Measuring Flow in an Interactive Tangible Touch Table Environment

Mark Brown
School of Engineering and ICT
University of Tasmania
M.T.Brown@utas.edu.au

Matthew Springer
School of Engineering and ICT
University of Tasmania
Matthew.Springer@utas.edu.au

ABSTRACT

User engagement is a highly desired feature of user interfaces, yet it fails to sufficiently articulate the most extreme type of engagement - flow. The measurement of flow in this paper was motivated by action research participation at the initial field test of the "Preparing for Bushfire" touch table Tangible User Interface (TUI) (Brown et al. 2015)). It was evident that measuring engagement alone would not adequately describe and quantify the engrossed behaviour demonstrated by the general public participants. A Flow Index was constructed to measure and quantify the level of intense focus. Since no standard Flow Index exists, this paper outlines the development process of the construction of the index, including its mathematical validation. It then shows how the Flow Index was used to assess success or failure of the implemented user interface design that was strategically designed for high engagement. The flow was measured during the TUI "Preparing for Bushfire" study using 64 adult members of the general public.

Author Keywords

Flow; Engagement; Participatory Design; Evaluation; Tangible, Multi-touch table

ACM Classification Keywords

H.5.2 User Interfaces: Evaluation/methodology.

INTRODUCTION

Modern technologies are often accused of distracting users to the point of endangering them. When a technology is so engaging that they lose touch with the real world, we call that flow (Csíkszentmihály 1997).

It is worth measuring and quantifying when flow occurs because it is difficult to achieve, but it is very difficult to, "Accurately and reliably assess the experience itself," (Jackson et al. 2008, p. 562).

The "Preparing for Bushfire" touch table interface used a Microsoft PixelSense which displayed local real world map information including online aerial photographs, property boundaries, building locations, elevation, fire

history, and fire defensive zones. Consequently the PixelSense interface system was designed for adults to complete short map-based interactive bushfire problem solving tasks using purpose-designed model objects. The general public participants of the "Preparing for Bushfire" touch table Tangible User Interface (Brown et al. 2015) showed a high level of concentrated interest in the touch table experience. Thus it was decided to quantify this engagement intensity.

A literature review revealed that measuring flow would quantify aspects of the observed engagement. The review revealed a wide variety of styles in which flow had been measured for tangible user interfaces (Hoffman & Novak 2009) however it did not identify a standard implementation for flow.

This paper discusses how flow attributes were collated into a single descriptive measure for the observed flow.

RELATED WORK

The immersiveness of engagement is a very important topic to TUI and many measures of flow have been developed, including the Long and Short measure of Flow for marketing, psychology and sports science (Jackson et al. 2008).

Zuckerman & Gal-Oz (2013), through their comparative study of Graphical User Interfaces (GUI) and TUI, showed that the "preference [for TUI] stemmed from high levels of stimulation and enjoyment from… physical interaction, rich feedback and high levels of realism," (2013, p803).

A measure of playfulness was measured by Schneider et al (2013), comparing a TUI to reading a text book. The experiment achieved positive learning outcomes from using the TUI in conjunction with the textbook. Playfulness was evaluated as a contributing factor to the experiment's success.

Presence is sometimes presented as a measure of flow (Zaman et al. 2011). However, presence relates to feelings of being in a mediated space which appears to be the real world (Lessiter et al. 2001, p285). Participants in the current research did not feel that they were in such a virtual world, meaning presence is not an appropriate measure.

SYSTEM DESIGN

The flow questions derived from a review of existing applications of flow from empirical studies (Hoffman & Novak 2009; Schneider et al. 2010; Novak et al. 2000; Zuckerman & Gal-Oz 2013). The reflection paper by Hoffman and Novak (2009) itself compares 22 conceptual

and structural models of flow.

The theory of flow is grouped into a number of subcategories. The most relevant subcategories were identified, then each question within was reviewed for suitability for the "Preparing for Bushfire" interface and circumstance.

Cognitive enjoyment, attention focus, and playfulness were identified as the best fit flow categories. Where the review of empirical studies found that questions had equivalent meaning or intent, they were consolidated. Also, questions not suited to measurement though Likert Scales, or not relevant to the TUI were removed.

The flow likert questions chosen were extracted from the following empirical sources: playfulness from Schneider, Jermann & Zufferey (2010), attention and focus from Novak et al. (2000), and cognitive enjoyment from Zuckerman & Gal-Oz (2013). A combination of positive and negative phrases was used, so that the participant would need to focus upon each question and think about the answer (Sharp et al. 2011). These six questions were grouped into a Flow Index in a similar fashion to the Flow Score of (Zuckerman & Gal-Oz, 2013). The six-question Flow Index is designed to measure flow as a single quantifiable number.

A Cronbach Alpha was calculated for the index as a measurement of internal consistency, to ensure the questions were balanced and fair (Sauro & Lewis 2012).

The final six questions are shown in Table 1.

Table 1: Flow Likert Questions

Q37	Using physical objects on the touch table was inherently interesting
Q38	Interacting with physical objects on the touch table engaged my imagination
Q39	When using the physical objects on the touch table with the Interactive Mapping with local recent air photography, I thought about other things I could be doing right now
Q40	When using the physical objects on the touch table with the Interactive Mapping with local recent air photography, I was aware of distractions
Q41	When using the physical objects on the touch table with the Interactive Mapping with local recent air photography, I was totally absorbed with what I was doing
Q41	To what degree do you believe using models (chainsaw, rake, house) helped focus your attention to the task?

The six questions ultimately chosen for the Flow Index focus on:

a) the participants' perceived level of concentration, and;

b) their *oneness* or immersion with the subject at hand.

Flow was measured according to six key factors – interest, imagination, engrossment, distraction, absorption and attention. All of the six flow questions were adapted from flow questions collated from empirical studies.

METHOD
After completing the "Preparing for Bushfire" exercise each participant completed a questionnaire. The Flow Index questions were a component of the engagement subsection.

RESULTS AND DISCUSSION
Aspects of the "Preparing for Bushfire" interface were carefully designed to appeal to traits of adult learners. The interface information was presented as real life scenarios from the local region. The interface tasks were real actions: clearing leaves and bark, removing trees and ember-proofing. These activities were aimed at reflecting the 'life-centred' context identified as the most effective for adult learners (Knowles et al. 2005).

The maximum possible index score for six questions was 30. Our results provide a value of the Flow Index of mean=22.86, sd=3.87, and range=12-28 with a Cronbach Alpha of 0.8, therefore our results are a strong indicator of occurrence of flow. Landauer (1997) notes that acceptable values for 'Evaluation [of] measurement reliability in the range of 0.7 to 0.8 is acceptable.'

All questions used a Likert Scale from Strongly Disagree to Strongly Agree (some reversed and adjusted accordingly in the analysis). The average value of each response equates to an overall value of *Agree* that flow is present.

The Flow Index helped with the evaluation of the original hypothesis of the "Preparing for Bushfire" project because it was succinct. It enabled simple evaluation of the experiment design.

LIMITATIONS
The questions in the Flow Index were customised to suit the experience being measured. All the characteristics likely to elicit the engaging behaviour should be included in the flow questions – designing a Flow Index for a different project must address all potential engaging behaviour within the questions.

CONCLUSIONS
The Flow Index clearly quantified the level of intense focus of the "Preparing for Bushfire" touch table interface occurred at a value of *Agree*, which is a positive quantifiable result well above the midpoint of the Likert Scale. The responses to the individual questions of the Flow Index further break down the contribution of flow into the categories of playfulness, attention focus, and cognitive enjoyment. This exercise successfully demonstrated the use of the Flow Index can effectively quantify intensely focused engagement.

REFERENCES
Brown, M., Chinthammit, W. & Nixon, P., 2015. An implementation of tangible interactive mapping to improve adult learning for preparing for bushfire. In *OzCHI 2015: Being Human - Conference Proceedings*.

Csíkszentmihály, M., 1997. Finding flow: the pschology of engagement with everyday life. *Psychology Today*, pp.1–7.

Hoffman, D.L. & Novak, T.P., 2009a. Flow Online: Lessons Learned and Future Prospects. *Journal of Interactive Marketing*, 23(1), pp.23–34.

Hoffman, D.L. & Novak, T.P., 2009b. Flow Online: Lessons Learned and Future Prospects. *Journal of Interactive Marketing*, 23(1), pp.23–34.

Jackson, S., Martin, A.J. & Eklund, R.C., 2008. Long and short measures of flow: the construct validity of the FSS-2, DFS-2, and new brief counterparts. *Journal of sport & exercise psychology*, 30(5), pp.561–587.

Knowles, M.S., Holton, E.F. & Swanson, R.A., 2005. *The Adult Learner*, Butterworth-Heinemann.

Landauer, T.K., 1997. Behavioral research methods in human–computer interaction. In M. Helander, K. T. Landauer, & P. Prabhu, eds. *Handbook of Human–Computer Interaction*. Amsterdam, Netherlands: Elsevier, pp. 203–227.

Lessiter, J. et al., 2001. A Cross-Media Presence Questionnaire: The ITC-Sense of Presence Inventory. *Presence: Teleoperators and Virtual Environments*, 10(3), pp.282–297.

Novak, T.P., Hoffman, D.L. & Yung, Y.-F., 2000. Measuring the Customer Experience in Online Environments: A Structural Modeling Approach. *Marketing Science*, 19(1), pp.22–42.

Sauro, J. & Lewis, J., 2012. *Quantifying the user experience: Practical statistics for user research* 1st ed., MA, USA: Morgan Kaufmann.

Schneider, B., Jermann, P. & Zufferey, G., 2010. Benefits of a tangible interface for collaborative learning and interaction. *IEEE Transactions on Learning Technologies*, 4(2), pp.1–12.

Sharp, H., Rogers, Y. & Preece, J., 2011. *Interaction Design: Beyond Human-Computer Interaction*,

Zaman, B. et al., 2011. Editorial: the evolving field of tangible interaction for children: the challenge of empirical validation. *Personal and Ubiquitous Computing*, 16(4), pp.367–378.

Zuckerman, O. & Gal-Oz, A., 2013. To TUI or not to TUI: Evaluating performance and preference in tangible vs. graphical user interfaces. *International Journal of Human-Computer Studies*, 71(7–8), pp.803–820.