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A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form

Heather L. O'Brien[a,*], Paul Cairns[b], Mark Hall[c]

[a] School of Library, Archival and Information Studies, University of British Columbia, Vancouver, Canada
[b] Department of Computer Science, University of York, York, UK
[c] Institute of Computer Science, Martin-Luther-University Halle-Wittenberg, Halle (Saale), Germany

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ABSTRACT

User engagement (UE) and its measurement have been of increasing interest in human-computer interaction (HCI). The User Engagement Scale (UES) is one tool developed to measure UE, and has been used in a variety of digital domains. The original UES consisted of 31-items and purported to measure six dimensions of engagement: aesthetic appeal, focused attention, novelty, perceived usability, felt involvement, and endurability. A recent synthesis of the literature questioned the original six-factors. Further, the ways in which the UES has been implemented in studies suggests there may be a need for a briefer version of the questionnaire and more effective documentation to guide its use and analysis. This research investigated and verified a four-factor structure of the UES and proposed a Short Form (SF). We employed contemporary statistical tools that were unavailable during the UES' development to re-analyze the original data, consisting of 427 and 779 valid responses across two studies, and examined new data (N=344) gathered as part of a three-year digital library project. In this paper we detail our analyses, present a revised long and short form (SF) version of the UES, and offer guidance for researchers interested in adopting the UES and UES-SF in their own studies.

1. Introduction

User engagement is a quality of user experience characterized by the depth of an actor's investment when interacting with a digital system (O'Brien, 2016a). Engagement is more than user satisfaction: it is believed that the ability to engage and sustain engagement in digital environments can result in positive outcomes for citizen inquiry and participation, e-health, web search, e-learning, and so on. Yet user engagement (UE) is an abstract construct that manifests differently within different computer-mediated contexts, and this has made it challenging to define, design for, and evaluate.

This research is fundamentally focused on the challenge of measuring engagement so that it can be used in design and evaluation. A range of methodological approaches have been utilized to measure engagement, including (Lalmas et al., 2014; O'Brien and Cairns, 2016):

- behavioural metrics such as web page visits and dwell time;
- neurophysiological techniques such as eye tracking and electrodermal activity (EDA);
- self-reports such as questionnaires, interviews, diary entries and verbal elicitation.

All methodological approaches have their advantages and limitations with respect to use with specific populations, settings, and time scales, from a single user-computer interaction to longitudinal observations. In addition, measures may capture interactions formatively or summatively, and subjectively or objectively (Lalmas et al., 2014). In general, there has been advocacy for multiple measures and mixed methods to reliably and validly capture constructs such as user engagement. This requires attention to the robustness of individual measures, as well as to triangulating multiple measures.

Our work is concerned with the User Engagement Scale (UES), a 31-item experiential questionnaire. The UES (or items derived from it) has been used to evaluate engagement in a range of settings: information search, online news, online video, education, and consumer applications, haptic technologies, social networking systems, and video games (see (O'Brien, 2016b) for an overview of this work). Although there is evidence to suggest that the UES is a reliable and valid means of

* Corresponding author.
E-mail addresses: h.obrien@ubc.ca (H.L. O'Brien), paul.cairns@york.ac.uk (P. Cairns), mark.hall@informatik.uni-halle.de (M. Hall).
URL: http://www.heatherobrien.arts.ubc.ca (H.L. O'Brien), https://www-users.cs.york.ac.uk/~pcairns/ (P. Cairns)

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capturing subjective user engagement, some findings have questioned its effectiveness, which are reported in O'Brien (2016b). Such findings may point to flaws in the UES, the ways it has been administered and analyzed in practice, or some combination of these. For instance, few researchers have used the UES in its entirety, which makes it difficult to assess its factor structure and robustness over time and across different digital applications. On the other hand, the decision to not use all 31 items raises pragmatic issues of using the UES in a study (i.e., length), or poor documentation regarding how to adapt, implement, and make meaning from the measurement tool.

In the current research, we applied state-of-the-art statistical techniques to re-analyze the data originally collected to develop the UES. Based on our findings, we proposed a revised long-form and short-form (SF) of the questionnaire, which we then evaluated with a new data set collected over a three-year period as part of a large digital library project. In the remainder of this paper, we provide background information on the UES and our approach to data analysis; present the revised UES and UES-SF with an explanation of our findings, and conclude with recommendations for the administration and analysis of the UES and UES-SF in future studies.

Our contribution is three-fold:

- firstly, we offer a robust measurement tool to measure user engagement in HCI settings; this tool can be used to guide the design of digital media or to evaluate user experience with computer-mediated systems;
- secondly, the validated UES can be confidently used as a benchmarking and corroborating tool for emerging methodological approaches or process-based metrics; and
- finally, we hope to improve the administration of the UES and other self-report questionnaires by providing guidance on how to adapt and interpret the UES in different research contexts.

2. User engagement

User engagement (UE) is a quality of user experience characterized by the depth of an actor's cognitive, temporal, affective and behavioural investment when interacting with a digital system (O'Brien, 2016a). Over the past two decades, the human-computer interaction (HCI) community has become increasingly interested in understanding, designing for and measuring user engagement with a host of computer-mediated health, education, gaming, social and news media, and search applications (O'Brien and Cairns, 2016). Collectively this work has demonstrated that UE is highly context dependent: each digital environment features unique technological affordances that interact with users' motivations to achieve some desirable end. For instance, in Massive Open Online Courses (MOOCs), learners participate for a variety of reasons, from professional development to curiosity about the topic, and take advantage of digital learning objects, like videos of lectures or quizzes, and opportunities for social interaction, say on discussion forums, to different degrees. Thus MOOC developers must take into account how individuals' goals and needs shape their investment in the course and what they wish to gain from it (Wiebe and Sharek, 2016). Designing for UE in news environments may be quite distinct. While personal goals may drive news interactions to some extent, content (and its presentation) generates situational interest, which in turn fosters engagement (Arapakis et al., 2014; O'Brien and McKay, 2016; Oh and Sundar, 2015). These examples illustrate that digital environments attract users for different reasons (e.g., to learn, to share, to stay current), and seek to sustain engagement for different durations (e.g., a daily ten minute news browsing session, a ten module MOOC) to achieve specific outcomes (e.g., continued loyalty to a news provider, MOOC completion).

The dynamic and variable nature of computer-mediated interactions is compounded by the abstractness of UE. There is some consensus that user engagement is affective, cognitive and behavioural in nature (O'Brien, 2016a; O'Brien and Toms, 2008). This idea is drawn from learning sciences research on student engagement: emotional engagement refers to the positive and negative responses students have to peers, teachers, and so on that influences their attachment to and willingness to work at school; cognitive engagement is the degree of effort students are willing to expend to master ideas and skills; and behavioural engagement involves participation in academic, social and extracurricular activities that discourages negative outcomes, such as dropping out (Fredricks et al., 2004) (p. 58). In HCI, users have emotional reactions to the system (e.g., frustration), content (e.g., shock, interest) or other users operating within the interaction space. Cognitively, the relationship between users' skills and the difficulty of the task determines the degree of mental effort required by users, and whether this results in boredom, engagement or frustration. Lastly, behavioural engagement refers to users' actions, such as clicking or querying, and frequency and duration of use.

Despite the recognition that engagement is multifaceted, a persistent challenge involves understanding what aspects of users' interactions with digital applications are indicative of user engagement. Time on task or physiological arousal may either suggest engagement with an application, or disorientation and frustration (O'Brien and Lebow, 2013; Webster and Ahuja, 2006). Several scholars in recent years have attempted to disambiguate these two contrasting experiences that share similar behavioural and physiological indicators. Edwards (2015) monitored electrodermal activity in participants completing frustrating and non-frustrating search tasks, where frustration was manipulated with different search results response latencies, while Grafsgaard examined facial expressions and body posture/movement as students interacted with an intelligent tutoring systems (Grafsgaard, 2014). Both researchers attempted to show different patterns inherent in engaged and frustrated participants by corroborating physiological data with other measures, including self-report questionnaires. While capable of monitoring interactive processes over time and in real-time (Rowe et al., 1998), neurophysiological methods are still developing as researchers continue to devise techniques for filtering noisy signals, making sense of the large volume of data generated, and syncing signals from different data sources, e.g., eye tracking and performance behaviour (Taub et al., 2017). In addition, interpreting signals to represent a psychological state such as engagement effectively requires an understanding of the concept itself.

One approach to operationalizing the concept of UE has been to isolate user-system attributes that constitute an engaging experience. Working in the area of educational multimedia, Jacques proposed six attributes of UE: attention (divided or focused), motivation, perception of control, needs satisfaction, perception of time ("dragging on" or "flying by") and positive or negative attitude (Jacques, 1996) (p. 67); Webster and Ho distinguished attributes of engagement, such as attention focus, curiosity, and intrinsic interest, from influences on engagement like challenge, control, feedback and variety (Webster and Ho, 1997) in their research on presentation software. Through a systematic multidisciplinary literature review and exploratory interview study with online learners, shoppers, searchers and gamers, O'Brien put forward existing and additional attributes of UE: challenge, aesthetic and sensory appeal, feedback, novelty, interactivity, perceived control and time, awareness, motivation, interest, and affect. These were mapped to a stage-based Process Model of User Engagement consisting of a point of engagement, period of sustained engagement, disengagement, and reengagement, where the attributes were depicted as ebbing and flowing according to the changing needs of users as they moved through dynamic digital interactions (O'Brien, 2008; O'Brien and Toms, 2008).

3. An attribute-Based approach to user engagement

An attribute-based approach to the definition of UE has the advantage of helping researchers operationalize user experience design guidelines or measurement tools. Jacques constructed ten design principles for engaging educational multimedia based on the attributes of UE he