion. I think just stating that we have prominent mobile-learning theory makes sense since we're introducing the theoretical frameworks below anyway (which includes the definition of m-learning). If this approach is inadequate, let me know.

**Theoretical Frameworks**

Our mobile app research (Harley, 2016, in press) is guided by theory and research. In this article we will focus theoretical discussion on how the CVT of achievement emotions (Pekrun, 2006; Pekrun & Perry; 2014) informed the design and evaluation of the app used in this study as well as how CVT helped shape our interpretation of the presented findings. We will also summarize a theory of mobile learning by Sharples and colleagues (2006; referred to henceforth as M-Learning Theory) and use it describe our mobile app, including the environment it was evaluated in. Finally, we will discuss how CVT and M-Learning Theory make a case for examining technology-related emotions and control over technology in studies with educational mobile apps. We will return to these theories in the discussion section and perform a critical-analytical analysis (Alexander, 2014) of how they do (or don't) relate to the presented findings and how they can inform future research.

**Emotions.** If effective learning is to take place, learners need to experience emotional states that are amenable to concentrating, reasoning, and other learning-related processes (Jarrell, Harley, Lajoie, & Naismith, 2017; Pekrun, 2006; Pekrun & Perry, 2014). Desirable emotions, such as enjoyment can enhance achievement by focusing attention and limited cognitive resources on achievement-related activities (e.g., when experiencing enjoyment of a task), fostering motivation, and promoting situationally-appropriate information processing and self-regulation strategies (Pekrun, Elliot, & Maier, 2009; Pekrun & Perry, 2014). Negative emotions such as hopelessness and boredom can, however, be maladaptive to achievement and undermine intrinsic motivation and interest (Pekrun & Perry, 2014) as well as consume cognitive resources needed for the achievement task (Meinhardt & Pekrun, 2003).

***Précis of the control-value theory of achievement emotions.*** A central tenet of the control-value theory of achievement emotions (CVT; Pekrun, 2006; Pekrun & Perry, 2014) is the role that appraisals of control and value play as proximal antecedents of emotions. Subjective control is defined as one's perceived ability to effectively manage achievement activities and their outcomes. More broadly, appraisals of control target one's beliefs concerning the causal influence they exert (agency) over actions and outcomes (controllability), including the subjective likelihood of being able to obtain said outcome (probability). Subjective value is defined as the perceived importance of an activity or its outcome(s) to oneself (goal relevance), combined with the perception that an action or outcome is positive or negative in nature (goal congruence—event supports or hinders goal attainment).

Another important component of the CVT is the role that focusing one's attention (object focus) on an academic achievement activity versus academic achievement outcomes has on the generation of emotions. Enjoyment from listening to an interesting lecture is an example of an activity emotion, whereas frustration from recalling one's low score on an exam perceived as unfair is an example of an outcome emotion. The CVT also draws a distinction between prospective, concurrent, and retrospective time frames for achievement emotions. When outcome foci are oriented toward the future, emotions are referred to as prospective emotions and when foci are oriented toward the past they are referred to as retrospective emotions. Concurrent emotions include emotions aroused from an activity one is currently undertaking. Together, appraisals and object foci influence and constrain emotional responses. For instance, if a learner feels highly in control of a task and also highly values a task, they are expected to experience (concurrent) enjoyment of the activity, experience hope or joy from looking forward to it (prospective), and/or take pleasure in recalling it (retrospective).

A final component of the CVT that held particular relevance for our study is that achievement emotions (and their proximal antecedents) are domain and subject-specific. In other words, one might experience anxiety learning about math, but not languages (domain-specificity; Goetz, Frenzel, Pekrun, Hall, & Lüdtke, 2007; Goetz, Frenzel, Hall, & Pekrun 2008) and trigonometry but not algebra (subdomains of math). The same applies to different tasks. Accordingly, we distinguished our measurement of topic emotions from technology-related emotions to disentangle how learners feel about a specific topic (queer history) in the domain of (history) and learning about it with specific task affordances (a mobile app). Similarly, emotions directed toward the app versus queer history content can also represent different object foci nested within the activity of using the app (see CVT and M-Learning Theory: Building a case for examining technological control and technology-related emotions).

***Application of CVT to the design of the Edmonton Queer History App and current study.*** These assumptions informed our measurement of emotions and design of the mobile Edmonton Queer History (EQH) App. For example, the EQH App provides user-directed navigation (e.g., choice in what learners pay attention to, for how long, and in what order), which can enhance their perceptions of control by supporting autonomy, pacing, and self-directed inquiry. Moreover, design decisions were made to leverage previous experiences using similar and familiar technologies (e.g., the app was powered with Google Maps). All learners also viewed an instructional video which provided them with a walk-through of how to use the different features and multimedia in the app. Relatedly, and to accommodate different levels of familiarity with LGBTQ+ terms (e.g., transgender, lesbian) used in the app, a glossary was created by the first and fifth authors. Learners had access to the glossary throughout the study. These and other design considerations stood to enhance learners' expectancies of success and self-efficacy to learn about content not covered in provincial curriculums and do so using a new app we developed.

In terms of enhancing value, the app provides historical information about real-world settings that are personally relevant to learners since the historical locations correspond to physical spaces in the city they are going to university in. In addition to this potential source of intrinsic value (where value stems from the activity itself), caring about LGBTQ+ individuals or history stand to serve as additional sources of intrinsic value. Some learners may also appraise the interaction with the app as extrinsically valuable if they believe that learning more about LGBTQ+ individuals and/or their history could help them in their studies (or more likely, given the broad sample) navigating social and professional contexts where LGBTQ+ individuals are increasingly 'visible'[1].

Collectively, these features and design decisions were expected to foster desirable emotions (e.g., enjoyment) and mitigate undesirable emotions (e.g., boredom) by enhancing perceptions of control and value. Fostering positive emotions is consistent with recent extensions by Plass and Kaplan (2015) to Mayer's multimedia learning theory (2005), which posit that incorporating emotionally and motivationally appealing design features (e.g., attractive content, graphics) can help to increase cognitive engagement and retain learners' attention.

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**M-Learning.** Mobile learning has gained traction over the last decade and a half (Bhardwaj & Jain, 2015), perhaps due to the increase of access to mobile technology and the many potential merits mobile learning affords education (Motiwalla, 2007; Traxler, 2007). However, there seems to be little in the way of consensus regarding the definition of M-Learning, with publications referencing frameworks from a wide array of sources (e.g., Heflin, Shewmaker, & Nguyen, 2017; Lam, 2015). In our review of the M-Learning literature and theoretical frameworks, Sharples and colleagues' framework of mobile learning stood out for a number of reasons. One of these was the broad influence this framework has had on M-Learning (Bhardwaj & Jain, 2015)[2]. We found this framework helpful in describing our mobile app as well as guiding and interpreting findings from our research. Specifically, M-Learning Theory, with Sharples' addition of dialectical layers (technological and semiotic, or pedagogical) to Engeström's activity model is a useful guide to help researchers explore and understand

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[1] This point is particularly applicable in Canada and other western countries, though important legal and social changes are also happening elsewhere. Opportunities to learn and broaden perspectives may, however, be even more limited in such places.

[2] Bhardwaj and Jain's (2015) study on recent trends in mobile learning found that Sharples citations per publication score was the highest of all 27 authors they identified as the "most prolific in M-Learning research publications".

technological and pedagogical layers of mobile learning environments (Frohberg, Göth & Schwabe, 2009; Taylor, Sharples, O'Malley, Vavoula, & Waycott, 2006).

Engeström's activity model is based on Vygotsky's and Leont'ev's work that proposed that people (subjects) acquire knowledge and understanding of their surroundings (objects) through social activities (tools; e.g., conversations and other physical interactions; Chung, Hwang, & Lai, 2019). These relationships are reflected in Vygotsky's triangular schematic with three points: tool, subject, object. Engeström (1996; 1999) emphasized the lack of focus in linking individuals to social structures and added three more points to the bottom portion of the triangle: Rules, community, division of labor. The resulting schematic expresses the relationship between (a) a subject that utilizes a (b) tool to transform an (c) object while said subject is tied to a (d) community through (e) rules and the community is tied to the subject through the (f) division of labor (Barab, Evans, & Baek, 2003; Chung et al., 2019). Sharples and colleagues (2006) adopted Engeström's perspective, where the transformation of a learner's (subject's) knowledge and skills (object) is mediated by tools. However, Sharples and colleagues renamed the cultural factors (rules→control, community→context, and division of labor→ communication) and divided the triangle schematic into two layers, giving each of the six points two labels: one for technological, and another for semiotic. This way of thinking aligns with Vygotsky's idea of having two categories of tools in his original model: material tools and psychological (semiotic) tools (Barab et al., 2003; Sharples et al., 2006). Sharples and colleagues' M-Learning Theory therefore provides a more technologically-focused lens to examine mobile learning with, as discussed below.

***Précis of Sharples and colleagues' M-Learning Theory.*** Sharples and colleagues (2006) propose mobile learning as "the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies" (p. 4). This definition highlights the importance of context and mobility, with the implication that learning does not occur in a fixed temporal and location setting, but instead “flows across locations, time, topics, and technologies” (Sharples, Arnedillo-Sánchez, Milrad, & Vavoula, 2009, p.4). It is worth noting that Sharples’ idea of *mobile* is not bound to just physical location, but rather extends to other general contextual factors such as time and surrounding technologies. This makes Sharples’ framework applicable to a wide array of educational scenarios using various technologies, even if the scenario does not involve changes in the physical location of the learner. For example, our EQH App can be used on a desktop which prohibits movements, unlike a phone or tablet that it can also be used with. However, the learner is constantly ‘moving’ their digital (i.e., virtual) location within (a) a map provided as part of the app’s main location interface, and (b) through the Street View function. The latter lets them transition from a traditional cartographic overview to a first-person virtual view to better explore the contemporary surrounding of their current ‘location’ which is associated with related historical multimedia. Hence, while the app can be used in scenarios where learners are physically on the move, it can also be ‘mobile’ in physically stationary learning scenarios.

Sharples and colleagues expanded Engeström’s (1996) model by adding two layers: the *semiotic* and the *technological*. The former accounts for signs and symbols that mediate the learner executing learning tasks and the latter accounts for learners engaging with technology to execute learning tasks. Sharples and colleagues posit that these layers can be viewed separately, or together depending on the purpose. We have imposed Sharples’ framework on our own mobile learning scenario to better describe how learners engaged with our mobile app to learn about queer history by virtually touring related locations in a major Canadian city (see Figure 1). Consistent with Sharples and colleagues, the *subject* is the focus of the model: a learner (i.e., study participant; semiotic layer) and user (technological layer). The *object* is the focus of the learning activity: improving the learner's knowledge of queer history (semiotic layer) and enabling access to such information (technological object). The *changed object* refers to the revised knowledge and skills, in this case, pertaining to queer history (e.g., knowledge of legal changes and social and institutional challenges).

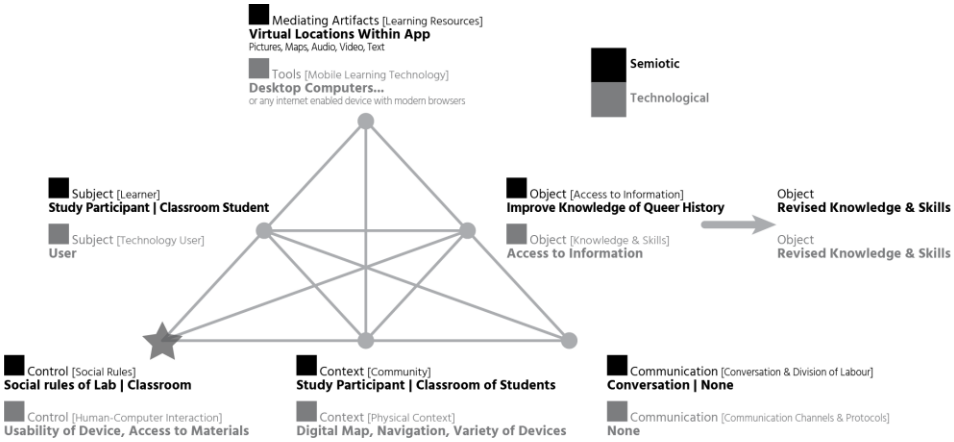


*Figure 1.* Sharples and colleagues' (2006) M-Learning Theory applied to our mobile learning scenario with the EQH App. The lines describe relationships and interactions between linked points. The star highlights the importance of technological control in this study. A single line "|" denotes descriptive modifications (e.g., to social rules) if the mobile app was used in a classroom instead of a laboratory, as was the case in the present study where a single learner used the app independently.

*Control* refers to social conventions regarding the use of technology (semiotic layer) and learners' ability to interact with and manipulate technology so that access to resources, pace and style of interaction can be adjusted as needed (technological layer). In our learning scenario, control would refer to social rules that take place in the learning environment (semiotic layer), and the general usability of the app and the devices used to interact with the app (technological layer). Like CVT, Sharples and colleagues propose that situations where control is compromised can lead to subpar learning. For example, he found that users with devices that had poor technological control (usability; e.g. pre-smartphone era mobile phones, and personal digital assistants), experienced significant barriers to accessing museum information due to the poor interface and search functions (Sharples et al., 2006). Further, because the aforementioned scenario took place in a museum, the semiotic layer of control implied that learners refrained from talking to each other (through non-electronic means) due to social norms. This example highlights the potential consequences of neglecting control in mobile learning environments. We placed particular emphasis on this component of Sharples and colleagues' model because of its influence on the generation of emotions (see "CVT and M-Learning Theory: Building a case for examining control over technology and technology-related emotions").

*Context* refers to the community of entities (people and technology) that afford interaction (semiotic layer) and the physical devices and the digital functions that are being utilized (e.g., a mobile phone and an app for video calling; technological layer). In our learning environment, context refers to learners (i.e., study participants; semiotic layer) and the variety of devices used to access the app, along with many of the digital functions the app has (e.g., digital maps, street-view navigation functions, etc). Appropriate contexts need to be formed for optimal learning to occur. If, for example, context is inappropriate for communication (e.g., conformity in answers explicitly valued from teachers over critical thinking), or bears hindrance to performing learning tasks (e.g., incompatible desktop version of a website used on mobile phones), learning quality will suffer. Studies such as Böhm and Constantine's (2016) help highlight the importance of context and context-aware tools, where use of a location-aware feature increased the score of students' perceived usefulness of an app. In our discussion of M-

Learning Theory at the end of the article, we provide additional scenarios in which the EQH app was designed to be used: context is one of the chief sources of variation between them.

*Communication* refers to conversations between people (semiotic layer) and the role of technology in enabling certain forms of communication (e.g., texting; technological layer). In our scenario, communication between people is mediated by the instructional strategies that are used. For example, the app is available cross-platform and device. Communication patterns will vary based on whether learners are using the app individually on personal devices (e.g., smartphones), working in groups (e.g., on computers), or having a teacher walk learners through the locations on a Smart board. Similarly, teachers assigning questions related to the material or posing questions as learners navigate through the app will impact conversation. Presently, there are no particular communication features enabled by the app, per se.

Lastly, Sharples and colleagues' framework draws attention to *mediating artifacts*. In our learning scenario, these include the virtual locations within the app (semiotic), and any Internet enabled device that runs modern browsers (technological; e.g., Chrome, FireFox, etc.).

***Using M-Learning to describe EQH App learning scenarios.*** We have imposed Sharples' framework on the different learning scenarios the EQH App was designed to be applied to: Laboratory, classroom, and fieldtrip scenarios. This article reports on the first study of the EQH app which was based in a laboratory setting and with undergraduate students to examine learners' interactions with the app and evaluate it prior to potential school-based studies. In the lab-based scenario, learners interacted with the app individually and in a controlled environment, minimizing the number of variables. As such, the learner (subject) attempted to assert control over methods of communication and the learning activity in the context of utilizing a touch-screen desktop computer under the supervision of a research assistant. Non-procedural communication between experimenter and learner was discouraged through the use of our study protocol. There was also little room to be physically "mobile", as the context remained stable throughout the learning experience. Within the digital context, however, learners accessed a variety of multimedia as part of their virtual tour of multiple historical locations, including the use of Google Maps, which they navigate between in order to learn about queer history. Technological control was primarily assessed in this scenario by asking learners to fill out a usability survey (see "Measures" section below). Potential classroom and fieldtrip scenarios with the EQH app are overviewed using M-Learning Theory in the Discussion section.

Sharples' framework is useful for mapping out each component of a learning experience, fostering multivariate comparisons between scenarios, including appreciating different ways to conceptualize and foster 'mobility' in an app. Applications of the framework have led to endeavors such as investigating learners' acceptance toward a mobile application (Liaw, Hatala, & Huang, 2010), and helped inform new frameworks to approach related concepts such as learning analytics (Fulantelli, Taibi, & Arrigo, 2015). However, its limitation lies in the way the framework tends to be descriptive rather than prescriptive. Indeed, it is difficult to generate concrete hypotheses from the framework alone when examining the learning scenarios described above. For example, the framework suggests that neglecting usability (technological control) would have a negative impact on learning, but how, and under what circumstances (etc.) is not clear. Below we discuss how CVT and M-Learning Theory can be used jointly to advance scientific understanding of control over technology and its relationship with emotions.

**CVT and M-Learning Theory: Building a case for examining control over technology and technology-related emotions.** While the CVT has traditionally been used to examine emotions aroused from learners attending to achievement activities or outcomes, more granular divisions of object foci also stand to influence the generation of emotions. Indeed, research on learning with technology, in particular, requires an understanding of the source of the emotion (Daniels & Stupnisky, 2012) within the context of an achievement activity. Prior research informed by the CVT has shown that students experience emotions in response to technology-rich learning environments themselves, including mobile apps, virtual pedagogical agents, and online courses (Butz et al., 2015, Harley et al., 2016a,b, in press; Loderer, Pekrun, & Lester, 2018).

Technology-related emotions in achievement situations are likely to be influenced by appraisals of control, just like emotions generated from attending to non-technological activities (e.g., a lecture) or outcomes (exam grade) or non-technological aspects of an achievement situation (e.g., instructional content in an online class or serious game). Appraisals of control over technology may differ, however, from those directed toward more prototypical aspects of achievement situations, such as academic control (Perry et al., 2001). Sharples and colleagues' M-Learning Theory differentiates two types of control in mobile learning: social norms (semiotic) and usability (technological). Of these three types of appraisals of control (academic, social, and usability) in mobile learning situations, usability is the most directly linked to emotions aroused from technology. While the CVT does not describe object foci within an activity, Sharples and colleagues draw on the human-computer interaction literature and the construct of usability, specifically, to describe technological control.

Usability is defined as the extent to which a product can be used by users (e.g., learners) to achieve specified goals with effectiveness, efficiency, and satisfaction in a particular context of use (Bevan, Carter, Harker, 2015; Bevan, Kirakowski, & Maissel, 1991). While usability research is extensive in many technological fields, little research has been undertaken in the context of education, including mobile apps (Nuland, Eagleson, & Rogers, 2017). Indeed, the literature on mobile apps for learning often *mentions* usability as something that is relevant to research, especially when developing an application, but rarely *examines* its influence on knowledge outcomes or learning-related psychological processes (Brito, Amorim, & Monteiro, 2015; Böhm & Constantine ,2015; Epp, McEwen, Campigotto, &Moffatt, 2016). A small collection of studies do, however, suggest that when educational mobile apps have good usability they have the potential to foster positive affect and increase performance (Cho & Castañeda, 2019; Hao, Lee, Chen, & Sim, 2019; Heflin, Shewmaker, & Nguyen, 2017), which provides preliminary support for technological control in Sharples and colleagues' M-Learning Theory as well as our adoption of usability to measure appraisals of control over technology. As such, M-Learning Theory provided insight at a fine enough layer of detail for us to adapt a widely-used and validated self-report measure (discussed in "Measures") of usability to measure appraisals of control over technology. Indeed, the popular instrument we used had items that can be related to self-concepts of ability (e.g., "I felt very confident using the Edmonton Queer History App") and expectancies ("I would imagine that most people would learn to use the Edmonton Queer History App very quickly"), for example, that are described in Pekrun's (2006; Pekrun & Perry, 2014) and other's definitions of appraisals of control (see Appendix A). More generally, several components of the definition of usability—the extent to which a product can be *used* by users and to achieve a specific goal with *effectiveness* and *efficiency*—underscore the role and importance of control in assessing usability.

**The Current Study**

In this study, we evaluated learners' appraisals of technological control, task value, and emotional engagement with the EQH App. We also examined whether appraisals of control and value predicted emotions directed toward interacting with the app (technology-related emotions) and queer history content (topic emotions). In turn, we examined whether technology-related and topic emotions predicted objective and subjective knowledge outcomes. Our analyses drew on self-reported topic and technology-related emotions used in previous studies with different mobile apps (Authors 2016, 2018), objective and subjective measures of knowledge, and self-reported appraisals of task value, and learner ratings of usability (appraisals of control over technology). One of the secondary aims of this paper was to conduct an evaluation of the design (and design principles) of the EQH app which our assessment of the abovementioned cognitive appraisals, emotions, and knowledge outcomes support. In order to address these objectives, we investigated three research questions.

**(RQ1) Did learners rate the EQH App as being high in technological control, task value, and emotional engagement?** We believed that usability and task value ratings as well as self-reported positive emotions would be high for this app because it was designed to foster positive appraisals of control and value, as discussed earlier. Moreover, learners rated an app that was the subject of previous research we conducted (and that helped inform the design of the EQH App) as high in usability, moderately high in task value, and reported positive emotions from interacting with it.

**(RQ2) Did learners' appraisals of control over technology and task value statistically significantly predict their (a) technology-related and (b) topic emotions?** Based on the CVT and research that has formally assessed the relationship between emotions and appraisals of control and value (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010; Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011), we hypothesized that appraisals of task-value would (a) positively and statistically significantly predict technology-related enjoyment and (b) statistically significantly and negatively predict technology-related boredom. We also hypothesized that appraisals of control over technology would be (a) statistically significantly and positively predictive of technology-related enjoyment and (b) statistically significantly and negatively predictive of technology-related boredom (Pekrun, 2006; Pekrun & Perry, 2014).

Our hypotheses for the relationship between appraisals of value and topic emotions were generally the same as those for technology-related emotions. With regard to control over technology, however, we hypothesized that there would not be a statistically significant predictive relationship because of the technology-specific focus of this appraisal, even though there may be some bleed over into topic emotions. For example, it might be hard to enjoy learning about a topic if one can barely figure out how to use the app the content is on. That said, we further hypothesized that negative technological control would be more likely to bleed over into topic emotions than positive usability. Given our expectations that learners would give high technological control ratings to the EQH App, however, we did not anticipate detecting any statistically significant differences.

**(RQ3) Did learners' (a) technology-related and (b) topic emotions predict their objective and subjective knowledge outcomes?** Consistent with the CVT, we hypothesized that enjoyment would be positively and statistically significantly related to objective and subjective knowledge outcomes while the opposite would hold true for boredom. More generally, we hypothesized that relationships between emotions and knowledge outcomes would be stronger for topic emotions than technology-related emotions because appraisals of value would be based on the topic rather than the technology itself.

## Methods

### Participants

Data were collected and analyzed from 57 undergraduate students (42 female; 26 Caucasian) ranging in age from 18 to 47 years old and studying in a variety of programs (52% STEM) at a North American university. Student GPAs ranged from 2.00 to 4.00 ($M$ = 3.32; $SD$ = .44) out of four. One participant identified as having a non-binary gender identity and six participants as having a non-heterosexual orientation (for a total of six sexual orientation and gender-identity minority participants). The study took approximately two hours and involved participants interacting with the EQH app we developed. Participants were compensated with $5 per half hour (up to $10/hour). Participants were recruited using posters and undergraduate student list serves to advertise the study. Recruitment materials did not mention the historical content of the app, only that the session would involve learning about history using an app.

**Mobile app**

The EQH app includes eight historical locations in the city of Edmonton (Alberta, Canada) that showcase challenges experienced by the LGBTQ+ community and highlight different ways in which events and places can serve as catalysts for change. The selected locations and multimedia vignettes (pictures, audio, video, and text from interviews and archival research) provide rich historical contextualization, particularly through the communication of a social frame of reference (van Drie & van Boxtel, 2008) that interweaves powerful personal histories as well as factual historical information, with a particular focus on the legal, institutional, socio-political and cultural conditions of life. Participants interacted with a desktop version of the mobile app (see Figure 1) on a touch-screen computer that emulated mobile functionality. The app was developed using the content management system Izi Travel which was chosen because of its similarity to other mobile app platforms we have worked with and found to effectively foster emotional engagement and history knowledge (Harley et al., 2016a, in press; Poitras, Harley, & Liu, in press). Moreover, Izi Travel provides updates for security and stability as well as cross-platform and device access to users (for free) through popular and widely available channels (e.g., iTunes store) which stand to meaningfully help with knowledge mobilization efforts in an era of (warranted) security sensitivity. Figure 3 showcases different interfaces and features of the EQH app using the mobile phone version (instead of the desktop version) to showcase cross-device compatibility and better illustrate the different types of multimedia the app includes.

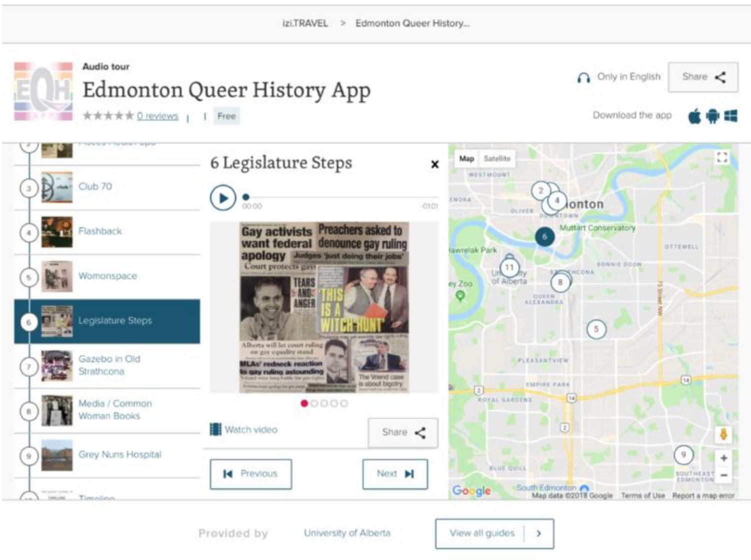


*Figure 2.* Screenshot of the Queer History app Interface. Left-hand panel provides an overview of the tour locations. Middle panel provides an overview of the tour locations multimedia content (in-app scrolling required to see all of the content). The play (arrow) button in the middle panel plays an audio interview clip and the "watch video" button plays an archival video; both related to the location. Additional images can be viewed full screen by tapping on the cover image. Text can be read by scrolling down. The third panel provides a pin corresponding to the location. This allows users to compare the present-day location to the past (e.g., historical images, video) using either the map function (visible) or street view (visible by selecting the yellow person icon in the bottom right-hand corner of the third panel).

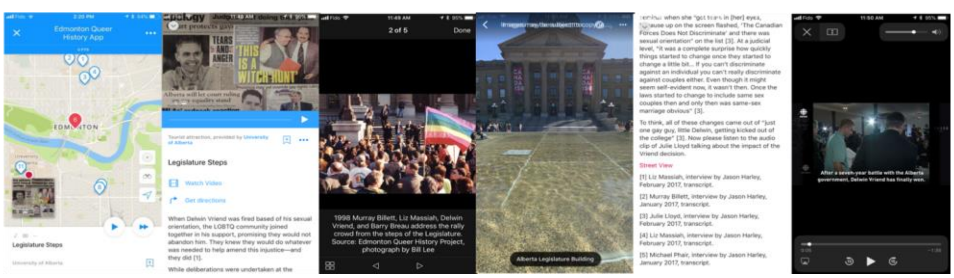

*Figure 3.* Screenshot of different Queer History app interfaces corresponding to different features. Descriptions start on the left-hand panel: (a) GPS-historical site interface, (b) historical site home page interface, (c) image and caption interface, (d) street interface, (d) narrative text interface, and (e) video interface

## Measures

**Emotions.** A modified version of the multiple object foci emotion questionnaire (MOFEQ) for educational mobile apps (Harley et al., 2016a, in press) was used for the wording of the questionnaires to assess learners' retrospective topic and technology-related activity emotions. The MOFEQ is a modified version of the academic achievement emotion questionnaire (AEQ; Pekrun, Goetz, Titz, & Perry, 2002) and uses a five-point scale where 1 corresponds to "strongly disagree" and 5 corresponds to "strongly agree." The MOFEQ includes five items; one for each of five emotions (enjoyment, boredom, frustration, anxiety, and curiosity) selected based on the prevalence of emotions in technology-rich learning environments and theoretical considerations (D'Mello et al., 2013; Pekrun & Perry, 2014). The five items were completed twice (after learners interacted with the EQH app) with slightly different instructions so that learners would report their topic emotions (how they felt learning about queer history) and then their technology-related emotions (how they felt about using the EQH app). An example of a topic emotion question is: "Learning about LGBTQ+ history and relevant Edmonton landmarks bored me". An example of a technology-related emotion is: "I enjoyed using the Edmonton Queer History App" (See Appendix B for the whole questionnaire). Correlations between emotions for both technology-related and topic emotions were in the expected directions (Pekrun & Perry, 2014; Pekrun et al., 2011), providing a measure of internal validity (see Table 1). Correlations with appraisals and perceived success were also in the expected direction, providing a measure of external validity (Pekrun et al., 2011; Pekrun et al., 2011). Please see Appendix C for correlations between additional variables not formally examined in this study, but which provide additional evidence of internal and external validity due to the direction of correlations. Correlational results were also similar to a previous administration of this questionnaire with a similar mobile app (Harley et al., in press).

**Control over technology.** Appraisals of control over technology was assessed using the System Usability Scale (SUS; Brooke, 1996), a widely used 10-item standardized questionnaire for the assessment of perceived usability. The SUS uses a five-point Likert scale to assess learners' usability rating where a ranking of 1 corresponded to "strongly disagree" and a ranking of 5 corresponded to "strongly agree". Our app-specific version of the SUS is reported in Appendix A. Cronbach alpha revealed that inter-item reliability was slightly below traditionally expected levels $\alpha$ = 0.65. Removing the first of the ten items increased the inter-item reliability to $\alpha$ = 0.69. After examining the first item, which had a lower mean score than all other items, we decided to remove it because it may not have been an appropriate question to ask in the context of this particular study. Specifically, it asked students whether "[they thought] that [they] would like to use the Edmonton Queer History App frequently." Since all students completed learning about all of the locations and had a chance to interact with additional pedagogical features such as glossary and timeline, we concluded that this question would be more appropriate for apps with more content or re-playability/usability (e.g., game, calendar or exercise tracking tool). In order to situate the average usability rating for the EQH App, which is based on a ten-time scale, we retained the single problematic item for our first research question. For the remainder of the analyses and descriptive statistics we excluded it (both are reported in Table 2). We did, however, run all analyses using both the reduced and full-scale items and it did not impact results.

The SUS accounted for 43% of post-study questionnaire usage in industrial usability studies (Sauro & Lewis 2009) and has been cited 6,315 times (examined on 9/19/2018; Brooke, 1996) according to Google Scholar. The reliability of SUS has been reported to range from $\alpha$

0.83 to 0.97, with an average alpha coefficient of 0.91 across 200 studies (Bangor, Kortum, & Miller, 2008). The SUS has been shown to tap into a single usability construct (Lewis & Sauro, 2017) that was useful for our purpose of getting a comprehensive evaluation of usability. Recently, Korturm and Sober (2015) demonstrated that the SUS can be used to effectively evaluate usability of phone and tablet apps and reported an overall Cronbach alpha of 0.88 over 3,575 response across 10 apps, and an average score of $\alpha = 77.7$.

**Task value.** Task value refers to the learners' evaluation of how interesting, how important, and how useful the task is perceived to be. Appraisals of task value are also instrumental in influencing the arousal of emotions. In order to measure task value, we adapted five items from the Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, 1991) for this study. A seven-point Likert scale was used to assess learners' task value where a ranking of 1 corresponded to "not at all true of me" and a ranking of seven corresponded to "very true of me". Cronbach's Alpha indicated that scale reliability was high for task-value questionnaire ($\alpha = .87$).

**Queer history knowledge score (percent correct).** Historical knowledge was assessed using a 28-item multiple-choice quiz. Each question contained four foils (i.e., options) and was designed to assess learners' knowledge of the history of Edmonton and Canadian queer history covered in the app. Items were developed by the first author and reviewed by the fifth author whom had expertise in LGBTQ+ rights and history[3]. Learners' response to an open-ended prior knowledge activation question about their knowledge of queer history strongly suggested that they had very low levels of prior knowledge, as expected. Specifically, an initial examination of learners' responses indicated that they most frequently referred to "AIDS" and "concentration

[3] Given that each item was designed to assess different historical information and concepts and was not organized around subscales, we did not necessarily expect nor observe high internal reliability: Cronbach's Alpha indicated that internal reliability of the 28 items was low ($\alpha = 0.55$). This indicates that the knowledge test was not always measuring the same type of knowledge of queer history, as we suspected. See the Limitations section.

camps" in response to prior knowledge activation questions. While of historical importance, the EQH App focus is more specific to Canada and the city of Edmonton which played a critical role in Canadian queer history.

**Perceived success.** In addition to measuring learners' post-tour knowledge of queer history, we were interested in how successful they thought they were. Previous studies have found high correlations between perceived success and actual achievement making this a good supplemental (subjective) measure of learning (e.g., $r = 0.78$, Hall et al., 2006; $r = 0.70$, Ruthig et al., 2007; e.g., $r = 0.67$, Daniels, 2008). In order to measure perceived success, we modified the question and item used in Daniels et al. (2008) to suit our study: ‘‘How successful do you feel you were in learning about LGBTQ+ history in Edmonton from the virtual tour you just completed?" (1 = ‘‘very unsuccessful'' to 10 = ‘‘very successful'').

**Procedures**

The study took approximately two-hours and involved participants interacting with the EQH App we developed. During the session, participants filled out a consent form, activated their prior knowledge about queer history, watched a short tutorial video about how to use the app, interacted with the app, and completed a post-app tour survey that included self-reported emotions, task value, control over technology (usability), and perceived success learning about queer history before they took the 28-item queer history test. Learners tended to interact with the EQH app for 30-45 minutes.

**Data analyses**

Variables were screened for outliers using the SPSS Explore function (selecting outliers and descriptive statistics), which displays stem-and-leaf and boxplot distributions, amongst other data, to identify extreme outlier values. Outliers were replaced with a score that was one unit larger or smaller than the next most extreme score on the distribution (Tabachnick & Fidell, 2007). All variables were also screened for skewness and kurtosis levels. Three variables were severely skewed after outlier cleaning: technology-related frustration, topic frustration, and technology-related anxiety. Given that there was not a good theoretical rationale to transform these variables' scores, they were excluded from analyses that assumed a normal distribution. Technology-related anxiety was excluded from analyses to help facilitate comparisons between retained technology-related and topic-related emotions: Enjoyment and boredom. One variable (topic enjoyment) was only mildly skewed ($z$ = 3.3) and retained for analyses. Of the 36 individual outlier scores that were cleaned across all fourteen variables, 29 of them were for the three variables which were excluded from analyses. As such, four outlier scores (from the eight remaining variables) were both cleaned *and* used in our analyses. Variables used in our analyses had no more than one outlier.

As noted above in the participants section, there were six (of 57) participants who identified as sexual orientation and/or gender identity minorities. While it is possible that LGBTQ+ participants may have had different appraisals, feelings, and knowledge outcomes because of the potential greater relatability and relevance of the content to themselves, conducting significance testing with such a small sample could lead to pre-emptively dismissing data. We therefore opted to run two sets of analyses to examine whether LGBTQ+ participants exerted a meaningful difference on results. Our findings indicated that they did not meaningfully or statistically significantly alter the results. Data screening and cleaning were conducted separately for samples with and without the LGBTQ+ participants. Those reported above are for the full sample (with LGBTQ+ participants).

In order to answer our second research question, we ran four multiple regressions where control over technology and task value were entered as predictor variables and technology-related or topic enjoyment or boredom were entered as the dependent variable. To investigate our third research question, we ran four additional multiple regressions where technology-related or topic enjoyment and boredom were entered as predictor variables and knowledge score (percent correct) or perceived success of learning was entered as the dependent variable.

Assumptions of linearity, multicollinearity, normality of residuals, homoscedasticity were tested across all multiple linear regression models. Linearity and multicollinearity assumptions were met across all models. The assumption for homoscedasticity was examined using Koenker–Bassett's test. In the model using task value and usability to predict topic enjoyment (see Table 3), the homoscedasticity null hypothesis was rejected ($LM$ = 13.68, $p < .05$), thus the significance level was adjusted using heteroscedasticity corrected standard errors and an HC3 estimator (Hayes & Cai, 2007). This adjustment did not lead to a change in the results (pre-to-post adjustment).

The assumption for normality of standardized residual was tested by visual inspection of actual versus fitted scatter plot, and Kolmogorov-Smirnov and Shapiro-Wilk tests. The Kolmogorov-Smirnov test was statistically significant for all models predicting knowledge score (percent correct) and perceived success of learning (Tables 5 and 6), providing an indication that the assumption of normality was not met. Visual inspect of the data, however, suggests the violation of normality is mild. Moreover, the Shapiro-Wilk test failed to reject the null hypothesis on models predicting perceived success of learning. We therefore interpreted the results of models predicting knowledge score (percent correct) and perceived success of learning with some caution, particularly when alpha values were not statistically significant below .01.

## Results

### (RQ1) Did learners rate the EQH App as being high in technological control, task value, and emotional engagement?

Descriptive statistics revealed a mean score of 88.76 with a standard deviation of 7.39 for the ten-item version of the SUS instrument. This usability score exceeded the highest usability range reported by Korturm and Sober (2015), suggesting excellent control over technology. It should be noted that the item that was dropped had the lowest mean score (*M* = 1.91/5; whereas question five had the next lowest mean score of *M* = 3.31/5), indicating that average usability ratings from the nine-item version of the SUS were higher rather than lower than the ten-item version. We used the nine-item version of the SUS in statistical analyses. Descriptive statistics also revealed relatively high levels of task value, high levels of enjoyment and low levels of boredom across both technology-related and topic emotions.

Table 1

*Zero-order correlations between study variables*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| Control Over Technology[a] | 1 | | | | | | | |
| Task Value | .12 | 1 | | | | | | |
| Tech-related Enjoyment | .43** | .65** | 1 | | | | | |
| Tech-related Boredom | -.28* | -.41** | -.45** | 1 | | | | |
| Topic Enjoyment | .13 | .73** | .71** | -.39** | 1 | | | |
| Topic Boredom | -.07 | -.53** | -.59** | .70** | -.57** | 1 | | |
| Knowledge Score (Percent Correct) | .15 | .13 | .17 | .01 | .16 | .05 | 1 | |
| Perceived Success of Learning | .30* | .38** | .49** | -.20 | .42** | -.45** | .26 | 1 |

*Note.* Topic = queer history. Technology = mobile app.
**p* < 0.05 ***p* < 0.01
[a] 9-item version of the system usability scale (SUS) used to measure usability (i.e., control over technology)

Table 2.

*Descriptive statistics for study variables*

| Variable | Observed Min | Observed Max | Possible Min | Possible Max | Mean | SD |
|---|---|---|---|---|---|---|
| Control Over Technology[a] | 65.00 | 90.00 | 0.00 | 90.00 | 83.38 | 6.93 |
| Control Over Technology[b] | 72.00 | 100.00 | 0.00 | 100.00 | 88.76 | 7.39 |
| Task Value | 2.40 | 7.00 | 1.00 | 7.00 | 5.25 | 1.20 |
| Tech-related Enjoyment | 3.00 | 5.00 | 1.00 | 5.00 | 4.32 | .63 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Tech-related Boredom | 1.00 | 3.00 | 1.00 | 5.00 | 1.56 | .68 |
| Topic Enjoyment | 3.00 | 5.00 | 1.00 | 5.00 | 4.54 | .63 |
| Topic Boredom | 1.00 | 3.00 | 1.00 | 5.00 | 1.49 | .63 |
| Knowledge Score (Percent Correct) | .57 | .96 | 0.00 | 1.00 | .81 | .09 |
| Perceived Success of Learning | 7.00 | 10.00 | 1.00 | 10.00 | 8.51 | .97 |

*Note*. Topic = queer history. Technology = mobile app.
[a] 9-item version of the SUS used to measure usability (i.e., control over technology)
[b] Full, 10-item version of the SUS

**(RQ2) Did learners' appraisals of control over technology and task-value statistically significantly predict their (a) technology-related and (b) topic emotions?**

Results revealed that learners' appraisals of control over technology and task value both contributed to the model that statistically significantly predicted technology-related enjoyment. Only appraisals of task value statistically significantly contributed to the model that statistically significantly predicted technology-related boredom. Predictor variables were positively associated with enjoyment and negatively associated with boredom (see Table 3). Findings also revealed that learners' appraisals of task value contributed to models that statistically significantly predicted topic enjoyment and boredom. Task value was positively associated with enjoyment and negatively associated with boredom (see Table 3).

Table 3

*Multiple regression results for usability and task value on technology-related and topic emotions*

| | Standardized coefficients | | $R^2$ | *Adjusted* $R^2$ | *p* |
|---|---|---|---|---|---|
| | Control Over Tech [a] | Task Value | | | |
| Tech-related emotions | | | | | |
| Enjoyment | .34** | .65** | .59 | .58 | .00** |
| Boredom | -.23 | -.43** | .27 | .24 | .00** |
| Topic emotions | | | | | |
| Enjoyment | .03 | .74** | .55 | .53 | .00** |

| | | | | | |
|---|---|---|---|---|---|
| Boredom | .00 | -.57** | .33 | .30 | .00** |

*Note.* Technology = mobile app. Topic = queer history. Control Over Technology measured using the Systems Usability Scale (SUS).
*$p < 0.05$ **$p < 0.01$
[a] 9-item version of the SUS used to measure usability

**(RQ3) Did learners' (a) technology-related and (b) topic emotions predict their objective and subjective knowledge outcomes?**

Results revealed that technology-related enjoyment statistically significantly predicted perceived success of learning and topic boredom statistically significantly predicted perceived success of learning (see Table 4). Technology-related enjoyment was positively associated with perceived success of learning while topic boredom was negatively associated with it.

Table 4

*Multiple regression results for technology-related and topic emotions on knowledge outcomes*

| | Standardized coefficients | | $R^2$ | *Adjusted* $R^2$ | *p* |
|---|---|---|---|---|---|
| | Tech-related emotions | | | | |
| Knowledge outcome | Enjoyment | Boredom | | | |
| Knowledge Score (Percent Correct) | .23 | .14 | .04 | .01 | .32 |
| Perceived Success of Learning | .45** | .05 | .19 | .16 | .00** |
| | Topic emotions | | | | |
| | Enjoyment | Boredom | | | |
| Knowledge Score (Percent Correct) | .31 | .19 | .06 | .03 | .18 |
| Perceived Success of Learning | .18 | -.31* | .19 | .16 | .00** |

*Note.* Technology = mobile app. Topic = queer history.
*$p < 0.05$ **$p < 0.01$

## Discussion

This study aimed to assess whether appraisals of control over technology and task value could be used to predict emotions directed toward using an app (technology-related emotions) and to learn about a topic (topic emotions). Second, it assessed whether technology-related and topic emotions predicted objective and subjective knowledge outcomes.  A secondary aim of this article was to conduct an evaluation of the design (and design principles) of the EQH app, the mobile app used in this study to assess the relationships between psychological states and knowledge outcomes.

The main results of this study were the following: (1) Learners' appraisals of control over technology, measured using usability, were in the excellent range according to Korturm and Sober (2015). (2) Relatively high levels of task value were also reported. (3) High levels of enjoyment and low levels of boredom across both technology-related and topic emotions were reported. (4) Learners' appraisals of task value contributed to models that statistically significantly predicted all emotions; appraisals of control over technology contributed to the model (along with task value) that statistically significantly predicted technology-related enjoyment. (5) Technology-related enjoyment and topic boredom statistically significantly predicted perceived success of learning. We discuss these findings in more detail below by research question, before discussing limitations and future directions, performing a critical-analytical assessment and offering conclusions.

**(RQ1) Did learners rate the EQH App as being high in technological control, task value, and emotional engagement?**

Results supported our first hypothesis that learners would rate the EQH app as high in control over technology, task value, and desirable emotional engagement. Indeed, when comparing the control over technology (i.e., usability) ratings to those established by Korturm and Sober (2015), they fell into the highest range. Our findings concerning emotional engagement are also important because they provide evidence that learners not only found the app highly usable, but also enjoyable to interact with. Much of the content was created (e.g., construction of short historical narratives with interviewee quotes to reinforce or highlight perspectives and on-the-ground events) or identified through archival research and/or LGBTQ+ community sharing, making the multimedia queer history content highly-customized for this app.

Results suggest that our efforts to combine historical facts with narrative and contrast past with present were effective in helping to communicate the importance of queer history as well as engendering enjoyment in learners toward a topic they did not know they were going to learn about.

**(RQ2) Did learners' appraisals of control over technology and task value statistically significantly predict their (a) technology-related and (b) topic emotions?**

Our findings concerning our second set of hypotheses were fully supported for enjoyment and mostly supported for boredom. Specifically, our hypotheses that both control over technology and task-value would statistically significantly and positively predict technology-related enjoyment, but that only task value would statistically significantly and positively predict topic enjoyment were supported. Our hypotheses that task value would be statistically significantly and negatively correlated with both technology-related and topic boredom were also supported. Appraisals of control over technology did not statistically significantly predict topic boredom, as hypothesized. Finally, while we hypothesized that appraisals of control over technology would statistically significantly predict technology-related boredom, the relationship was not statistically significant. It might be helpful to note, however, that the contribution boredom made to the multiple regression model approached significance ($p$ = 0.057) and was statistically significantly and negatively correlated with usability (Table 1). It may therefore have reached statistical significance in a multiple regression model with a larger sample size than 57 learners.

**(RQ3) Did learners' (a) technology-related and (b) topic emotions predict their objective and subjective knowledge outcomes?**

We found mixed support for our third set of hypotheses related to perceived success and no support for our hypotheses related to knowledge scores. Our findings that technology-related enjoyment positively and statistically significantly predicted perceived success of learning and topic boredom negatively and statistically significantly predicted perceived success of learning supported our hypotheses. No other statistically significant relationships with perceived success or knowledge outcomes were observed, counter to our hypotheses. It is possible that technology-related enjoyment, but not topic enjoyment statistically significantly predicted perceived success if learners who struggled with the app and enjoyed it less perceived that they were less successful learning (perhaps from feeling less efficient navigating through the different interfaces) and vice versa. Conversely, it is possible that finding the topic of queer history boring had a much greater impact on perceptions of success (than finding the topic enjoyable or the app itself boring) if topic boredom led to these learners (1) struggling more to focus on the task and (2) they were aware of challenges to paying attention and their potential impact on their ability to learn.

One potential explanation for the lack of support for our hypotheses from the knowledge score is that learners' levels of boredom were not high enough in intensity, on average, to impact it. Similarly, an insufficient range of enjoyment may have been experienced to observe an impact on knowledge scores. While academic achievement emotion literature started to flourish just fifteen years ago, we still know little about the relationship between emotional intensity and achievement (Harley, Pekrun, Taxer, & Gross, 2019). Relatedly, it is possible that learners are relatively sensitive to smaller gradations of emotions, thus potentially explaining the impact of emotions on perceived success, but not knowledge scores. Finally, we highlighted problems with the assumption of normality of the standardized residuals for the knowledge scores which may have affected the robustness of our analyses and corresponding results.

**Limitations and Future Directions**

Our findings that control over technology was a statistically significant predictor of one of two technology-related emotions (enjoyment) highlight the importance of this appraisal in the generation of emotions during interactions with educational technology. In this study, we used usability as an appraisal of control over technology given conceptual fit. Findings and correlations provided support for this treatment. This should be seen, however, as a preliminary investigation and effort to extend the granularity of measurements of appraisals of control in technology-rich learning environments; a methodological approach that is particularly important when technology-related emotions are measured. Future research should examine appraisals of control over technology in unison with traditional measures of academic control to examine relationships and better understand conceptual overlap between the two appraisals of control.

A related limitation was the need to remove one of the ten items from the SUS which did not conceptually fit with our app, in retrospect. Even with the removal of this item, which stood out as far lower than the others, the inter-item reliability was marginally below ideal levels. Accordingly, results concerning appraisals of control over technology should be interpreted with some attentiveness to this fact, though the scale has proven reliable and valid from extensive study. It might also be helpful to note that the inter-item reliability reported in this study for appraisals of control over technology using the SUS were higher than those of other studies using different instruments to measure this appraisal (Butz et al., 2015).

A future direction we are interested in exploring is formally assessing appraisals of control over technology across devices and platforms. While interfaces are similar and features are identical, differences in appraisals of technological control with the EQH App might emerge and would be helpful to have to inform adoption of specific technologies and platforms, when available, for use with the app. Indeed, even triple-A title commercial videogames (with large multidisciplinary studios supporting their development) contain interface differences between platforms and devices, so this is to be expected. Nonetheless, this would represent a novel research direction, especially in education, and could represent an especially good use of the SUS for educational technology research.

Another limitation of this study was the limited variance and skewed responses to questions about learners' frustration and anxiety which warranted their exclusion. While the low levels of these, often distracting, emotions was likely beneficial for learners' emotional engagement and knowledge outcomes, it also restricted our ability to formally test hypotheses with a greater array of discrete emotions. This has been a common limitation in both of our previous studies with mobile apps and history learning (Harley et al., 2016a, in press) and, on balance, it might be said to be a good problem to have from a user perspective.

Our measurement of emotions was also limited by our reliance on self-report data. The use of single-item self-report measures may also be seen as a limitation when compared to questionnaires with more items per scale that have been well established in the literature (e.g., AEQ; Pekrun et al., 2002). There are, however, also advantages to using self-reported measures with a single-item. For example, single-item self-report questionnaires limit item fatigue, are less intrusive than multi-item questionnaires, and can also be more flexible. Asking learners to indicate how they feel about different object foci in a technology-rich learning environment (Conati & Maclaren, 2009; Harley, 2016a,b, in press), as this study did, is an example and something that established measures like the AEQ do not formally assess, presently. Indeed, asking learners which aspect of a learning environment generated which emotion highlights an advantage of self-report measures of emotion over others: one cannot easily discern what elicited an emotion from behavioral or physiological data in open-ended learning environments (Harley, 2015). Studies have also found that the external validity of such measures is supported by behavioral measures of emotion (e.g., facial expressions; Harley, Bouchet, Hussain, Azevedo, & Calvo, 2015), learning strategies and appraisals of task value (Pekrun et al., 2017) and volunteered expressions of emotion from session transcriptions (Harley et. al., 2016a). Similar to Pekrun et al., 2017, the self-report measures of emotion used in this study are supported by correlations with one another and with task value, control over technology, and perceived success of learning in the expected directions. Nonetheless, the addition of behavioral (e.g., facial expressions) and physiological measures of emotions (e.g., electrodermal activity; Harley, 2015; Harley et al., 2015; Harley, Jarrell, & Lajoie, 2019) is an important future direction and one that is currently being undertaken.

Our measure of perceived success shared the same limitation as our measures of emotions, though it was a modified version of a single-item measure used in another study that found large and statistically significant correlations between perceived success and actual achievement (Daniels et al., 2008, $r = .67$). As mentioned above, the direction of the statistically significant relationships between perceived success and emotions provides a measure of external validity. While we noted that one of the two tests employed for the assumption of normality of standardized residuals was not met, the other was. Moreover, our visual inspection suggested the violation was mild. Finally, the strength of the significant models predicting perceived success exceeded the conservative standard we set as an additional precaution. Therefore, we are fairly confident in the robustness of our results concerning perceived success. A potential explanation for the lack of relationship between knowledge score and perceived success variables in our study is that our study focused on achievement outcomes that were not tied to university students' courses whereas these other studies dealt with curriculum-based performance. It is therefore possible that learners evaluated their success learning non-curricular material differently than curricular material. Another explanation is that our knowledge score (percent correct) variable may have been less robust than our perceived success variable, as noted previously.

Another limitation of this study was the lack of a formal measure of prior knowledge regarding queer history. While participants' responses to open-ended prior knowledge questions indicated low prior knowledge, as expected[4], coding open-ended responses that did not contain answers found in the multiple-choice test was deemed inappropriate for formal comparisons. A new study is presently underway with a counter-balanced pre and post-test using responses to the post-tour test items in this study.

Another limitation with our knowledge assessment was the low inter-item reliability. Each item included in the post-tour test of this study was designed to assess different information and we therefore should not expect high internal reliability on the test (Rowe et al., 2017)—as other mobile app (and other types of technology-rich learning environment) researchers might find should they examine the internal reliability of their tests (e.g., Chang et al., 2015; Ibáñez et al., 2015; Li et al., 2013; Taub, Azevedo, Bradbury, Millar, & Lester, 2018; Wilson et al., 2018; Yoon et al., 2017). While others have reported low internal reliability (e.g., Chiang et al., 2014; Harley et al., in press; Rowe et al., 2017), we do recognize that this limits our ability to make arguments regarding the reliability of the measure. Therefore, a direction for future research would be to expand on this first iteration of the knowledge test and include more items designed to test common concepts.

Additional limitations to this study include the non-experimental design and corresponding absence of a control group. While this did not impact our ability to answer our particular research questions, it does limit the research questions that this study can help answer. A new study is underway to address this limitation.

Our analyses for this study were limited by the size of sample. Not only did our sample of 57 learners limit the statistical power of our analyses, but it made running analyses, such as a

[4] Based on this information not being covered in provincial curriculums.

path analysis that could have combined our multiple linear regression models into a single analysis, inappropriate (Ding et al. 1995; Wolf, Harrington, Clark, & Miller, 2013). Relatedly, we could have run a confirmatory factor analyses on the SUS with a larger sample size to help ensure that all of its items loaded onto a single factor for our particular study (despite its extensive use and validation). While studies with educational technology and lengthier sessions often suffer from smaller sample sizes than other types of (quantitative) educational research studies, recruiting larger sample sizes is an important future direction, particularly to be able to take fuller advantage of analytical approaches that require sample sizes in the hundreds. In addition to recruiting larger samples, research should be conducted with the app in high schools in order to formally examine the generalizability of findings beyond undergraduate students.

We acknowledge that the emerging literature on immersion may be another corpus of empirical evidence to consider in relation to advancing scientific understanding of emotion and learning with mobile apps. Immersion is defined as “the participant's suspension of disbelief that she or he is 'inside' a digitally enhanced setting" (Dede, 2009; p.66). The applicability of immersion to educational mobile apps, however, is not yet clear. For example, Shin (2017) states that immersion is indeed an emerging concept to be studied, but more so in games (e.g., Christou, 2014). Witmer and Singer’s (1998) description of immersion offers further support for this point of view: “Immersion is a psychological state characterized by perceiving oneself to be enveloped by, included in, and interacting with an environment that provides a continuous stream of stimuli and experiences” (p.3). Educational studies, perhaps reflecting these definitions, overlap with research on games and tend to focus exclusively on augmented reality (e.g., Ferrer, Perdomo, Rashed-Ali, Fies, & Quarles, 2013; Georgiou & Kyza, 2018) or virtual reality (e.g., Zhou, Ji, Xu, & Wang, 2018; Riva et al., 2007), and use theoretical frameworks meant primarily for such environments (e.g., Dalgarno & Lee, 2010; Georgiou & Kyza, 2017).

Accordingly, we did not draw upon this important, but peripheral body of work in the current study which examined different psychological processes and in a technology-rich environment that immersion may not necessarily readily apply to. Formally examining immersion with the EQH App or other location-aware mobile apps represents a future direction, however.

**Critical-analytical Assessment**

Our critical-analytic focus in this article involved reflection on the big picture: what can we take away from our findings and say about emotions, appraisals, and knowledge outcomes from a (a) theoretical and (b) empirical perspective? We commence our critical-analytical assessment with the CVT before focusing on M-Learning Theory and contributions and conclusions that can be drawn from the present study.

**CVT.** We have already discussed several critiques and future directions, such as the importance of better understanding the role of intensity in the experience of emotions, related psychological processes, and achievement outcomes. Relatedly, our findings and discussion of them have also highlighted the importance of assessing multiple object foci within an achievement activity when one asks a learner how they feel, particularly in retrospective contexts and technology-rich environments. Indeed, results revealed that enjoyment and boredom differed in their relationships with proximal antecedents (appraisals of control and value) and knowledge outcomes (perceived success learning) when they were technology-directed versus topic emotions. The AEQ (Pekrun et al., 2002), which is the most widely used measure of emotions in educational situations is not designed to examine object foci within achievement activities, thus additional instruments, such as the MOPAQ used in the present study, might be used to help improve the granularity of achievement emotion theory and research in this regard.

Our results concerning the predictive role of appraisals of control over technology and task value supported the CVT and replicated previous studies (Pekrun et al., 2010, 2011), but with a different type of learning environment (e.g., mobile app) and topic (queer history) than those typically examined in academic achievement emotion literature (Daniels et al., 2008, 2017; Goetz et al., 2006, 2007, 2008, 2013, 2014; Pekrun & Linnenbrink-Garcia, 2012). This stands to help generalize propositions made by the CVT. Results also provide preliminary support for measuring appraisals of control over technology in technology-rich learning environments and using validated usability instruments (e.g., SUS) to do so. Much of the research on achievement emotions that formally evaluates propositions of CVT takes place in traditional classroom settings (Pekrun & Perry, 2014), though that is beginning to change (Camacho-Morles, Slemp, Oades, Pekrun, & Morrish, 2019; Loderer, et al., 2018). Therefore, our findings may be particularly helpful for researchers wishing to assess control when students interact with educational technology, and mobile apps in particular, though more research directly examining other facets of control in academic achievement situations should also be conducted. Our findings related to objective and subjective knowledge outcomes were less clear in supporting assumptions made by CVT, though the relationships that were statistically significant were in the direction CVT would predict and there were limitations associated with the knowledge score measure.

**M-Learning Theory.** Sharples and colleagues' (2006) M-Learning Theory provided valuable guidance on how to conceptualize and measure appraisals of control related to technology with their focus on mobile learning technologies and human-computer interaction that led us to adopt a widely used measure of usability. This was a particularly valuable contribution in the absence of more granular conceptual guidance regarding appraisals of technological control from the CVT and related literature. Otherwise, however, this framework was not well-suited for independently informing the development of testable hypotheses. Indeed Taylor, Sharples, O'Malley, and Vavoula (2006) note that:

**Commented [TA4]:** Convert to past tense?

> "The task model is not itself prescriptive (e.g. what contexts are important for what types of learning) nor do the elements need to be explicitly modelled in the technology (e.g. whether the technology should contain a computational model of the learner, or of the context). But these lower level considerations can now be explored through case studies, and further empirical work, to illuminate the model further." (p. 16).

Therefore, our study typically relied on building a bridge between theories to connect the rich higher-level, contextual and descriptive features of M-Learning Theory with the prescriptive, lower-level considerations of the CVT. For example, M-Learning Theory helps highlight considerations for generalizability with our results, including future directions for different learning scenarios. In the section where we described M-Learning Theory, we provided an overview of how M-Learning Theory was applied to our lab-based scenario. M-Learning Theory helped us to conceptualize 'mobile' as more than just physical movement, but transitions through virtual/digital spaces (e.g., using geolocation and virtual touring; Sharples et al., 2009). This helps us contrast the lab-based scenario with classroom and real-world mobile learning ones below: scenarios the EQH App was designed to be used in. Please see Appendix D for a summary.

***Classroom-based scenario.*** While there is overlap between the classroom and lab-based scenarios, key differences include the introduction of the social dynamics of a classroom (e.g., students, teacher), along with the potential for devices other than a desktop. These new elements have several implications according to Sharples and colleagues' (2006) model. Primarily, they imply a shift in control, where the semiotic layer of control will no longer be based on the social rules of a laboratory setting, but rather those of a classroom. Further, the use of a device is no longer limited to a controlled lab-computer, but becomes applicable to various hardware (e.g., different form factors of smart phones) and software (e.g., different smart phone operating systems, different internet browsers or apps to render the content). Accordingly, the layers connected to the control layers (subject, context, and object) will be directly impacted. That is, no longer is the semiotic layer referring to a lab participant, but rather a student in a classroom. Meanwhile, the semiotic context will also be a classroom setting, where there are many more branches of scenarios to be appreciated. Applying Sharples and colleagues' framework of what mobile learning is, this learning scenario would have a substantial increase in the potential for "mobility" (traversing through contexts for conversing): physically talking to teachers and peers, texting and sending screen shots or pictures to others, "moving around" in the virtual map with a friend and comparing what others would see (and so on), would all be part of what makes these learning scenarios "mobile".

All of these changes are, however, susceptible to disengagement and distraction to learning and have the potential to contribute towards the change of object, and the revision of knowledge and skills the students hold. This would mean that teachers using different devices would want to familiarize themselves with small changes when interacting with the app across platforms and devices. Toward this end, we have created an instructional resource for teachers to give them maximum flexibility to use the app with whatever technologies they and their students have access to. Further, it should be noted that students might share a device in a classroom context, depending on the availability of technology.

Appraisals of control over technology may differ in this context from the present study, as students may be using different devices and accessing the app through different operating systems. Assessing such differences, whether they are additive or retract from psychological and knowledge outcomes would be important to understand. Communication between teachers and students and the role different types of conversational patterns, prompts, scaffolds, and on vs.

off-task behavior have on psychological processes and knowledge outcomes should also be examined. Relatedly, distinctions should be drawn between teacher and student emotions in a classroom learning scenario and emotional contagion (between teacher and students and students and students) would be valuable to consider.

***Real-world mobile scenario.*** The third scenario is the real-world mobile learning scenario, where users can venture out to visit the physical locations the Queer History App showcases. Like the classroom scenario, the fieldtrip scenario also holds many variables, including whether students take the tour together or individually. Additionally, while the devices used are likely to be mobile phones as opposed to tablets (tablets being less likely to have roaming plans), computers, or SmartBoards, small differences still exist in the user interface between operating systems. The most interesting feature of this scenario to investigate might be the role that being on vs. off-site has on psychological processes. It is possible that learners might feel more connected and engaged with the app and queer history content if they are on location and physically moving between locations rather than doing so virtually.

In sum, M-Learning Theory highlights many variables that may impact the generalizability of the results of this study to other learning scenarios, thus generalizability from laboratory to classroom or field should not be assumed. Assessing these variables and the relationships between them in future studies in diverse learning scenarios provides many future directions that may prove fruitful in extending theory on mobile learning.

**Additional contributions.** Aside from the opportunities to expand and integrate theory we have raised, this article also sought to evaluate an app to teach students about queer history: a topic so controversial and/or under-valued that it was given no more space in high school textbooks (at the time this article was written[5]) in the Canadian province of Alberta this study was conducted in than (1) an optional reading or activity and (2) the inclusion of LGBTQ+ people in the list of concentration camp victims. We were aware that while the app stood to address a critical educational gap in the provincial (i.e., state) curriculum, it also (and hopefully) had positively psycho-social transformative effects in addition to educational gains for participating students. Indeed, while this article is part of a larger study that included an examination of changes in empathy and hope toward LGBTQ+ people from interacting with the EQH app, we believe that these results present some equally important indicators of success. First, the design of the app, which included features informed and aligned with CVT, M-Learning Theory, and our previous empirical work with mobile apps, yielded excellent control over technology ratings and high levels of technology-related enjoyment and low levels of technology-related boredom. Moreover, despite learners not knowing that they were going to be learning about queer history, they reported high mean levels of enjoyment learning about the topic and appraised it as high in value. Given the diverse backgrounds of undergraduate students (e.g., area of study) we found this promising preliminary evidence that the app's content was accessible and engaging. Finally, learners had high objective and subjective learning outcomes, which suggests that it has the potential to be an effective educational resource. Indeed, our findings provide clear and consistent evidence that our app was (1) easy, efficient, and pleasant to use; (2) that learners reported enjoying learning about queer history, (3) appraised learning about it as valuable, and (4) had high mean levels of objective and subjective knowledge. Given the sparsity of resources available to learn about queer history and reticence to integrate it into social studies and history curriculums beside other historically marginalized and disadvantaged

[5] This was identified with the support of a high school social sciences and history professor who has expertise with textbook content analyses and is well-versed with the textbooks used across the province as part of the curriculum.

groups and associated movements (e.g., civil rights and suffrage movements) it is important that such educational resources are done properly. Our findings suggest just this, while also providing some design guidelines for mobile apps, and constructive, critical future directions for theory and research alike.

**Conclusion**

In conclusion, this study builds upon prior work by Harley and colleagues (2016, in press) to extend scientific understanding of emotional engagement with mobile apps, particularly concerning emotions directed toward different object foci. This study used M-Learning Theory to position the EQH app and this study within the literature on mobile learning and to help measure appraisals of control over technology. The CVT was used to inform the development of our hypotheses, as a prescriptive theory, and the majority of our results provide further support for the assumptions outlined in CVT, particularly those concerning the role of appraisals of control and value as proximal antecedents of emotions. Findings also supported Sharples and colleagues' M-Learning Theory framework, particularly, the importance of control in mobile learning by highlighting its relationship to technology-related emotions and these emotions to knowledge outcomes. In sum, this article helps extend scientific understanding of emotions, their proximal antecedents, and knowledge outcomes in mobile learning environments and highlights future directions for both the EQH app, specifically, as well as the rapidly developing field of mobile learning.

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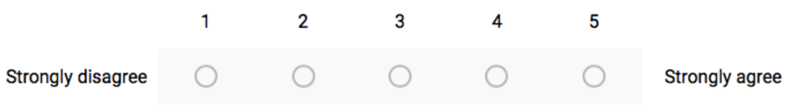
## Appendix A

The SUS adapted from Brooke (1996) for the Edmonton Queer History App

This section assesses your interaction with the Edmonton Queer History App. Please rate your experience using this application.

Record your answers below, using the appropriate number, where 1 indicates that you "strongly disagree" with a statement and 5 indicates that you "strongly agree".




1. I think that I would like to use the Edmonton Queer History App frequently.
2. I found the Edmonton Queer History App unnecessarily complex.
3. I thought the Edmonton Queer History App was easy to use.
4. I think that I would need the support of a technical person to be able to use the Edmonton Queer History App.
5. I found the various functions in Edmonton Queer History App were well integrated.
6. I thought there was too much inconsistency in the Edmonton Queer History App.
7. I would imagine that most people would learn to use the Edmonton Queer History App very quickly.
8. I found the Edmonton Queer History App very cumbersome to use.
9. I felt very confident using the Edmonton Queer History App.
10. I needed to learn a lot of things before I could get going with the Edmonton Queer History App.

## Appendix B

The multiple object foci emotion questionnaire (MOFEQ) for educational mobile apps modified for the Edmonton Queer History App from Harley and colleagues (2016, in press)

**Emotions: Part 1. About the historical learning content of the tour**

Learning about LGBTQ+ history with the Edmonton Queer History App can induce different feelings. This survey refers to the emotions you may have experienced when learning about history in today's virtual tour. Specifically, the following questions pertain to feelings you experienced WHILE learning about LGBTQ+ history with the Edmonton Queer History App. Record your answers below using the appropriate number, where 1 indicates that you strongly disagree with a statement and 5 indicates that you strongly agree.

1. I enjoyed learning about LGBTQ+ history and relevant Edmonton landmarks.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

2. Learning about LGBTQ+ history and relevant Edmonton landmarks bored me.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

3. Learning about LGBTQ+ history and relevant Edmonton landmarks annoyed me.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

4. Learning about LGBTQ+ history and relevant Edmonton landmarks made me want to learn more about queer history in Edmonton and/or other parts of Canada.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

5.Learning about LGBTQ+ history and relevant Edmonton landmarks made me feel anxious.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

**Emotions: Part 2. About the Edmonton Queer History App**

This survey refers to the emotions you may have experienced when using the Edmonton Queer History App in today's virtual tour. Specifically, the following questions pertain to feelings you experienced WHILE using the app in today's virtual tour. Record your answers below, using the appropriate number, where 1 indicates that you strongly disagree with a statement and 5 indicates that you strongly agree.

1. I enjoyed using the Edmonton Queer History App.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

2. The Edmonton Queer History App bored me.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

3. Using the Edmonton Queer History App annoyed me.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

4. Using the Edmonton Queer History App made me want to use it to learn more about queer history in Edmonton and/or other parts of Canada.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

5. Using the Edmonton Queer History App made me feel anxious.

| | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|
| Strongly disagree | ○ | ○ | ○ | ○ | ○ | Strongly agree |

**Appendix C**

Correlations between all study variables, including excluded emotions

*Zero-order correlations between study variables*

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 8 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Control Over Tech [a] | 1 | | | | | | | | | | |
| Task Value | .12 | 1 | | | | | | | | | |
| Tech-related Enjoyment | .43** | .65** | 1 | | | | | | | | |
| Tech-related Curiosity | .14 | .74** | .54** | 1 | | | | | | | |
| Tech-related Boredom | -.28* | -.41** | -.45** | -.33* | 1 | | | | | | |
| Topic Enjoyment | .13 | .73** | .71** | .58** | -.39** | 1 | | | | | |
| Topic Curiosity | .13 | .64** | .48** | .81** | -.33* | .57** | 1 | | | | |
| Topic Boredom | -.07 | -.53** | -.59** | -.45** | .70** | -.57** | -.49** | 1 | | | |
| Topic Anxiety | -.08 | -.01 | .01 | -.26 | .00 | -.14 | -.21 | .09 | 1 | | |
| Knowledge Score (Percent Correct) | .15 | .13 | .17 | .15 | .01 | .16 | .14 | .05 | .19 | 1 | |
| Perceived Success of Learning | .30* | .38** | .49** | .27 | -.20 | .42** | .25 | -.45** | .02 | .26 | 1 |

*Note.* Topic = queer history. Technology = mobile app. SUS = system usability scale.
$*p < 0.05$ $**p < 0.01$
[a] 9-item version of the SUS used to measure usability (i.e., control over technology)

**Appendix D**

Implementing Sharples and colleagues' (2006) M-Learning Theory model to learning scenarios.

| | Learning Scenario | | |
|---|---|---|---|
| | Laboratory (Study) | Classroom | Fieldtrip |
| Semiotic Mediating Artifacts | Virtual locations, maps, pictures, audio, videos | Virtual locations, maps, pictures, audio, videos | Virtual locations, maps, pictures, audio, videos |
| Technological Tools | Touch-screen desktop computer | Various devices (desktops, laptops, tablets, phones, etc.). Can be 1 device per user, or 1 device for multiple users. | Mobile devices (phones, tablets). Most likely 1 device per user scenario. |
| Semiotic Object | Improve knowledge of queer history | Improve knowledge of queer history | Improve knowledge of queer history |
| Technological Object | Access to information | Access to information | Access to information |
| Semiotic Communication | Questions regarding app use | Conversations, exchange of ideas, division of labour more likely if there is a well-structured learning activity. | Conversations, exchange of ideas, division of labour more likely if there is a well-structured learning activity. Or, potentially none at all if user is all alone. |
| Technological Communication | None. Despite the device used has affordances for communication, none are allowed. | None. However the devices used have affordances for communication. | None. However the devices used have affordances for communication. |
| Semiotic Context | "Partnership" of participant & researcher | Classroom of students | Potentially alone, or with peers or mentors. |
| Technological Context | Digital map, navigation, desktop computer with a large screen | Digital map, navigation, variety of devices with varying screen sizes and other peripheral devices | Digital map, navigation, devices with smaller screen sizes |
| Semiotic Control | Social rule of participating in an experiment (expectation to follow rules and protocols) | Social rules of a classroom | Social rules of being out in public |
| Technological Control | Usability of device/app (Desktop - touch screen monitor, keyboard, mouse) | Usability of device/app (Variety of devices) | Usability of device/app (Most likely touch screen phones/tablets) |
| Semiotic Subject | Study participant | Classroom student | Learner/pedestrian |
| Technological Subject | User | User(s) (potentially multiple users for one device) | User |