Creating and Maintaining Psychological Flow State in Augmented Reality Applications

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Abstract – *Designing successful products for e-commerce, e-learning, and e-government has many challenges. This is especially true for emerging technologies such as augmented reality (AR) where one of the primary determinant success factors is user acceptance. While much is known about usability and user experience (UX) design, less has been researched about creating designs to support a psychological flow state, where users become fully engaged with a product. Designers should consider flow state as optimum user experience and seek to keep their users in a broadly defined flow channel. Potential interruptions to flow affecting usability are identified as flow exit points and can be actively accounted for in design. Flow exit points indicate potential issues with a continuous interface experience, such as those found in many augmented reality applications. This paper examines psychological flow and offers incremental steps in an application design process to seek optimum user experience for augmented reality applications.*

Keywords: augmented reality, application design, psychology, user experience, flow state

1 Introduction

Designing successful products for e-commerce, e-learning, and e-government has many challenges. This is especially true for emerging technologies such as augmented reality (AR) applications where one of the key determinant success factors is user acceptance. Many factors drive user acceptance, and the most important one is the usability of the product. While much is known about usability and user experience (UX) design in a functional usability domain, less has been researched on the aspects of a psychological flow state, where users become fully engrossed while using a product. Much of the existing literature is in the game domain, but all applications can benefit from considering this advanced form of user experience during the design, development, and test phases of product development.

There are many psychological factors designers should consider for AR application development [1]. All these factors contribute to ease of use and user satisfaction. For example, proper use of color for representation of states can make an important cognitive connection (e.g., red for warning or trouble). The employing of Gestalt principles for pattern making and visual processing where patterns allow or require the user's mind to complete the meaning provides a unique type of user engagement and challenge [2]. For a thorough treatment of user design principles' evolution and frameworks see Johnson [1].

While many factors contribute to better UX, the attainment of optimal experience is dependent on the user's ability to reach a psychological flow state. A flow state is where the user becomes so engaged with the application, that he or she loses track of time and extraneous activities unrelated to that particular experience [3]. Maximum engagement in an experience leads to this flow state, and the conscious planning of flow states and user control to affect and control key aspects of the experience can provide an advantage for augmented reality applications with respect to user acceptance.

Flow has been studied in game design and use [4][5][6][7]. For example, a specific flow-centered study of the game Bejeweled showed attaining flow could alter a user's mood. By measuring heart rate, electroencephalogram (EEG), and evaluating self-questionnaires, users attaining a flow sate were shown to improve mood and decrease stress [4]. These are powerful results from the use of a computer application and demonstrate that application designers who desire an optimum user experience should consider flow state creation as part of their design process.

Flow has also been examined in relation to web site usage for marketing effectiveness as a measure of persuasion [8]. In fact, psychological flow states have been examined in a variety of technology domains from the study of game addiction [9], use of social media sites such as Facebook [10], trust in recommender systems [11], and mobile media adoption [12]. There has been research in flow for exercise and gaming applications known as exergaming [13].

Flow states are important for e-commerce applications because users in a flow state are subject to persuasion [8]. In e-learning, flow states facilitate learning [8]. These implications go beyond simply creating satisfying user experiences and move into the realm of persuasion. For example, in online experiences, flow has been found not only to lead to increased learning, but also exploratory and positive behavior, positive subjective experience, and users' perceived sense of control over their interactions [8]. Once in a flow state, cognitive dissonance, or resistance to contra opinion and information, is lowered and users may be more prone to suggestions. Uneven flow and poor interface design, however, may allow users to pause and reflect, which may allow dissonance to affect the decision process [14]. In all applications seeking to create flow, ease-of-use, general usability, and design all contribute to flow state attainment.

Augmented reality applications vary widely in their utility and many applications, such as navigating to a coffee shop with geographic overlays, do not have considerations for flow. However, a key consideration for all user experience designers is to keep the user engaged in their application.

Therefore, while not all applications require or even attempt to evoke a flow state, those that do will provide an optimum user experience, which will reflect positively on the application.

Game applications in particular are often flow state appropriate, where the user becomes immersed in game play. History domain e-learning AR applications where users can narratively transport back in time to an event they find interesting is an example of an e-learning or e-government application. Narrative transportation is the ultimate form of flow where the users' engagement reaches a point that they are psychologically transported into the story [15]. In summary, psychological flow has a wide range of potential as a new class of applications for e-learning, e-commerce, and e-business emerge.

2 Psychological Flow States

A flow state is achieved when a person experiences a mental state of immersion and engagement. Miháli Csíkszentmihályi described flow states by defining the main properties contributing to flow [3]:

- Challenging activity(ies) requiring skill(s)
- Merging of action and awareness
- Clear goals with feedback
- Concentration on the task at hand
- Sense of control and lack of concern about its loss
- Loss of self-consciousness including awareness of time passage

These points provide the underpinnings of psychological flow state for application designers. Challenging activities requiring skill provide a basic direction where there must be tasks to accomplish a goal. The goals must be clearly defined and reachable. Feedback for both attainment of the goal or failure to reach the goal assists the user in understanding.

Merging of action and awareness provide the subconscious integration of these activities to awareness within the task progression. This consciousness might, from a psychologically perspective, not be a loss of consciousness but more of the balancing of challenges and skills to create the need in the user for focused concentration on the task at hand [16]. Concentration is then balanced with a sense of control and lack of concern about its loss. Finally, users can often lose track of time in this process. Any combination of these components can contribute to a user experiencing a flow state [3].

Massimini and Carli provided an emotional state diagram and distributed range of emotional states corresponding to flow state [17]. Figure 1 illustrates these ranges of emotions from apathy to anxiety and from relaxation to flow. It provides insight for the designer to study where in a flow state diagram emotions reside. This diagram also provides an illustration where the flow channel moves though the center of these emotions, balancing the border between boredom and anxiety. These emotional states are key to understanding because attention is affected by emotion [2], and attention combined with emotion strongly influences whether a person can enter a flow state [10].

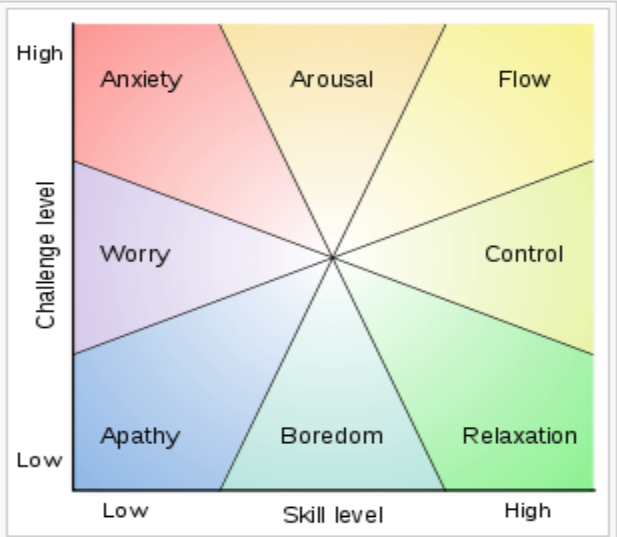

Figure 1: Emotion display challenge versus skill levels (WikiCommons adapted from Massimini and Carli [17])

Designers can incorporate Figure 1 into their initial conversations concerning user experience. For example, this emotional range landscape provides a grounding point for designers to actively discuss the user experience and emotions that are desired during the experience. While game applications are obvious, other applications such as a corporate dashboard monitoring a manufacturing process must battle the boredom and apathy emotions while anxiety over the experience may inhibit the effectiveness of information communication and transfer.

Another potential use of Figure 1 is to gain a better understanding of how emotions are layered in a skill versus challenge paradigm. While application changes can be dramatic and move a user from one extreme state such as apathy to another extreme state such as arousal, the crossover points are narrow and may be difficult to attain. Moving gradually between the adjacent emotional states provides a more continuous experience, which is appropriate for many applications. Obviously, if startling a user in a game with sudden attacks and activities is desired, extreme changes can occur, but designers should be especially cognizant at those points of the potential to exit the flow state.

Flow is not a singular status, and a user is considered in flow state if he or she is in a temporal area timeline known as a flow channel, defined as an area that moves horizontally, and somewhat notionally, at an angle from the bottom left to the top right of the emotional state layout shown in Figure 1 [3]. Figure 2 shows a representative flow channel navigating between user boredom and user anxiety.

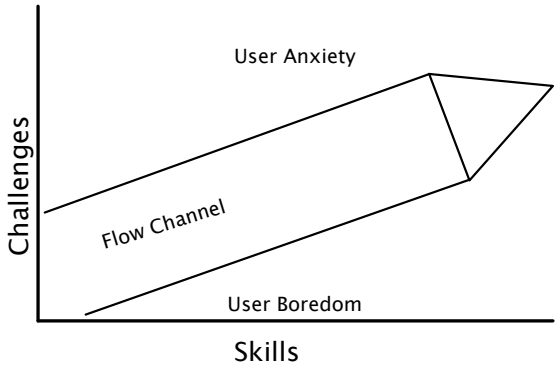

Figure 2: Flow Channel where balance of skills versus challenges occurs (Adapted from Csíkszentmihályi [3])

Figure 2 shows a linear and uniform flow state channel. However, it is unlikely that any user would have experiences that moved in this geometric pattern given differences in skills and emotional reaction to challenges [18]. Additionally, users' experiences vary because of a host of external factors, such as distractions, time of day, and current interest level. This leads to a more realistic flow channel shown in Figure 3 with peaks and valleys along the border of both boredom and anxiety. This diagram is specific to individuals, as different users have different flow zones, which need to be accounted for by designers [18].

In Figure 3, the traditional flow channel is reshaped to form jagged edges, as users would move through an emotional landscape, as depicted in Figure 1. The peaks and valleys would change for different users because skills vary, which impacts emotional reactions to the challenges. The jagged peaks and valleys provide an indication of points where the user is in danger of exiting the flow channel.

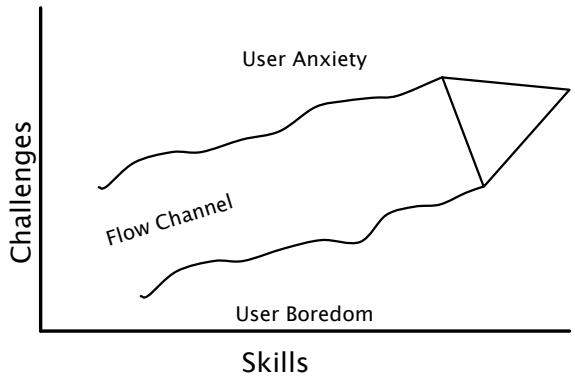

Figure 3: Individual user variations of a flow channel

The uneven lines bordering this channel illustrate points along the increasing skill challenges axis where individual users would be found. For example, new users will likely track nearer the anxiety border while experienced and highly skilled users will track closer to the boredom line. As the lines move outward from the center of the channel, a potential indication of an issue crossing into anxiety or boredom exists. If these states are reached, then flow will end. Thus, designers should be cognizant of these potential flow exit points during design and testing and provide options at those points to keep the user in flow.

2.1 Flow exit points

A flow exit point is often simple to identify. For example, the ultimate flow exit point is exit from the program. Error messages or configuration settings that require user intervention also exit the user from a flow state. In fact, any activity that takes the user's attention away from the task of using skills to meet challenges has potential to exit the user from a flow state.

The varying flow channel in Figure 3 is unique to an actual user. However, if a designer were to attempt to create charts based on empirical data, it is likely that this channel could not be repeated even with the same user. Skills and application knowledge improve, which reduces anxiety and pushes the line towards boredom. This concept of mapping individual user flow channel boundaries, while impractical in practice for individual users, can still serve as a theoretical reference for flow states in user design.

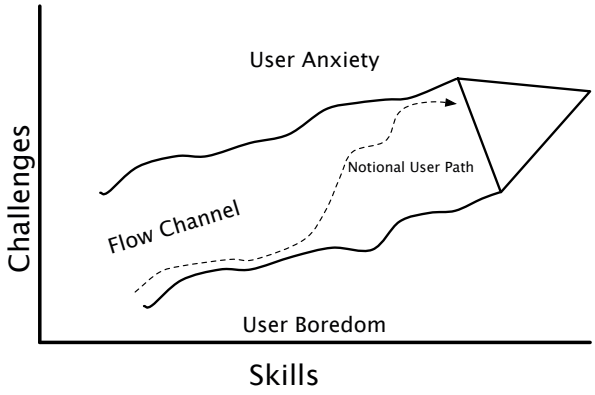

Figure 4. Example user movement through the flow channel.

Flow channel exit points are, however, difficult to identify across a range of widely differently skilled users. One solution is to combine a small range of individual flow channel representations by defined personas, a technique already used in other user interface design tasks to provide a portrait of a user. These personas can represents skill bands to help create realistic diagrams. For example, beginners will likely track near the anxiety line boundary, as they are new to the system, inexperienced with the user interface controls, and potentially unskilled or inexperienced. Advanced users will likely track along the boredom line, at least in areas of the application they have used before. Design and testing can help identify these points along the boundary lines where persona skill bands can assist in predicting flow exit points for user skill levels.

2.2 Flow state measurement and testing

One important consideration for UX design and artifact creation is the ability to measure and track metrics. Testing and measuring flow states are difficult [8], and testing flow in an application presents its own set of challenges. For example, in video games, not only is flow difficult to test, the flow conditions may even change the more a user plays the game, and skills of users can change during the game itself [5].

For measurements, there are two methods available for designers. In one method, psychophysiological devices are required to measure heart rate, pupil dilation, electroencephalogram (EEG), and respiratory activity [4][10]. These tests on human subjects require procedures, expertise, and equipment that may not be available to a project. The second method is self-evaluation through questionnaires. While this is an inexpensive and readily available technique, the accuracy of the results might be in question due to inconsistencies in self-rating by users [8].

Whichever method is chosen, a formal measurement that can be repeated and communicated to stakeholders and designers is essential. It is possible to gain value from a few considerations of flow and tracking through normal tests, but the design team may desire a specific, tailored artifact for their processes. Even if neither of these options is appropriate for a particular design organization, it is important to formalize measurements or quantification of application challenges and skill activities to achieve a flow state. For example, if the application is seeking flow as a main component as its goal, a framework closely matching elements of flow such as concentration, challenge and skills matrix, user control, goal clarity, feedback notion of immersion, and social interaction can be incorporated into a model for evaluating design [7].

3 User Interface Development Processes

No new idea or process change can exist in isolation from the overall product development process. When a new design consideration is added, user experience (UX) engineers and software designers have to first determine where in their process changes can be accommodated. The introduction of any new information and process change must fit into existing process frameworks, or they must at least be able to be integrated at some level. Typically, artifacts are created for requirements details, feature design, and testing. Artifacts can prove valuable, and the addition of a new process step must be done with care. For the integration of flow design considerations, two separate process additions are proposed.

The first step is to formally agree that flow state considerations are appropriate and desirable by the product stakeholders. Varying levels of interest can be accommodated from tacit awareness to detailed user testing. Formal discussion and approval of these goals are recorded in the project UX documentation.

The second process addition is to integrate flow channel user persona definitions and highlight potential flow exit points. Several user persona skill bands can represent the temporal change during application use along the challenges versus skills flow channel. Once flow exit points are identified, one method to deal with these boundary conditions is to embed choices into the application at these exit points [18].

A waterfall process is the most straightforward integration. Steps can be added in the sequential process, which require these actions to complete. An agile development process provides opportunities for iterative user experience design, but it can be more complex for iterations. While there initially appears to be conflict with product iterations and user interface interactions due to cycle time (i.e., product cycle time of 4-8 weeks and user interface cycles of hours or days), careful and purposeful planning can synchronize these nested iterations [19]. These potential conflicts can be managed to allow input of multiple UX iterations into a single agile sprint. Thus, while agile process requires more planning, flow state process changes can also be integrated in a straightforward manner to improve UX design.

4 Flow State in User Experience Design

There are a host of psychological considerations for designers to study before formal user experience design can begin. The augmented reality (AR) user experience differs in several key ways from traditional keyboard display applications, since AR applications work integrated with real-world displays and data.

In AR applications, the goals of most designers are to affect the emotion of the user [20]. This is aided by the integration of real, physical backgrounds, which can provide emotional context [8]. One technique designers should consider is to focus on a cognitive task design versus functional task. Given the greater cognitive demands faced by users of AR products, designers should consider evolving their approaches to match these demands [20]. The typical functional approach to design would give way to one that includes focus on the cognitive aspects. Cognitive task design, with its emphasis on the mental processes of the user, should be one consideration in application design [20]. This is especially true in a decision tree where the designer is striving to keep the user in the flow channel [18].

There are subtle complexities in application usage concerning flow states. For example, user errors leading to messages might outwardly be considered an interruption of a positive flow, but some games might introduce error potential as part of its skills challenge [1]. Focus itself has many dimensions. For example, the triune brain model suggests three main areas of focus for targeting design and analysis, one for each level of the brain: instinctual responses, emotional responses, and identity responses. They can function independently, but, given the inter-relatedness of the brain, are more often simultaneous and mutually reinforcing [21].

Video game designers typically consciously leverage the aspects of flow [18]. Keeping players in the flow zone is a designer's goal, but the difficulty increases with the size of the user base [18]. As feature sets are designed and revised, a list

of questions about the design focused on user goals and skills versus challenges can assist designers [5]. Thus, user base size and diversity necessitates formal documentation (e.g., lists) for challenges versus skills activities.

One final note for designers is to understand the power of flow states. For example, there may be safety concerns for AR applications that create a flow state for a user while he or she is walking down a street immersed in the application. There are also potential ramifications from increased persuasion for immersed users. Therefore, designers should be aware that ethical considerations must also be considered for enhanced user engagement, particularly persuasion [22].

4.1 Flow state design management

When considering techniques to create and maintain a user flow state, designers must first consider interruptions and interface confusion. Causing a user to stop and think outside the experience will break flow, as they become aware of their surroundings. Too many choices are overwhelming and having to pause to make choices and can also be disruptive for a user [18].

Many general UX design principles assist with flow achievement. First, a well-designed interface that provides seamless use and interaction contributes by not distracting the user from the current task/challenge by requiring a conscious non-application activity for every user interaction required. In AR applications specifically, immersive narrative looks to identity for a place in the immersive story.

User experience designers and stakeholders typically understand the desired functional flow of their products quite well. To create and maintain a flow experience, several additional steps are required. Banding by user persona type of expert, average, and beginner skills serves as an overlay to the edge case interactions, which are mapped near the boundaries of these bands. Use case testing by developers and stakeholders can provide illumination as to these boundary cases as well.

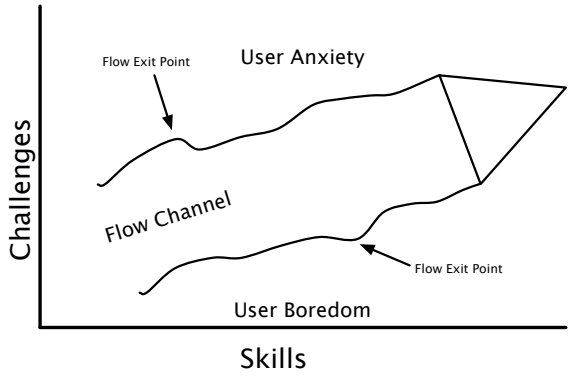

Figure 5: Flow exit points along the flow channel

Boundary points where a measurement (e.g., psychophysiological or self-questionnaire) can show potential flow exit points as anxiety or boredom emotional states are approached. Identification of these potential flow exits allow for planning actions for users when these occur.

The boundary cases must then be examined for options. For example, an action that advances a user a minor next step with minimal intervention and few choices is unlikely to affect flow. In UX functional flow process documents, identify the points where users potentially exit by providing options to maintain state is a goal of this analysis. Alternatives for exit conditions at extreme boundary points should be identified. This can be a tree of options [18] or a branch to a new level in a game or additional data visualization in a corporate application. It is recommended that a small number of potential flow exit points be reviewed and considered with options provided in the user interface and retesting conducted. Once the process works smoothly, the design team can decide how many iterations or exit points to address during test and iterative development.

Adding flow channel representations to a persona will enable discussion about points of concern that may lead to flow exit points for that user profile. The visual nature of this artifact as it was represented in Figure 4. Potential issues that cause flow channel exit are noted and the accompanying design comments will discuss why that point is a potential exit point as well as potential course of action. One likely solution is user or system intervention based on a set of defined parameters (e.g., lapsed time since later user input) that provides the user with options to navigate back to the flow channel and become reengaged with the application.

4.2 Augmenting your design process: The key points

The amount of information presented and potential solutions are additional work for an often time-constrained and burdened development and design team. While implementing enhanced artifacts or even introducing new artifacts to track and address flow state may be most desirable, smaller process changes can also provide benefit. For example, training for designers, product managers, marketing, and quality assurance engineers can provide improvements in general usability as well as provide an understanding of when optimal user experiences are achieved.

There are four key components for creating and maintaining a flow channel for users of AR applications. These are 1) Create and maintain a flow channel for optimum experience, 2) Observe each user as unique, use persona skill bands, 3) Identify flow exit points during design, and 4) Implement incremental, non-evasive process integration. These steps will allow designers and software developers to create a better user experience and help users create and maintain a flow state, which can serve application designers well and enhance the potential for application success.

5 Future Research

Measuring incremental process changes is difficult and often does not provide sufficient justification to perform. Quantitative studies are difficult as well and most product

development teams will chose to continue to focus on improving their product instead of expending time and energy attempting to measure potential benefits. Therefore, future research should be focused on the inclusion of psychological factors leading to flow in overall studies. When appropriate, data can be examined for decision methodology and product improvements. In particular the concept of flow exit points should be considered in user interface design and feature implementations.

6 Conclusion

Designing successful products for e-commerce, e-learning, and E-government has many challenges. This is especially true in emerging technologies such as augmented reality (AR). One of the primary determinant success factors is user acceptance. Several designers' teams are beginning to consider techniques for evoking flow state, but most research has been conducted in game application areas. However, all applications can benefit from considering this advanced form of user experience during the design and test phase of product development.

Designers should consider flow state as optimum user experience and seek to keep their users in a broadly defined flow channel. Potential interruptions to flow affecting usability are identified as flow exit points and can be actively accounted for in design. Flow exit points indicate potential issues with a continuous interface experience, such as those found in many augmented reality applications.

This paper examined psychological flow and offered incremental process steps to incorporate into existing application design processes. Designers and application should seek optimum user experience with a framework for application design process for augmented reality applications in these four steps: 1) Create and maintain a flow channel for optimum experience, 2) Observe each user as unique, use persona skill bands, 3) Identify flow exit points during design, and 4) Implement incremental, non-evasive process integration.

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