Examining Physiological and Self-report Indicators of Empathy during Learners' Interaction with a Queer History App

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Abstract

Mobile apps take advantage of the ubiquity of mobile phones and can be used to share unique pedagogical experiences with multimedia content not yet available in curriculums. This preliminary study used a quasi-experimental pre-post-test design to examine changes in self-reported empathy toward sexual orientation and gender identity (SOGI) minority people. We also report on the associations between gender and a physiological measure of emotional activation, skin conductance level (SCL), on self-reported empathy. The main results of this study that examined 57 undergraduate students at a Canadian University whom interacted with a queer history app individually were the following: Preliminary evidence that (1) students' empathy toward SO and gender identity GI minorities can be measured using a modified version

of the scale of ethnocultural empathy (SEE). (2) Statistically significant increases in empathy toward SO and GI minorities pre to post app interaction. (3) Students' pre- and post-empathy levels were statistically significantly higher toward SO than GI minorities. (4) Female students had statistically significantly higher self-reported empathy toward SO and GI minorities than males. (5) Male students had statistically significantly higher SCL than females. (6) Statistically significant interaction between SCL grouping and questionnaire administration on GI minority empathy. Findings and implications are discussed in lieu of the contributions that mobile apps can play to support social change, in particular, by fostering empathy.

Keywords: Mobile app; empathy; emotion; affect; skin conductance; physiological activation; mobile learning; LGBTQ; queer history

Structured practitioner notes

What is already known about this topic

- Evidence that mobile apps are effective learning tools
- Evidence that mobile apps are emotionally engaging
- Evidence that education can help dispel ignorance, known to contribute to homophobia and transphobia, and promote empathy
- Empathy has an emotional component
- Empathy can be measured as a general trait or toward specific groups
- Queer history is excluded from many formal educational curriculums

What this paper adds

- Preliminary evidence that a self-report tool can be used to measure empathy toward both sexual orientation (SO) and gender identity (GI) minorities
- Preliminary evidence that undergraduate students' empathy toward SO and GI minorities increased after interacting with the Edmonton Queer History (EQH) app

- Preliminary evidence that students' empathy toward SO was statistically significantly higher than it was toward GI minorities at both pre and post.
- Preliminary evidence that female students had statistically significantly higher self-reported empathy toward SO and GI minorities than males
- Preliminary evidence that male students had statistically significantly higher skin conductance levels (SCL) than females.
- Preliminary evidence of a statistically significant interaction between SCL grouping and questionnaire administration on GI minority empathy

Implications for practice and/or policy

- Mobile apps can be used to teach students about queer history and these interactions may lead to increases in empathy
- Educators can supplement their curriculum with educational technologies, such as mobile apps, to fill important gaps
- Educators should consider gender differences in teaching topics that may or are intended to inspire empathy
- Educators should not assume that empathy toward SO and GI minorities are the same

Introduction

Learning about LGBTQ+ history is one approach to expanding inclusive education. Education stands to help dispel ignorance, which is known to contribute to homophobia and

transphobia (Bowleg et al., 2003; Grace, 2015) and in doing so, foster a sense of empathy (van Drie & van Boxtel, 2008). In order to accomplish these objectives, we created the Edmonton Queer History App (EQH app) which leverages multi-media and location-aware augmented reality (AR) features to help students better understand the present through an appreciation of the past (Wu, Lee, Chang, & Liang, 2013). The current study examined students' self-reported empathy toward LGBTQ+ people before and immediately after interacting with the EQH app and examined the relationship between self-reported empathy and emotional activation (via average skin conductance levels) during the interaction with the app. We also examined whether students' gender influenced their self-reported empathy and skin conductance levels. The research presented herein is the first to our knowledge that aims to (1) use a mobile app as an educational intervention to enhance empathy toward LGBTQ+ people. (2) Examine whether learners classified as low, medium, or high in emotional arousal (skin conductance, a physiological measures) reported significantly different levels of empathy. And (3) investigate whether gender has an effect on emotional arousal. We used a group-specific frame of empathy to investigate students' levels of empathy toward LGBTQ+ minorities, specifically, rather than assessing students' general level of empathy which is a fourth unique contribution. Below, we introduce constructivism, empathy, emotions and learning with mobile apps, and physiological measures of emotion to frame the study and its contributions.

Constructivism

The core constructivist idea that knowledge is constructed though peoples' experiences and actions (van Bergen & Parsell, 2019) has many pedagogical implications, including an emphasis on factors that contribute to the learners' active experiences: the learner, and their environment (Ertmer & Newby, 2013). We took a constructivist approach to designing the EQH App by focusing on providing authentic contexts for our learners. For example, our learners

attended university within the city the EQH App focuses on; a focus that includes historical events directly relevant to current day events (e.g., pride parades) and controversies (e.g., gay-straight alliances in schools). Further, we included audio and video recordings featuring prominent community members' personal narratives that provide learners with opportunities to construct knowledge on how the historical locations, events, and the community involved transformed LGBTQ+ rights as we know it. Learners were also able (and encouraged) to explore virtual 3D maps (via Google Street View) to compare and contrast how the past locations have transformed and decided how much time they invested learning from various multimedia and historical sites. These and other design decisions (see Harley, Liu et al., 2019) are anchored in constructive learning experience, especially the notion that educational technologies should strive to be more than a specialized area of the curriculum, a substitute for an instructor, or merely a tool that teachers can use to achieve traditional aims (Scott, Cole, & Engel, 1992).

The EQH App aimed to achieve Scott and colleagues' (1992) vision for constructivist technology in a number of ways: by leveraging different forms of multimedia, it shares human perspectives along with facts in a user-paced and engaging manner (Harley, Liu et al., 2019). By exploiting open-access (free) and ubiquitous technologies (e.g., mobile phones, computers) and established best practices in user experience (e.g., Google Maps), the EQH App maximizes accessibility to users with different levels of technological knowledge and financial resources. Perhaps most importantly, our app empowers educators and individuals to learn about the histories of LGBTQ+ minorities that remain outside of formal curriculums.

Empathy

Generally-speaking, empathy refers to "the consequences of perceiving the feeling state of another as well as the capacity to do so accurately" (Spreng, et al., 2009, p.1). Research has distinguished between emotional and cognitive components of empathy. Emotional empathy

refers to one's emotional reaction (e.g., experiencing compassion) to another person's emotional expression (e.g., expressing sadness through tears; Spreng et al., 2009). In contrast, the cognitive component involves an intellectual or imaginative understanding of another person's emotional state (Spreng et al., 2009). Empathy is important because it helps people to make sense of the behaviour of others, predict what they might do next, how they feel, and feel more connected to them, and respond appropriately to others (Allison, et al., 2011). Empathy is often construed as a trait or general ability (Wang, et al., 2003; Duan & Hill, 1996), where some individuals are more empathetic than others. Women, for example, often score higher on measures of empathy than men (Spreng et al., 2009; Wang et al., 2003). Research has also shown that empathy can be altered to increase valuing of other peoples' wellbeing and help change attitudes towards oppressed groups (Batson et al., 1995,1997). Indeed, research has found that general empathy can predict positive explicit attitudes toward gay and lesbian people (Burke et al., 2015).

Like Wang and colleagues (2003), we advocate building an understanding of group-specific empathy because general empathy tendencies do not necessarily apply equally to all groups, particularly when individuals have little knowledge of and/or may have biases for seeing groups as lesser than themselves. Toward this end, we assessed students' empathy toward LGBTQ+ minorities, specifically. Research has shown that educational interventions, such as professional development training programs for teachers, can significantly increase empathy toward LGBTQ+ students and their specific challenges (Greytak, 2013). Preliminary evidence suggests that engaging alternatives to lectures, such as role playing and simulations, have potential to be even more effective for enhancing empathy toward gay and lesbian people (Hodson et al., 2009). Such findings supported our use of a mobile app as an educational intervention for the development of empathy toward LGBTQ+ people.

Emotions and Learning with Mobile Apps

We chose a mobile app as the platform to deliver our content because this technology leverages the popularity of mobile devices and the flexibility they afford for both formal and informal learning (Bacca et al., 2014; Wu et al., 2013). Moreover, research has found that they can be effective tools to promote learning. Across a number of experimental studies, students learned better with mobile apps than low (e.g., digital book) or no-tech control conditions (Chang, et al., 2015; Chiang, et al., 2014; Efstathiou et al., 2018; Li, Zhang, et al., 2013; Yoon et al., 2017). Using a mobile app also permitted the authors to build upon their previous research using location-aware mobile apps to teach students about history (Harley, et al., 2016, 2018, 2020; Poitras et al., 2019). This program of research principally contributed to the literature by examining the emotional engagement of using mobile apps to learn about history; a gap in mobile app research that is important to address because of the important links between emotions and academic achievement (Pekrun, 1992; Pekrun et al. 2017; Pekrun and Linnenbrink-Garcia, 2014). To-date, we have consistently found that learners tend to experience higher levels of enjoyment and curiosity and low levels of boredom, frustration, and anxiety while using such apps to learn about history, including the one examined in this article (Harley et al., 2016, 2018, 2019, 2020; Poitras et al., 2019). These findings are important because they further highlight the potential of using mobile apps to teach students about history. Many gaps still exist, however. For example, our previous research, like most educational psychology studies, relied on self-report measures to examine emotions with the EQH App.

Physiological Measures of Emotion

Given the multicomponential nature of emotions that includes behavioral (e.g., facial expressions; Ahn & Harley, in press) and physiological (e.g., skin conductance) expression components (Gross, 2015; Harley, Pekrun et al., 2019; Pekrun, 2006), research should assess more than the experiential (i.e., feelings) component of emotions that self-reports tap into. Many

methods are available to measure physiological arousal, such as cortisol sampling from saliva (Jamieson et al., 2010; Spangler et al., 2002), heart rate (i.e., cardiac vagal tone; Butler et al. 2006; Dan-Glauser and Gross 2015; Li et al. 2009), and pupil dilation (Scrimin et al., 2016). In the current study, we used skin conductance (SC) because it is one of the most widely-researched physiological channels for measuring emotion (Harley, 2015; Harley et al., 2015; Harley, Jarrell, et al., 2019; Kapoor et al., 2007; Kreibig, et al., 2015; Mauss & Robinson, 2009; Picard, et al., 2016), especially in technology-rich learning environments (Calvo & D'Mello 2010; Harley, 2015; Woolf et al., 2009) where the importance of multimodal data, and developing the analytical approaches to leverage it, is becoming widely acknowledged (Azevedo et al., 2018; D'Mello et al., 2017).

Using SC to measure learners' emotional activation during their interaction with the EQH App provided us with a valuable opportunity to collect physiological data during a learning session with content that was hypothesized to be emotionally stimulating. Learning about social injustices could elicit sadness and frustration. Similarly, hearing about positive social and legal changes and the way people stood up for one another and a great good could stimulate hope and be enjoyable. In many cases, educational content is much more emotionally-neutral when it comes to the topic (e.g., the circulatory system; Harley, Bouchet et al., 2015) and this can limit the statistical variance in physiological responses, limiting potential insight. SC data also provided us with an opportunity to investigate the relationship between this component of emotion and empathy; a relationship that no prior research that the authors are aware of have examined. This is a particularly interesting relationship to explore because empathy is widely agreed upon as consisting of both cognitive and emotional components. As such, physiological activation stands to help assess empathy and do so in a way that transcends reliance on self-report measures.

Current Study

This study contributes to addressing the aforementioned gaps in the literature by examining the relationship between physiological activation, empathy, and gender-based differences while learners interacted with a mobile queer history app deployed in a laboratory setting. We used skin conductance level (SCL) to assess emotional activation physiologically (see methods section). Self-reported empathy was examined toward sexual orientation (SO; e.g., lesbian, bisexual) and gender-identity (GI; e.g., transgender, non-binary) minorities separately; two broad dimensional characteristics that inform the LGBTQ+ acronym (see APA, 2015). The first objective of our study was to examine learners' self-reported empathy toward SO and GI minorities and whether this changed after their interaction with the EQH App. The second objective was to examine whether learners' level of SCL influenced learners' self-reported empathy levels. Our third objective was to examine whether gender differences influenced learners' empathy or interacted with SCL to do so. Our fourth objective was to examine whether gender differences influenced learners' SCL. We investigated the below research questions to address our objectives:

RQ1: (a) What were learners' self-reported pre- and post-app interaction levels of empathy toward SO and GI minorities? (b) Did their levels of empathy significantly differ toward SO vs. GI minorities? (c) Did learners' levels of empathy significantly increase from pre to post-app interaction? Theory and empirical research did not provide us with sufficient grounds to formulate a strong hypothesis for RQ1a or b, but we did hypothesize that a significant difference would be observed pre-to-post app interaction on account of learning about queer history and the associated struggles and victories.

RQ2: Did learners' level of (a) SCL influence their self-reported empathy toward SO and GI minorities? We hypothesized that learners grouped as those highest in SCL would also report the highest levels of empathy, both pre- and post-app interaction.

RQ3: Did learners' gender influence (a) their empathy or (b) interact with SCL to do so? Based on previously research, we hypothesized that women would report higher levels of empathy toward SO and GI minorities than men.

RQ4: Did learners' gender influence their SCL? We hypothesized that women would have higher levels of SCL, potentially, from experiencing higher levels of empathy.

Methodology

Participants

Data were collected from 57 undergraduate students (42 female; 26 Caucasian) ranging in age from 18 to 47 years old. Students were eligible to participate if they were fluent in English and enrolled in an undergraduate program (52% STEM) at one 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 and six participants as having a non-heterosexual orientation (for a total of six SO and GI minority participants). The study took approximately two hours and involved participants interacting with the EQH app developed by the authors. 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 that showcase challenges experienced by the LGBTQ+ community and uses multimedia vignettes to highlight

different ways in which events and places can serve as catalysts for change. 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, chosen because of its similarity to other mobile app platforms the authors have worked with and found to effective (see Harley, Liu et al., 2019). The desktop version of the EQH App can be accessed here: https://izi.travel/en/0468-edmonton-queer-history-app/en

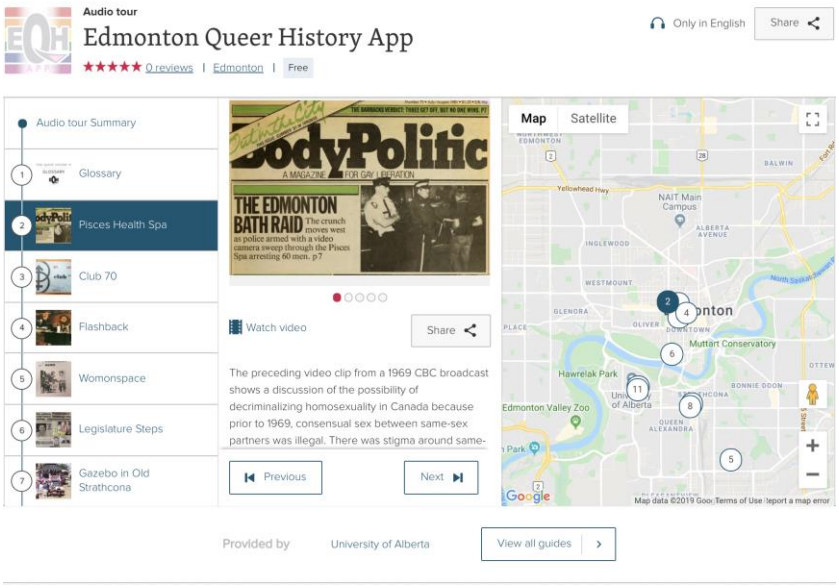

Figure 1. Screenshot of the Edmonton Queer History app Interface

Measures

Empathy. Empathy toward SO and GI minorities was assessed pre and post app interaction using a modified version of Wang and colleagues (2003) scale of ethnocultural empathy (SEE). The SEE was selected and modified after a review of the literature for valid and reliable scales assessing empathy toward SO and GI minorities failed to identify any. After reviewing the SEE, 26 of 31 items were retained and modified for SO (e.g., lesbians) and GI (e.g., transgender) minorities. Example items with changed text marked with an asterisk * and former text in [square brackets] include: “When I hear people make *homophobic/ transphobic

[racist] jokes, I tell them I am offended even though they are not referring to *a group with the same sexual orientation as me [my racial or ethnic group].” The full scale for both SO and GI minorities can be found in the supplemental material. Overall, we found the scale amendable to modifications which did not surprise us given the explicit suggestion by the authors of the SEE for future research to modify the scale for measuring empathy toward people with different SOs (Wang et al., 2003). Cronbach’s Alpha indicated that SEE total-scale internal consistency was good or better for both SO (pre-, $\alpha = 0.93$; post-app interaction, $\alpha = 0.93$) and GI minority scales (pre-, $\alpha = .94$; post-app interaction, $\alpha = .94$). Total-scale internal consistency is similar to that reported in other studies ($\alpha = 0.91$, Wang et al., 2003; $\alpha = 0.92$, Albiero & Matricardi, 2013; $\alpha = 0.93$, Özdikmenli-Demir, & Demir, 2014)

While the SEE has been found to have four underlying factors (Wang et al., 2003) that correspond to different components of empathy, our research questions were better suited by examining a total empathy score, particularly, given the lack of agreement among researchers and theoreticians on the interrelated psychological processes contributing to empathy (Spreng et al., 2009). Moreover, our sample size was too small to properly conduct a factor analyses that might have confirmed the four-factor structure identified by Wang and colleagues (2003) and replicated by some (e.g., Albiero & Matricardi, 2013; Italian), but not all language translations examining ethnocultural empathy (Özdikmenli-Demir, & Demir, 2014; Turkish). Research has used variables derived from both the multi-factor and total-scale of the SEE to examine gender differences (Cundiff, & Komarraju, 2008; Özdikmenli-Demir, & Demir, 2014; Wang et al., 2003).

As a measure of external validity, we also collected learners’ general empathetic tendencies using the sixteen-item Toronto Empathy Questionnaire (TEQ; Spreng et al. 2009). Cronbach’s Alpha indicated that scale reliability was good ($\alpha = .88$). As expected, general

empathy as measured by the TEQ was positively and significantly correlated with empathy toward SO minorities pre- (r = .30, p < .05) and post-app interaction (r = .40, p < .01) as well as post-app GI (r = .36, p < .01). The TEQ and pre-app empathy toward GI minorities correlation was positive and approaching significance (r = .30, p = .057).

Skin conductance. Skin conductance (SC) was collected using an Empatica E4 bracelet from learners during their interaction with the EQH app to measure their emotional activation. SC is part of the electrodermal activation complex which includes skin conductance level (SCL), the slower aspect of the electrodermal signal (i.e., tonic; Dawson et al., 2001; Nagai et al., 2004).

Experimental Procedure

This quasi-experimental (i.e., pretest-post-test design without a control group) study took approximately two-hours and involved students interacting with the EQH App developed by the authors. During the session, students filled out a consent form, completed a pre-app interaction survey that included the TEQ, modified SEE and open-ended questions about their prior knowledge of queer history (in general and Edmonton, specifically). Next, students put on the SCL sensor bracelet, watched a short tutorial video about how to use the app, interacted with the app, and completed a post-app survey that included the modified SEE again as well as the 28-item queer history test. Learners tended to interact with the EQH app for 30-45 minutes.

Data Analyses

Empathy. We excluded participants who were SO minorities (six) from statistical analyses examining empathy toward SO minorities and GI minorities (one) from statistical analyses examining empathy toward GI minorities to consistently examine outgroup rather than ingroup empathy. The GI minority student was also a SO minority, meaning that we had a total of six LGBTQ+ students in our sample of 57.

Gender. Due to only one participant having a non-cisgender identity and this participant also having a non-heterosexual orientation, they were removed in all sets of analyses examining empathy. This meant that the remaining 56 students identified as either uniformly male or female for both their sex and gender. We therefore refer exclusively to gender throughout this article.

Skin Conductance. SCL was extracted through Continuous Decomposition Analysis (CDA, Benedek & Kaernbach, 2010) that allows the decomposition of SC data into continuous periods of tonic (SCL) activity by modelling the sudomotor–response characteristics. Students' average SCL was derived from taking an average of all of the SCL values for the entire app interaction session for each student. Due to hardware failure, seven participants with corrupted or no SCL recordings were removed from analyses, allowing us to retain 50 participants. Raw data prior to a fixation and baseline measurement task were trimmed from SCL analyses. In order to examine SCL, we split learners into low, medium, and high SCL groups. This approach is preferable to a median split because it affords more opportunity to observe variance while still using rank-ordered cut-off points.

Statistical analyses. 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 applicable statistical assumptions were met for reported analyses (e.g., normal distribution for DVs, homogeneity of variances). Small cell sizes, including a low of $n = 2$ (males in mid-SCL grouping; see Table 1) for mixed models examining the interaction of both gender and SCL (together) on empathy required us to discard associated interaction results. Accordingly, results were only reported for statistically significant results where the lowest cell size was $n = 14$ (e.g., males or high or low SCL groupings for SO empathy). Participants who identified as SO or GI minorities were excluded from analyses examining in-group empathy levels.

Results

Levels of Empathy Directed Toward Sexual Orientation and Gender Identity Minorities

Descriptive statistics reported in Table S1 revealed moderately high mean levels of empathy toward SO and GI minorities. A paired sample t-test revealed significantly higher levels of pre-app interaction empathy toward SO, $t(43) = 2.88$, $p = .006$ ($M = 4.11$; $SD = .67$), than GI minorities ($M = 3.99$; $SD = .76$). A second paired sample t-test revealed the same pattern for post-app interaction empathy, $t(43) = 3.54$, $p = .001$: where learners reported higher levels of empathy toward SO ($M = 4.59$; $SD = .56$) than GI minorities ($M = 4.48$; $SD = .63$). See Table S1 for descriptive statistics for study variables. Empathy scores were not correlated with queer history knowledge (see Table S2). See the supplemental materials section for results of paired sample t-tests run on the full sample (results consistent in statistical significance). See Table S3 and S4 descriptive statistics for study variables and zero order correlations for study variables when SO and GI participants are included.

Skin Conductance, Gender, and Empathy

In order to examine whether learners' levels of SCL and their gender influenced their self-reported empathy toward SO and gender GI, and whether their self-reported empathy increased from pre-to-post app interaction, we ran two mixed model ANOVAs where gender (two levels: male or female) was entered as an independent variable in all models, SCL (three levels: low, medium, high) was entered as a second independent variable, and pre- and post-app interaction empathy scores (two levels; within-subjects variable) were entered for either SO minorities or GI minorities.

A mixed model ANOVA examining the effect of learners' SCL and gender on empathy directed toward SO minorities revealed a significant main effect of empathy questionnaire administration, $F(1,38) = 93.62$, $p = .000$, $\eta^2_p = .71$ and an interaction effect between empathy questionnaire administration and gender, $F(1,38) = 4.91$, $p = .03$, $\eta^2_p = .11$. Between subjects

tests revealed a significant main effect of gender on empathy, $F(1,38) = 13.21$, $p < .001$, $\eta^2_p = .26$. Descriptive statistics revealed that self-reported empathy levels were significantly higher post app-interaction than pre and that both male and female students self-reported empathy increased; females started and ended higher than males.

Table 1

Empathy toward sexual orientation (SO) and gender identity (GI) minorities by SCL and gender

		Empathy Toward SO (pre)		Empathy Toward SO (post)			Empathy Toward GI (pre)		Empathy Toward GI (post)		
Gender	SCL	Mean	SD	Mean	SD	N	Mean	SD	Mean	SD	N
Female	High	4.06	.68	4.49	.66	6	4.19	.82	4.81	.73	8
	Mid	4.34	.60	4.79	.50	14	4.12	.80	4.62	.69	14
	Low	4.40	.43	4.85	.32	10	4.54	.50	4.90	.43	13
	Total	4.31	.56	4.75	.49	30	4.30	.71	4.77	.61	35
Male	High	4.06	.64	4.46	.61	8	3.95	.79	4.30	.68	8
	Mid	2.90	.90	4.03	.51	2	2.38	.76	3.88	.77	2
	Low	3.39	.29	3.98	.33	4	3.49	.35	3.86	.50	4
	Total	3.70	.71	4.26	.55	14	3.60	.84	4.11	.64	14
Total	High	4.06	.63	4.48	.61	14	4.07	.78	4.55	.73	16
	Mid	4.16	.78	4.70	.55	16	3.90	.97	4.52	.71	16
	Low	4.12	.61	4.60	.51	14	4.30	.65	4.65	.63	17
	Total	4.11	.67	4.60	.55	44	4.10	.81	4.58	.68	49

Note[1]. SO = sexual orientation minorities. GI = gender identity minorities.
Note[2] N = 44 and 49 for empathy toward SO and GI, respectively, from exclusion of SO and GI participants in associated analyses in addition to participants without SCL data. See Data Analyses section for details. Also see Table S1 for descriptive statistics for all study variables for *N* = 44 and Table S3 for descriptive statistics for all study variables for all participants, excluding those without SCL data; *N* = 50)

A second mixed model ANOVA examining the effect of learners' SCL and gender on empathy directed toward GI minorities revealed a significant main effect of empathy questionnaire administration, $F(1,43) = 89.04$, $p < .001$, $\eta^2_p = .67$, and a significant interaction effect between empathy questionnaire administration and SCL, $F(2,43) = 7.14$, $p = .002$, $\eta^2_p = .25$. Between subjects tests revealed a significant main effect of gender on empathy, $F(1,43) = 15.24$, $p = .000$, $\eta^2_p = .26$. Descriptive statistics (see Table 1) revealed that self-reported empathy

levels were significantly higher post app-interaction than pre. Moreover, although females started and ended higher than males, both male and female students' self-reported empathy increased (see Figure 1 and Table 2). Students classified as moderate in SCL were the lowest in self-reported empathy across pre and post-measures, though students in this group increased the most in their self-reported empathy. In contrast, students in the low SCL group had the highest levels of self-reported empathy at both time points and increased the least (see Figure 2 and Table 1).

To unpack the interaction effect between empathy questionnaire administration and SCL, we ran simple main effect analyses (with Sidak adjustment for Type 1 errors). The results revealed that students with different levels of SCL all showed significant increases in mean empathy levels toward GI minorities, Fs(1,43) = 12.04, 52.31, 28.32, ps $\leq .001$, η^2_p = .22, .55, .40, for low, medium and high levels of SCL, respectively. Consistent with the effect sizes shown in the simple main effect analyses, another simple main effect analysis based on the difference scores showed that students classified as moderate in SCL increased the most in their self-reported empathy, compared to those classified a low-SCL (p = .002) and high-SCL (p = .010). However, students classified as moderate in SCL were the lowest in self-reported empathy in the pre-test measure of empathy toward GI minorities: significantly lower than those classified as high in SCL (p = .04) and marginally lower than those classified as low in SCL (p = .078). Students classified as moderate in SCL were not significantly different from the those in the low and high SCL groups in their post-test measure of empathy. Moreover, students in the low SCL group and high SCL group showed no significant differences in both pre- and post-measure self-reported empathy.

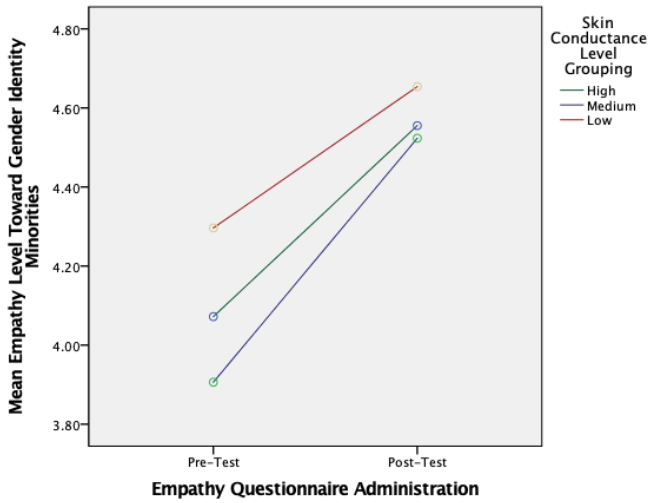

Figure 2. Interaction effect of empathy questionnaire administration and skin conductance level grouping on empathy toward gender identity minorities

Effect of gender on Skin Conductance Level

In order to examine whether gender influenced SCL, we ran a two-sample Kolmogorov-Smirnov Test (non-parametric test) which revealed a significant effect of gender on SCL, $D(49) = 1.45$, $p = 0.031$ where males ($M = .86$; $SD = .94$) had significantly higher levels of SCL than females ($M = .54$; $SD = 1.03$). The effect of gender on SCL was maintained when both SO and GI were removed from analyses, $D(44) = 1.49$, $p = 0.024$.

Discussion

This research is the first to: (1) Use a mobile app as an educational intervention to enhance empathy and do so (2) toward LGBTQ+ minorities with (3) a novel empathy self-report instrument. (3) Examine whether learners classified as low, medium, or high in emotional arousal reported significantly different levels of empathy. And (3) investigate whether gender had an effect on emotional arousal.

Levels of Empathy Directed Toward Sexual Orientation and Gender Identity Minorities

Our findings that undergraduate students reported moderately high levels of empathy toward both SO and GI minorities was a welcome finding, particularly given the diversity of

disciplines students belonged to (31 STEM [science, technology, engineering or mathematics] and 26 non-STEM). It is possible that students reported statistically significantly higher levels of empathy toward SO than GI minorities because they knew and understood less about trans and non-binary people, particularly prior to interacting with the app. It should also be noted, that of the eight locations, only one focused primarily on GI minorities. The greater focus on SO minorities in the EQH App is rooted in the history of LGBTQ+ rights development, and the fact that the gay rights movement emerged and had its first victories much earlier than the trans rights movement which is relatively recent. It is possible that with a better balance between GI and SO content, that significant differences in post-app interaction empathy between GI and SO groups would not have been observed. Given differences in the amount of content available for GI versus SO minorities, observing significant increases for both SO and GI minority people is promising. This last finding was aligned with the only hypothesis that we were equipped to make for our first research question.

Skin Conductance Level, Gender and Empathy

Consistent with prior research examining gender-based differences on empathy, we found that females reported higher levels of empathy than males and toward both SO and GI minorities. Counter to our hypothesis, learners' classified as having higher levels of SCL did not have statistically significantly higher levels of empathy compared to those learners classified as having low or moderate levels of SCL. No between SCL group findings were found, however, there was a statistically significant interaction between SCL grouping and empathy toward GI minorities, revealing potentially meaningful differences in increases in empathy pre- to post-test between the three SCL groups. Simple main effects analyses revealed that learners with moderate SCLs had the greatest increase in empathy toward GI minorities compared to those classified as low or high in SCL; the difference between moderate and low being statistically

significant. Simple main effects analyses revealed that the statistically significant interaction effect was driven by differences between SCL groups in the pre-test rather than post-test empathy scores toward GI minorities. Therefore, while all students statistically significantly increased their empathy toward GI minorities, post-test empathy did not vary significantly by SCL grouping, but pre-test did: a statistically significant difference existing between moderate and low SCL groupings. One possible explanation for these findings is that learners with moderate SCL profiles may have been experiencing emotions more directly associated with increasing empathy, some of which may have been activating (outrage) and others which may have been non-activating (sadness). In contrast, other groups' emotional activation may have been based on a greater incidence of emotions directed toward the app itself or learning about queer history.

Effect of Gender on Skin Conductance

Gender exerted a strong effect on empathy and we were curious whether it would also affect SCL, hypothesizing that it would, given the emotional component of empathy. Our finding partially confirmed our hypothesis: we found a significant difference in SCL based on gender, but not in the direction we anticipated. This unexpected finding may be explained by our previous account that not all discrete emotions that are congruent with experiencing empathy are activating in nature (e.g., sadness) and that some activating emotions (e.g., enjoyment) are unlikely to be related to experiencing empathy toward accounts of historical challenges minority groups have faced.

Implications for Social Change and Empathy Building

Results provide preliminary evidence that our mobile app can be used empower educators and individuals to learn about the histories of minorities that remain outside of formal curriculums: an aim well-aligned with constructivist technologies (Scott et al., 1992). Such

technologies are critical because teachers and students cannot always rely on curriculums, even those that explicitly value equity and diversity (Alberta & Student Learning Standards Division, 2016), to not have blind spots—unintentional or otherwise. Indeed, queer people are only fleetingly mentioned in some curriculum social studies materials, such as in-use high school social studies textbooks in Alberta, Canada which only offer 1) a short optional reading or activity and 2) listing LGBTQ+ minorities as concentration camp victims (Fielding et al., 2009; Harding et al., 2008). Such gaps are missed opportunities given how knowledge can be a useful tool in building perspective-taking and sensitivity to different and diverse perspectives that students and teachers might not always have the direct benefit of, given the low estimated incidence of LGBTQ+ people (3% of the general Canadian population self-identity as SO minorities; StatsCanada, 2014). Moreover, SOGI minorities continue to face many challenges, including over-representation in hate crimes, especially violent ones (StatsCanada, 2018), being subjected to SO or GI change efforts (20% of SO men; Community-based Research Centre, 2020) and having preferred pronouns ignored (NBC News, 2019; The Guardian, 2018). SOGI minorities are also exposed to divisive debate about gay-straight-alliances in Alberta schools (GSA; Washington Post 2019), homophobic positions from endorsed political candidates for major parties (CTV News, 2019), and being refused apologies from elected members of parliament for past homophobic remarks (The Star, 2019). In sum, knowledge and perspective-building in this article can be seen as a sociocultural construction using innovative technology to provide new ways for students to make meaning and sense in learning about queer history. The EQH App is a medium for this vital and timely engagement that has lagged behind other historically marginalized and disadvantaged groups and associated movements (e.g., the civil rights and suffrage movement).

Limitations and Future Directions

As mentioned, the small sizes of some of the groups that students were classified into when interactions between gender and SCL were jointly examined led us to disregard associated findings. It should be pointed out, however, that relative to other studies of physiological measures of emotion in education, this study had a good overall sample size, even if it might still be classified as small at 50. A related limitation of our small sample size was our inability to properly examine additional individual differences associated with attitudes toward LGBTQ+ people and/or outgroup empathy more generally, such a culture, religion, and ethnicity (Bettinsoli et al., 2019; Cikara, Bruneau, & Saxe, 2011; Moreno et al., 2020; Zika, 2014).

Another limitation was the lack of a self-report measure designed to assess emotions related to empathy. While participants were asked to self-report how they felt, the wording of the questionnaires in the study this article drew data from were designed to capture emotions related to the topic (e.g., LGBTQ+ history) or technology (app) and therefore offer limited insight into how learners felt about SO and GI minorities, specifically. For example, the following item "Learning about LGBTQ+ history and relevant Edmonton landmarks annoyed me" might tell us they were frustrated, but not whether it was because the activity was aversive (e.g., they would rather do something else) or because the content made them feel frustrated on behalf of LGBTQ+ minorities. Other items faced similar specificity limitations. In order to better relate emotions to empathy, future research should endeavor to develop a self-report measure to ask students about a broad set of emotions they might feel toward or about SO and GI minorities, particularly those directly or indirectly represented or affected by the historical events described.

A methodological limitation of the present study was the use of a quasi-experimental design and associated absence of a control group to ensure that increases in empathy were not due to a test-retest effect or social desirability. Being asked to complete a survey about empathy shortly after their interaction with the EQH App may have led students to feel like they should or

were expected to report increased empathy. While some features of the design may have mitigated these effects, such as being asked to complete a survey on emotions first and the experiment having no relationship with their coursework (or other aspects of their academic degree), we cannot rule out such an effect. Interestingly, a significant difference between self-reported empathy toward SO and GI minorities existed between both pre and post-test surveys which this effect would not account for. Regardless, one approach to dealing with this limitation would be to ask learners about their self-reported empathy at a later point in time via a survey to assess whether changes persisted and minimize social desirability effects. A randomized control study is currently underway to help clarify a potential social desirability effect. In the meantime, results concerning pre-post-test changes of empathy should be treated as preliminary rather than causal evidence. Future research and analyses will also examine fluctuations in SCL in response to specific events to enrich our understanding of this dynamic channel and its association with empathy and other psychological processes and outcomes. Doing so is critical to advancing the emerging literature on multimodal data (D'Mello et al., 2017) and applications of physiological data to educational research, in particular.

Another limitation to this study stems from the cross-sectional design where measurement of study variables took place within a single session; a limitation that applies even when variables were examined at two or more points within the session. This limits the generalizability of our results.

Conclusions

This study stands to contribute to the literature by sharing a self-report measure with good initial psychometric properties to assess empathy toward SO and GI minorities as well as offering preliminary support for using the EQH App as an educational intervention to increase empathy. The physiological findings highlighted how SCL may add a new and, we argue,

valuable lens to examining empathy, while also outlining directions for future research on the intersections between it and empathy-related discrete emotions. The advancement of physiological and behavioral measures are especially important to compliment self-report measures of psychological states experienced during and in response to sensitive and emerging educational research foci, such as queer history. Moreover, such data contribute to a "thick description" of a psychologically complex process we have identified as an essential learning outcome to co-construct a better tomorrow: empathy.

Statements on open data, ethics and conflicts of interest

Any request to access the data should be directed to the first author (Jason M Harley; jason.harley@mcgill.ca). An IRB approval was obtained prior to the conduct of the study and informed consent was obtained from participants. We declare that we do not have any conflicts of interest regarding the study.

Acknowledgements

This research was supported by funding from the Social Sciences and Humanities Research Council of Canada (SSHRC; Grant ID: 430- 2016-01133) awarded to the first, fourth and fifth authors. The authors would like to thank Dr. Nigel Mantou Lou for his support with the simple main effects analyses.

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Supplemental Material/ Appendices

Table S1

Descriptive statistics for study variables: sexual orientation and gender identity minorities excluded

Study Variable *n* = 44	Mean	SD	Observed Min	Observed Max	Possible Min	Possible Max	*z*-skew	*z*-kurt
Toronto Empathy Questionnaire	46.64	6.33	29.00	62.00	0	100	-.50	1.04
Empathy Toward Sexual Orientation Minorities: Pre	4.12	.67	2.27	5.31	1	6	-.42	.01
Empathy Toward Sexual Orientation Minorities: Post	4.60	.55	3.62	5.50	1	6	-.20	-.95
Empathy Toward Gender Identity Minorities: Pre	3.98	.76	1.85	5.31	1	6	-.41	-.07
Empathy Toward Gender Identity Minorities: Post	4.48	.64	3.33	5.73	1	6	-.16	-.67
Queer History Knowledge Score (Percentage)	.82	.09	.57	.96	0	1.00	-.87	.32
Average SCL	.60	1.00	.05	5.73	-	-	3.90	17.24

Table S2

Zero-order correlations between empathy, SCL, and knowledge variables

Study Variable *n* = 50	1	2	3	4	5	6	7
Toronto Empathy	1						
Empathy Toward Sexual Orientation Minorities (pre)	.25	1					
Empathy Toward Sexual Orientation Minorities (post)	.39**	.90**	1				
Empathy Toward Gender Identity Minorities (pre)	.21	.93**	.86**	1			
Empathy Toward Gender Identity Minorities (post)	.35*	.85**	.94**	.87**	1		
Queer History Knowledge	-.16	.06	.06	.06	.05	1	
Average SCL	-.21	.12	.07	.12	.08	-.08	1

Note. *. Pearson correlation is significant at the 0.05 level (2-tailed); **. Pearson correlation is significant at the 0.01 level (2-tailed).

Table S3

Descriptive statistics for study variables

Study Variable *n* = 50	Mean	SD	Observed	Observed Max	Possible Min	Possible Max	*z*-skew	*z*-kurt

			Min					
Toronto Empathy Questionnaire	47.08	6.31	29.00	62.00	0	100	-1.58	1.29
Empathy Toward Sexual Orientation Minorities: Pre	4.27	.76	2.27	5.65	1	6	-.64	-.49
Empathy Toward Sexual Orientation Minorities: Post	4.72	.62	3.62	5.92	1	6	-.34	-1.38
Empathy Toward Gender Identity Minorities: Pre	4.13	.83	1.85	5.65	1	6	-.99	-.37
Empathy Toward Gender Identity Minorities: Post	4.60	.69	3.33	5.77	1	6	-.61	-1.22
Queer History Knowledge Score (Percentage)	.82	.09	.57	.96	0	1.00	-2.61	.64
Average SCL	.63	.14	.05	5.73	-	-	10.35	21.76

Note. Pre and post refer to whether the questionnaire was answered before (pre) or after (post) the app interaction.

Table S4

Zero-order correlations between empathy, SCL, and knowledge variables

Study Variable *n* = 44	1	2	3	4	5	6	7
Toronto Empathy	1						

Empathy Toward Sexual Orientation Minorities (pre)	.20	1					
Empathy Toward Sexual Orientation Minorities (post)	.37*	.86**	1				
Empathy Toward Gender Identity Minorities (pre)	.16	.91**	.82**	1			
Empathy Toward Gender Identity Minorities (post)	.31*	.79**	.93**	.83**	1		
Queer History Knowledge	-.19	.03	.04	.05	.04	1	
Average SCL	-.23	.08	-.01	.10	.03	-.11	1

Note. *. Pearson correlation is significant at the 0.05 level (2-tailed); **. Pearson correlation is significant at the 0.01 level (2-tailed).

Levels of Empathy Directed Toward Sexual Orientation and Gender Identity Minorities: Full Sample, including sexual orientation and gender identity minorities.

Descriptive statistics reported in Table S3 revealed moderately high mean levels of empathy toward sexual orientation and gender identity minorities. A paired sample t-test

revealed significantly higher levels of pre-app interaction empathy toward sexual orientation, $t(50) = 3.13$, $p < .01$ ($M = 4.14$; $SD = .66$), than gender identity minorities ($M = 3.98$; $SD = .74$).

A second paired sample t-test revealed the same pattern for post-app interaction empathy, $t(50) = 3.23$, $p < .01$: where learners reported higher levels of empathy toward sexual orientation ($M = 4.62$; $SD = .55$) than gender identity minorities ($M = 4.52$; $SD = .62$), though the mean difference shrank when comparing post ($M = .10$; $SD = .23$) to pre ($M = .16$; $SD = .35$) empathy scores between LGBTQ+ minorities and both means increased. See Table S1 for descriptive statistics for study variables. Empathy scores were not correlated with queer history knowledge (see Table S4).

Modified Scale of Ethnocultural Empathy (SEE)

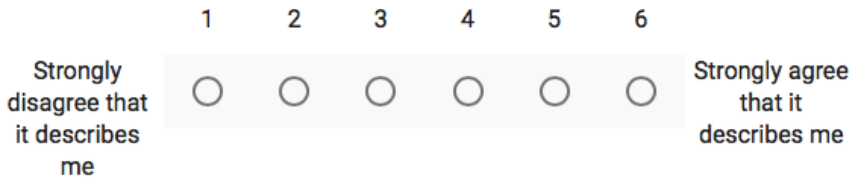
Scale of Gay, Lesbian, and Bisexual Empathy

Instructions: Please respond to the questions below, thinking of people with a different sexual orientation than your own. In other words, if you identify as straight (i.e., heterosexual), please fill this out thinking of lesbian, gay, and bisexual individuals (i.e., LGB). If, however, you identify as a lesbian, gay, or bisexual individual please see the following instructions:

- *if you identify as a bisexual individual, please fill this out thinking of gay and lesbian individuals.*

- *If you identify as a gay or lesbian individual, please fill this out thinking of bisexual individuals.*

Please record your answers using the appropriate number, where 1= "strongly disagree that it describes me" and 6 = "strongly agree that it describes me". Please see definitions, as needed.



1. When I hear people make homophobic jokes, I tell them I am offended even though they are not referring to a group with the same sexual orientation as me.
2. I don't care if people make homophobic statements.
3. I rarely think about the impact of a homophobic joke on the feelings of people who are targeted.
4. When other people struggle with homophobic/biphobic (see definitions) oppression, I share their frustration.
5. I feel supportive of people with a different sexual orientation than myself, if I think they are being taken advantage of.
6. I share the anger of those who face injustice because of their sexual orientation.
7. I share the anger of people who are victims of hate crimes (e.g., see definitions).
8. When I know my friends are treated unfairly because of their sexual orientation, I speak up for them.
9. I get disturbed when other people experience misfortunes due to their sexual orientation.
10. I am touched by movies or books about discrimination issues faced by gay, lesbian, and/or bisexual individuals other than my own.
11. When I see people who are gay, lesbian, and/or bisexual succeed in the public arena, I share their pride.
12. I am not likely to participate in events that promote equal rights for gay, lesbian, and bisexual individuals.
13. I seek opportunities to speak with gay, lesbian, and/or bisexual individuals about their experiences.
14. When I interact with gay, lesbian, and/or bisexual people, I show my appreciation of their norms.
15. I express my concern about discrimination to people with other sexual orientations.
16. It is easy for me to understand what it would feel like to be a gay, lesbian, and/or bisexual person with a sexual orientation different other than my own.
17. It is difficult for me to relate to stories in which people talk about homophobic discrimination they experience in their day to day lives.
18. It is difficult for me to put myself in the shoes of someone who has a different sexual orientation from me.

19. I know what it feels like to be the only person of a certain sexual orientation in a group of people.
20. I can relate to the frustration that some people feel about having fewer opportunities due to their sexual orientation.
21. I feel uncomfortable when I am around a significant number of people who have a different sexual orientation than me.
22. I don't know a lot of information about important social and political events of people with different sexual orientations than my own.
23. I am aware of how society differentially treats sexual orientation minorities other than my own.
24. I recognize that the media often portrays people based on sexual orientation stereotypes.
25. I can see how other gay, lesbian, and/or bisexual people are systematically oppressed in our society.
26. I am aware of institutional barriers (e.g., restricted opportunities for job promotion) that discriminate against people with sexual orientations other than my own.

Scale of Transgender and Non-binary Empathy

Instructions: Please respond to the questions below, thinking of people with a different gender identity than your own. In other words, if you identify as a cis-gender individual, please fill this out thinking of non-binary and transgender individuals. If you identify as a non-binary individual, please fill this out thinking of transgender individuals. If you identify as a transgender individual, please fill this out thinking of non-binary individuals.

Please record your answers using the appropriate number, where 1= "strongly disagree that it describes me" and 6 = "strongly agree that it describes me". Please see definitions, as needed.

1. When I hear people make transphobic jokes (see definitions), I tell them I am offended even though they are not referring to my gender identity.
2. I don't care if people make transphobic statements against people with non cis-gender identities.
3. I rarely think about the impact of a transphobic joke on the feelings of people who are targeted.
4. When other people struggle with transphobic oppression, I share their frustration.
5. I feel supportive of people with non cis-gender identity, if I think they are being taken advantage of.
6. I share the anger of those who face injustice because of their non cis-gender identity.
7. I share the anger of people who are victims of hate crimes (e.g., see definitions).
8. When I know my friends are treated unfairly because of their non cis-gender identity, I speak up for them.
9. I get disturbed when other people experience misfortunes due to their non cis-gender identity.
10. I am touched by movies or books about discrimination issues faced by people with non cis-gender identities.
11. When I see people who have a different gender identity succeed in the public arena, I share their pride.
12. I am not likely to participate in events that promote equal rights for people of all gender identities.
13. I seek opportunities to speak with individuals of other gender identities about their experiences.
14. When I interact with people with non cis-gender identity, I show my appreciation of their norms
15. I express my concern about discrimination to people with non cis-gender identity.
16. It is easy for me to understand what it would feel like to be a person with a non cis-gender identity.
17. It is difficult for me to relate to stories in which people talk about the transphobic discrimination they experience in their day to day lives.
18. It is difficult for me to put myself in the shoes of someone who has a non cis-gender identity.
19. I know what it feels like to be the only person of a certain gender identity in a group of people.
20. I can relate to the frustration that some people feel about having fewer opportunities due to their non cis-gender identity.
21. I feel uncomfortable when I am around a significant number of people who have a non cis-gender identity.
22. I don't know a lot of information about important social and political events of non cis-

gender identity groups.

23. I am aware of how society differentially treats groups with a non cis-gender identity.
24. I recognize that the media often portrays people based on non cis-gender identity stereotypes.
25. I can see how people with a non cis-gender identity are systematically oppressed in our society.
26. I am aware of institutional barriers (e.g., restricted opportunities for job promotion) that discriminate against people with a non cis-gender identity.