

Designing Instructional Media To Create a Flow State for Learners

Final Masters Project

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October, 2005

Table of Contents

(1) Abstract

Theoretical Underpinnings:

(2) Concept Approach and Problem Definition

(3) Learning Theory, Instructional Design and Technology

(4) Social and Emotional Learning

Flow:

(5) What is Flow?

(6) Flow and Media

(7) An Example of Creating Flow with Media

(8) Flow and Learning

Prototype:

(9) *Flow Builder*

a. Concept & Learning Elements

b. Design Elements for Flow

c. Description of Flow Builder

(10) Further Research

Abstract

Flow is a euphoric state of concentration and involvement, often claimed to be one of the most enjoyable and valuable experiences one can have. In flow, one tends to be happy, motivated, and cognitively efficient—a combination of factors that often leads one to achieve success in the activity in which one is engaged. If being in a flow state can help to realize success, can we not seek to create learning experiences that create flow, helping young people achieve more? Research validates the hypothesis that engaging with media, and particularly playing video games, is an activity that possesses the combination of characteristics that can bring learners to a state of flow. This project attempts to synthesize findings from many studies of the phenomenon of flow across various disciplines. In evaluating these ideas, we then attempt to distill out the attributes of a situation that contribute to an individual achieving state of flow in a media experience. We then hypothesize that by applying this information with what we know about student engagement, we can begin to design instructional media that create a state of flow for learners, providing them with a more engaging, challenging, and rewarding learning experience. Lastly, a design and prototype of such an application called Flow Builder is introduced. Flow Builder is an interactive, instructional video game intended to engage children ages 12-15. Flow builder allows them to use a simple graphical user interface to build original creations, requiring that they apply their prior knowledge while they learn strategy, planning, decision making, systems thinking, analytical thinking, holistic thinking and understanding of interdependencies through building creations of their choice.

Theoretical Underpinnings

Concept Approach and Problem Definition

All students bring their own complicated set of variables to a particular learning moment, including: different sets of prior knowledge, varying levels of cognitive ability, individual strengths or weaknesses with various learning modalities, varying degrees of and social and emotional maturity, and their temporary emotional state. Many examples of instructional technology that seek to help children improve a skill often attempt to address a single factor of learning modality and fail to account for the cognitive and social and emotional “blueprint” that a student brings to a learning experience. Thus, given the myriad of challenges that educators and instructional designers are met with when attempting to design instruction for learning, it would seem like progress to design learning experiences that offer a flow experience, as many of flow’s qualities appear to transcend some considerable hurdles for learning such as: anxiety, apathy, boredom, lack of concentration, and lack of presenting an appropriately matched challenge. John Sherry, a prominent researcher in the field, goes as far to say that “educational media designed without understanding how the flow experience is facilitated through the uses and gratifications of a particular medium and individual cognitive abilities stands to prevent engagement with the material” (Sherry, 2004)¹. At a minimum, it seems worthwhile to distill that which is happening during flow experiences, and identify characteristics that harness the power of flow. With this information, instructional designers could begin to think about “designing for a flow experience.”

Learning Theory, Instructional Design and Technology

According to Wikipedia, instructional design is “the analysis of learning needs and

systematic development of instruction. [A method of instructional design], instructional technology utilizes technology as a way to uniquely solve educational problems.

Instructional design models typically specify a method, that if followed will facilitate the transfer of knowledge, skills and attitude to the recipient or acquirer of the instruction.”(Wikipedia, 2005)ⁱⁱ

Though the ideas from many learning theorists and instructional design experts have accounted for a broad range of approaches to designing learning instruction, this paper will discuss the subset that are relevant to and supported by research related to flow. Further, we will identify several theories that have shaped the instructional design of *Flow Builder*.

According to Lev Vygotsky, the instructional design of learning material should be structured to encourage student interaction and collaboration. Additionally, because he purports that cognitive change occurs within the zone of proximal development, a developmental level that is just above the student's current developmental level, Vygotsky asserts that instruction should be designed to teach students at that level. (Vygotsky, 1978)ⁱⁱⁱ This idea is consistent with the research to be discussed in this paper about the elements that create a flow experience, namely a good match between challenge and skill.

Scaffolding is an effective strategy to match an experience with a student's zone of proximal development. During scaffolding, the teacher is meant to engage students' interest, simplify tasks so they are manageable, and motivate students to pursue the

instructional goal. (Hausfather, 1996)^{iv}. *Flow Builder* will employ such a scaffolding mechanism to engage students early and keep them motivated throughout the instruction.

A great deal of instructional design, including blended learning design, attempts to address one or two learning modalities. Few, however, attempt to account for multiple intelligences that a diverse group of learners can have. Howard Gardner's theory of multiple intelligences suggests that there are a number of distinct forms of intelligence that every individual possesses but in varying degrees. (Gardner, 1982)^v Gardner proposes seven primary forms:

1. Linguistic - capacity to use language to express oneself.
2. Musical - capacity for one to think in music, to be able to hear patterns, to recognize them, and manipulate them.
3. Logical-Mathematical – capacity to understand the underlying principles of some kind of a causal system; ability to manipulate numbers, quantities, and operations.
4. Spatial - ability to represent the spatial world internally in one's mind.
5. Body-Kinesthetic - capacity to use one's whole body or parts of one's body (eg. hands, fingers, arms), to solve a problem.
6. Intrapersonal - ability to understand oneself, who one is, who one is not, what one is capable of, what one wants to do, how one reacts to things, which things one should avoid, and which things one should gravitate toward
7. Interpersonal – capacity to understand other people; social skills. (Gardner, 1983)^{vi}

The implication of the theory, as Gardner describes, is that instruction and learning should focus on the particular intelligences of each individual. For example, if a particular person is strong kinesthetically and interpersonally, then these areas should be identified and developed. Gardner asserts that individuals should be encouraged to use their preferred intelligences in learning, that assessment of abilities should test via all forms of intelligence, that instructional activities should appeal to different forms of intelligence, and not just linguistic and logical-mathematical. (Gardner, 1983)^{vii} The design of *Flow Builder* embraces Gardner's theory of multiple intelligences and uses it as the basis for building a flow experience.

Maria Montessori anticipated another relevant paradigm to creating a flow experience in instructional design. A teacher (or learning technology), she maintained, should protect a child's motivation and encourage feelings of mastery and efficacy by knowing when to help the child and when to back off and let the child work alone. (Montessori, 1965)^{viii} Aside from the research that we will discuss linking the theories of Montessori with the tenants of a flow experience, *Flow Builder* is designed to allow the learner to quickly feel the power of mastery, at the same time allowing them the ability to work alone and develop their own learning.

The instructional design of *Flow Builder* is centered in constructivist theory, a hands-on approach where one learns by doing rather than being explicitly told the answer. Learners interacting with the game are left to make their own inferences, discoveries and draw their own conclusions. The instruction is based on Jean Piaget's view of constructivism that suggests that children should not to abandon their world-views in lieu of an expert view. At the same time, the application is an example of

Seymour Papert's constructivism that focuses on learning through a strong emphasis on making things, just as his *Logo* programming language uses a media tool to facilitate constructivist learning. (Edith, 2001)^{ix} As such, *Flow Builder* encourages users to create their own artifacts, during which time they engage in self-directed learning, and ultimately facilitate the construction of new knowledge

Reigeluth's elaboration theory of instruction provides a foundation for how *Flow Builder* is designed. According to elaboration theory, for optimal learning, instruction should be organized in increasing order of complexity. As in the design of *Flow Builder*, the simplest version of a task is presented first; subsequent lessons (or levels) present additional complexity, and along the way the learner is reminded of each of the lessons in a summary. A key idea of elaboration theory is that the learner needs to develop a meaningful context, after which subsequent ideas and skills can be assimilated. (Regeluth & Stein, 1983)^x We believe that the design of *Flow Builder* has the potential to not only engage the learner deeply, but to facilitate better retention and transfer of learning.

Instructional design theorist Robert Gagné demonstrated a concern for different levels of learning. Specifically, he identified nine instructional events that detail the conditions necessary for learning to occur. *Flow Builder's* design borrows from Gagné's conditions of learning theory, providing nine necessary conditions for designing instruction and selecting the appropriate media (Gagne, Briggs & Wager, 1992)^{xi}. The mapping of conditions and design elements will be identified later in this paper.

Combining the theories we have discussed, and utilizing the general structure from Dick and Carey's Systematic Design of Instruction, (Dick & Carey, 2000)^{xii} *Flow Builder* employs the following instructional design model:

- *Instructional goals:* To deeply engage children ages 12-15 and create a flow state by providing them an environment to build original creations through applying their prior knowledge and skills. Depending on the mode of learning that the learner chooses, the goal is to teach strategy, planning, decision making, systems thinking, analytical thinking, holistic thinking and understanding of interdependencies within a linguistic, musical, logical-mathematical, spatial, body-kinesthetic, intrapersonal, or interpersonal learning mode.
- *Needs Assessment:* Though no formal needs assessment was conducted when designing this instruction, through interviews with several 6-8th grade teachers at Ethical Culture Fieldston School, an independent school in New York City, the following needs have been identified: an expressed need for creating more engaging learning environments for this increasingly apathetic age group, a presumed future need of creating learning environments that utilize video games (a predominant medium used by the target age range), and a critical incident need: The target is 12-15 year olds (7th-10th grades), as this is the prime age where apathy can set in. (Eccles, Wigfield, Midgley, & Reuman, 1993)^{xiii} In fact, studies have shown that by the time students reach middle school, lack of interest in schoolwork becomes increasingly apparent, and by high school (as measured by dropout rates), too many students are not sufficiently motivated to succeed in school (Lumsden, 1994)^{xiv}.
- *Selection of instructional materials:* Instruction will be delivered through an interactive video game. While selecting a medium that is already engaging to its target audience, this technology is the only one that will allow for interactivity and immediate feedback, critical elements of creating a flow experience.

Intended outcomes: If followed, this instructional technology will facilitate sustained engagement by 12-15 year old children, and students will be able to become better problem-solvers and creators within learning modalities in which they feel most confident.

Social and Emotional Learning

Social and emotional learning (SEL) refers to the process of teaching and learning skills, knowledge and values that provide the foundation for social and emotional competencies^{xv}. The field consists of topics that include, but are not limited to:

- awareness and management of one's emotions
- using social awareness to build and maintain positive relationships
- demonstrate emotionally sound decision making to achieve success
- understanding the connection between emotions and learning
- how to remove the emotional blocks to learning
- the neuroscience of how the brain processes information, and the interplay between cognition and emotion
- emotional intelligence
- flow and peak performance

Popularized by Daniel Goleman's book of the same name, *Emotional Intelligence*, (Goleman & Whitener, 1995)^{xvi} (EI) is now recognized as a key factor in high performance and success at work, at school, and in most other social settings. Today, most in the field would not argue that learning is strongly affected by both cognitive and emotional psychology. Through his research, Goleman has found that EI is a much better predictor of success in individuals than "academic intelligence." (Goleman, 1995)^{xvii}

At the same time, Martin Seligman's movement of "positive psychology" (Seligman, Csikzentmihalyi, 2000)^{xviii} has become one of the most influential themes in the field in recent years. Seligman explains "during its first century, psychology justifiably focused most of its attention on human suffering...such as depression, anxiety, and phobias. Positive Psychology is founded on the belief that...we have the opportunity to create a science and a profession that not only heals psychological damage but also builds strengths to enable people to achieve the best things in life." (Seligman, Csikzentmihalyi, 2000)^{xix} In his book *Learned Optimism*, Seligman describes his many studies of how controlling emotion, in particular positive emotions like optimism, can lead to improvements in school, testing, work, and other aspects of life. (Seligman, 1991)^{xx}

Joseph Ledoux's research supports that emotions are composed of physical body states, and that "emotion...is a slave to the physiology, not vice versa: we do not tremble because we are afraid or cry because we feel sad; we are afraid because we tremble and sad because we cry." (Ledoux, 1996)^{xxi} Much of his research supports that the amygdala, part of the limbic system and located in the brain's medial temporal lobe, is believed to play a key role in the emotions in humans and other animals; this "emotional switching station" is linked to both fear responses and pleasure.

Other physiological observations can help us to understand our emotions, in particular the flow state. Positive and negative emotions can effect how the brain processes and retrieves information. An "emotional high" provokes the release of endorphins in the brain that in turn trigger the flow of acetylcholine, the vital neurotransmitter that orders new memories to be imprinted in various parts of the brain

(Kotulak, 1997)^{xxii}. Whereas each type of brainwave generally predominates during a particular daily activity (be that sleeping, working, problem solving, etc), Anna Wise has measured the brain wave patterns of spiritual leaders, artists, high-performing businessmen, athletes, and others during periods of flow, and found something quite different. Each of these individuals have shown to exhibit a specific brain wave pattern in which the four categories of brain waves (beta, alpha, theta, and delta) are combined and working harmoniously (Wise, 1997).^{xxiii}

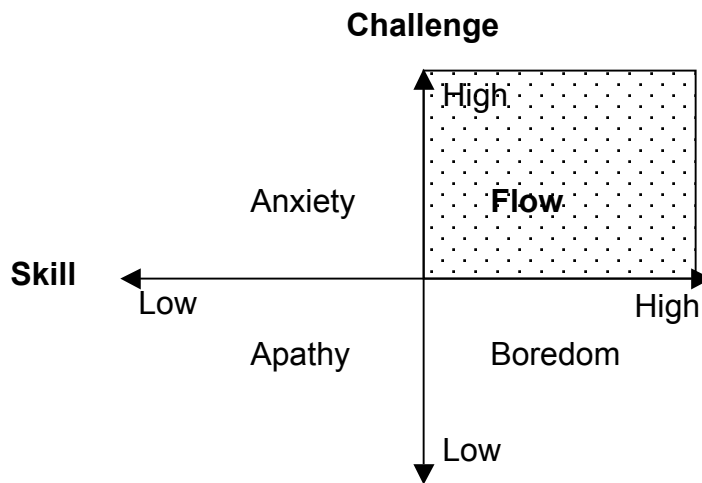
In summary, though different emotions affect learning differently, it is clear that there is a connection between the two. Just as negative emotions such as anxiety can have a negative impact on learning (Hembree, 1988),^{xxiv} flow can lead to the highest levels of achievement (Csikszentmihalyi & Le Fevre, 1989)^{xxv}.

Flow

What is Flow

Flow was originally coined in the 1970s to describe a euphoric state of concentration and involvement, (Csikszentmihalyi, 1974)^{xxvi} often claimed to be one of the most enjoyable and valuable experiences one can have (Csikszentmihalyi 1992).^{xxvii} Flow is characterized by “action, awareness and a loss of reflective self-consciousness”, as well as a distortion of temporal experience. This state is sometimes described as relaxed wakefulness, and always intrinsically rewarding. In flow, one tends to be happy, motivated, and cognitively efficient; one becomes completely absorbed in an activity, capable of blocking out distractions that are not relevant to the task at hand. A key attribute of flow is a match between one’s perceived skills and the challenges associated

with an activity. This symbiotic relationship between skill and challenge is illustrated in Csikszentmihalyi's often replicated diagram below:



Activities that produces flow are often described as autotelic--so gratifying that one is willing to undertake the activity for its own sake, without concern of what the results will be (Csikszentmihalyi , 1992, Chen, 1999).^{xxviii}

Maslow first introduced a term called “peak experience” in the context of his description of self-actualized individuals. A peak experience can be defined as a moment of highest joy and happiness accompanied by distinctive cognitive states such as heightened awareness of reality as well as clarity of perception and vision (Maslow, 1968).^{xxix} Csikszentmihalyi later proclaimed "the best moments usually occur when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worth-while. Optimal experience is thus something we make happen." (Csikszentmihalyi, 1997)^{xxx} Though often discussed in the same context, flow can be distinguished from a peak experience in that flow describes a heightened joy stemming from the optimal experience in a given activity while peak experience is based on both emotional and cognitive states, but not necessarily related to performance.

Since the early 1970s, Csikszentmihalyi and his colleagues have interviewed thousands of individuals, and their research shows that irrespective of age, gender, culture, or the task at hand, people describe their optimal experiences in the same way. This includes athletes, artists, computer programmers, video gamers and musicians. Similar themes resonate across the various disciplines:

- a task that can be completed, has clear goals, and
- provides immediate feedback with the ability to deeply concentrate on the task effortlessly, while
- maintaining a sense of control over one's actions, with a
- decreased concern for self *during* the task but a stronger sense of self *after* the task is complete, all with
- an altered sense of time.

For his doctoral thesis in 1965, Csikszentmihalyi attempted to answer the question "How do visual artists create art?" by studying photos taken every three minutes as artists created a painting. As he describes, he was "struck by how deeply they were involved in work, forgetting everything else. That state seemed so intriguing that I started also looking for it in chess players, in rock climbers, in dancers and in musicians."

(Csikszentmihalyi 1997)^{xxx}

Csikszentmihalyi expected to find substantial differences in these activities, but across many interviews with individuals across many disciplines, people reported very similar accounts of how they felt. This then inspired him to study professions like surgery and computer programming, and he found that the great majority of flow experiences are reported when working, not when in leisure. (Csikszentmihalyi & LaFerve, 1989)^{xxx}

Athletes, Csikszentmihalyi describes, call flow experience being in the "zone" - an optimal psychological and physiological climate for peak performance. Brazilian soccer player Pele, for example, has described days when everything was going right, and feeling "a strange calmness I hadn't experienced in any of the other games. It was a type of euphoria; I felt I could run all day without tiring, that I could dribble through any of their teams or all of them, that I could almost pass through them physically. I felt I could not be hurt." Other examples include basketball players who reported that the basket seems bigger, and the legendary hitter Ted Williams who has said that sometimes he could see the seams on a pitched baseball. (Csikszentmihalyi, 2003)^{xxxiii}

Through his research on flow, Csikszentmihalyi determined that to understand the dynamics of mental health, it is essential to develop measures for the frequency and the patterning of mental processes in every-day-life situations. Out of this realization, he developed the Experience-Sampling Method (ESM), also now known as the "beeper method," which is a valid instrument to describe variations in self-reports of mental processes. (Csikszentmihalyi, 1994)^{xxxiv} The method has been used by Csikszentmihalyi and many others since to obtain empirical data on variables such as:

- I. frequency and patterning of daily activity, social interaction, and changes in location;
- II. frequency, intensity, and patterning of psychological states, i.e., emotional, cognitive, and cognitive dimensions of experience;
- III. frequency and patterning of thoughts, including quality and intensity of thought disturbance. (Csikszentmihalyi & Larson, 1987)^{xxxv}

In many studies to understand the dynamics of flow, Csikszentmihalyi used the ESM sending random signals to subjects' pagers, and when the beeper went off, asking them to document their answers to questions such as "How creative do you feel?" "What is your level of concentration?" "How do you feel?" "How is your production?"

Since the research began in the early 1970s, Csikszentmihalyi and his colleagues have accumulated well over 300,000 documented data points, each study producing similar patterns and validating his assumptions about the characteristics of flow. (Gardner & Csikszentmihalyi, 2003)^{xxxvi}

Flow and Media

Now that we have defined the state of flow, the next question we must address is can media be used to create a flow state? Though undeniably we have all been emotionally consumed and lost track of time watching a compelling film or television program, research has shown that watching television or film is not an activity conducive to flow, as people generally report higher levels of stress, depression, and tension after watching television, and as the medium itself occupies the mind without the demand for deep thinking. (Bryant & Miron, 2002)^{xxxvii} TV, claims Csikszentmihalyi, "is closer to apathy than flow. It is more like a warm bath of information flowing through you, but you are not in control." (Csikszentmihalyi, 2003).^{xxxviii}

Computers, describes Csikszentmihalyi, are inherently more flexible than TV, and can be used to achieve or enhance flow. (Csikszentmihalyi, 1996)^{xxxix} Ruth Rettie has conducted the most work with respect to internet use and flow, and has mapped traits of internet user experience to Csikszentmihalyi's dimensions of flow. (Rettie, 2001)^{xl} Steven Pace's research (Pace, 2003)^{xli} has validated the critical skill and challenge

balance can be achieved using the web, and Scott Berkun of Microsoft Corporation has conducted extensive usability testing among users of the world wide web, seeking to identify other characteristics that lead users to achieving flow. He has concluded that the single most critical factor is that designers must account for the five or ten most important tasks or actions that users of a particular website need to complete. If these actions are clear and simple, there is a higher likelihood that users are able to quickly find and match their interest and appropriate challenge.

John Sherry, through observing flow and media enjoyment, (Sherry, 2004)^{xliii} has found that an individual's decision to use a particular medium is dependent upon the enjoyment that an individual derives from the media. Further, his studies have found that those who enjoyed media also reported some of the same qualities of flow. But entertaining and engaging media, Sherry argues, does not necessarily trigger flow. The key factors, he finds, are consistent with Csikszentmihalyi's description of flow, in that the challenge of interpreting the media and skill level of the recipient ought to be evenly matched. His conclusion, thus, is that beyond TV and film, video games seem to be the medium most capable of helping users to achieve flow. Sherry cites several studies supporting video games as the medium most capable of triggering flow, including Grodal's study of pleasure and control, (Grodal, 2000)^{xliiii} as well as Collins and Kimura's study of gender and video games that finds that boys in particular are capable of finding flow while playing video games as they are hard-wired with advantages in spatial rotation, dis-embedding, spatial perception, and targeting, (Collins & Kimura, 1997)^{xliv} qualities that are inherently challenging in many games.

Researchers have begun to understand the utility of flow for creating an engaging, positive experience when designing video games. Through using Daniel Johnson and Janet Wiles' illustration of how components of flow manifest themselves in video games (Johnson & Wiles, 2003),^{xlv} we can begin to identify design attributes that help to create a flow experience:

- The use of incrementing levels in games (ie. challenge and skill matched)
- Player-selected levels or artificial intelligence to appropriately match the challenge with a player's skill level
- Detailed worlds that require deep concentration to navigate
- Clear goals as described in complex narratives (eg. *Ico*), or familiar schemas (eg. *Madden NFL*)
- Immediate feedback provided in the form of point-scoring or eliminating foes
- Control over actions taken, as exhibited by mastery of game controllers among the best gamers
- The notion that concern for self during flow is lost, sense of self after is high as exhibited by players' inhibitions in putting their avatar (digital representation of oneself) in dangerous situations for the euphoric feeling of success after
- A combination of pursuit of mastery, enjoyment, and deep concentration in games trigger an altered sense of the duration of time, as in flow
- Since the screen in games is often taken up by the action around the task at hand, the lack of distraction and focus could lead to flow

T.W. Malone, identified 3 components to intrinsic motivation that contribute to the exceptional appeal of computer-based gaming, qualities which are consistent with flow:

- Our innate tendencies to solve problems
- Humans as information processors that focus on pleasure and curiosity
- Perceived control and self determination (Malone,1981).^{xlvi}

It is noteworthy to point out that because the flow state is intrinsically rewarding, individuals seek to replicate flow experiences. This introduces a selective mechanism into psychological functioning that fosters growth (Nakamura and Csikszentmihalyi, 2002).^{xlvii} Similarly, if we think about interaction with video games, it is not uncommon for players to play a game continually in the pursuit of mastering a particular level, or in fact the entire game.

Narrative games such as *Myst* and *Zork* have also been studied for their ability to deeply engage users. Critics of interactive narratives such as these have historically described texts as being either immersive or engaging (Douglas, Hargadon, 2000)^{xlviii}. The pleasure of immersion stems from our propensity to be absorbed in a familiar narrative schema. The pleasure of engagement, on the other hand, lies in our ability to grapple with an array of schemas in search of meaning about a particular text. Most texts such as books or films, however, do not offer the interactive element that narrative games and texts do. It is that interactivity that provides some of the same attributes which lead to the flow state:

- split-second decision making to progress the story
- unpredictable twists in the narrative
- ability to read other characters' intentions

There are some documented studies of flow patterns within MUD communities. MUD is an acronym for "Multi-User Dungeon", which are text-driven games in which

players read descriptions of rooms, objects, events, other characters, and computer-controlled characters in a virtual world. The results in the most influential study by McKenna and Lee supported the view that flow within MUDs is positively related to the player's communicative patterns (McKenna & Lee, 1995).^{xlix} This probably accounts for why behavior within MUDs is sometimes described as addictive, where users lose track of their time when communicating with others in the community.

To avoid pitfalls when designing instruction for flow, as Johnson and Wiles further articulate, it may also be useful to identify attributes of some games that may detract from flow:

- Readability of menus is often sacrificed for aesthetics
- Animation and color are often used at the expense of functionality
- Lead in movies or animations often inhibit one's ability to enter a flow-like state
- Long loading time of certain games detract from one's ability to engage
- Lack of online help in context may break the flow state
- Forcing a user to reconfirm their options at the end of a game may break a state of flow

Further experiments that attempted to create a "flow" experience by repurposing the *Neverwinter Nights* gaming engine to build a rapid prototype for a foreign language environment proved to be failure, however, several more learnings can be gleaned from this exercise (Chen & Johnson, 2004)^l:

- Complicated game controls and a difficulty understanding the conventions of the game engine seemed to detract from the users' ability to enter a state of flow

- Extreme simplicity of the game allowed users to guess the outcomes and did not serve to achieve the appropriate balance of skill and challenge
- Repurposing of a game with embedded fantasy-genre schemas proved to distract players from entering the flow state

As we have seen, extensive research has validated the hypothesis that flow can be achieved through engaging with media. Likewise studies of interactive media, particularly video games, seem to yield the highest concentration of characteristics that lead to flow experiences.

An Example of Creating Flow with Media

Though studies have found high correlation between flow and media, it is important to determine whether media has a causal relationship with flow. Further, if we are to design media to create experiences conducive to flow, it is crucial to determine if such media has ever been created or tested. A paper titled “On the Design of a Musical Flow Machine (Pachet, 2004)^{li}” by Francois Pachet describes just that. Beginning in 2000, Pachet began designing an interactive musical system, called the *Continuator*, at the Sony Computer Science Lab in Paris, where he is tasked with helping Sony to develop products and features that increase engagement for its users. Though the *Continuator* was intended to help musicians practice, Pachet found that it did more than mimic a string of notes – it served to generate a flow experiences for his subjects. The musician plays musical sequences of any kind, either monophonic or polyphonic, in any playing style. When the phrase is terminated, the *Continuator* generates a music phrase in response. The returning phrase has the characteristics of being stylistically similar to the phrases played by the user initially. Technically, it is a complementary “continuation” of that last input phrase.

The architecture of the technology is capable of detecting, analyzing, and playing back a unique string of music. Through extensive testing and research, Pachet has found that the experience with the *Continuator* provokes a positive reaction, and that users develop attachment behaviors that he likens to the Japanese toy *Tamagotchi*.

Pachet highlights that the *Continuator* produces all of the essential factors to creating flow. In addition to providing clear goals and immediate feedback; it provokes a focused concentration; supports intrinsic motivation and encourages a sense of control and a loss of self consciousness; the *Continuator* by definition produces a response corresponding to the skill level of the user. This ability to “think like the user,” Pachet claims, is one of the key reasons why this machine has proven to create flow experience for its users. The brilliance of the *Continuator*, it seems, is seated in the system’s ability to reproduce the users’ personality, allowing the user to “grow” with the technology, as each interaction with the system contributes to changing its future behavior.

Pachet has conducted numerous studies of 3-5 year old children interacting with the *Continuator*, and found that indeed the machine served to generate many of the inherent characteristics of flow. Pachet notes that interaction with the machine seems to tap a child’s “natural, deep interest in exploring oneself,” as subjects’ center of attention were not focused on the end product but on the experience. Further, he observed that interaction served to increase attention span, generate an “A-ha” (or surprise) factor, as well as elicit autonomy, exploration, creativity, and playfulness from users. Pachet concluded that systems like the *Continuator* that are able to learn and react to the user could develop a desire to learn within that user (Pachet & Adressi, 2004).^{lii}

Flow and Learning

It is hypothesized that by applying this information with what we know about student engagement and flow, we should be able to design instructional media that create a state of flow for the learner, providing them with a more engaging, challenging, and rewarding learning experience.

In his experiments with 3-5 year old children, Pachet also observed that by helping the children to learn to play, the *Continuator* allows for a scaffolding of the complexity of the interaction, whereas most pedagogical tools do not. He speculates that this is why people are not motivated to use many learning tools. It is with this mindset that we evaluate the connections that have been made between flow and learning.

(Csikszentmihalyi, 1997)^{liii}

Csikszentmihalyi thinks it is important to explore applying that which we have learned about flow to learning environments. Particularly some of the characteristics like providing clear goals and immediate feedback, he explains, can easily be adapted by teachers in a classroom, but can also be leveraged when designing instruction.

(Csikszentmihalyi, 2005)^{liv} Of course, the most difficult challenge when instructing a group of many students is ensuring that each student can find a balance of equilibrium between the level of challenge and personal skill.

In a longitudinal study conducted by Shernoff and Csikszentmihalyi, 526 high school students in the U.S. were studied to determine under which conditions they were engaged in a “flow-like” learning experience (Shernoff, Csikszentmihalyi, 2003)^{lv}. It is not surprising that the study found that an abundance of lectures, note-taking, and passive video viewing were found to be some of the least engaging experiences. Group work and individual autonomous tasks were found to be far more engaging. In addition, they found

that engagement rose significantly when the challenge and skill were perceived to be high and in balance.

Kevin Rathunde draws many parallels between Maria Montessori's "child centered" or "developmentally appropriate" vision and Csikszentmihalyi's vision of flow and education. (Rathunde, 2001)^{lvi} As we know, a great deal of evidence suggests that adolescents are often laboring through their classes while being sporadically engaged, (Eccles et al, 1993)^{lvii} and Rathunde thinks that Montessori's emphasis on active student engagement could offer valuable insight on the problem. The basis for the connection between Montessori's vision and flow is drawn from Csikszentmihalyi and Rathunde's "The Development of a Person," where they explain the experiential nature of flow. (Csikszentmihalyi & Rathunde, 1998)^{lviii} The experiential nature is remarkably similar to Montessori's perspective on concentration and learning that explains that sustaining experiences of deep concentration and returning again and again to them is thought to set up an upward spiral of growth that instigates further concentration and learning. The other major link between the two theories is that social contexts (eg. schools) can and should be designed in ways that promote children's concentration, interest, and psychological complexity.

In "Controlling Emotional Conditions for Learning," Bencheitrit and Frasson explore methods by which to incite "positive emotion" during learning experiences for adults. (Bencheitrit & Frasson, 2004)^{lix} Through their research, they have found that the impetus to engage in a learning activity is directly linked to the emotional state of the learner, namely how the learner feels about himself and his motivation toward a subject. The researchers argue that e-learning environments need to consider these states, and

designers must create more positive conditions to improve learning.

There are many factors that contribute to students' interest and level of engagement in learning, many of which teachers have little control over (Lumsden, 1994). Intrinsic motivation is a key driver of engagement, as research has shown that intrinsically motivated students:

- earn higher grades and achievement test scores than extrinsically-motivated students (Skinner & Belmont, 1991)^{lx}, and
- are better adjusted to school from a social and emotional.

Intrinsically motivated students actively engage themselves in learning out of curiosity, interest, or enjoyment, or in order to achieve their own intellectual and personal goals. (Dev, 1997)^{lxi} This connection between intrinsic motivation and student engagement is consistent with its necessity for a student to enter a flow state.

It is clear that many of the tenants of flow are grounded in learning theory and student engagement research, providing a clear suggestion that creating flow states during learning experiences could lead to deeper learning.

Prototype: *Flow Builder*

Concept & Learning Elements

Flow Builder is an interactive, instructional video game intended to engage learners ages 12-15 and allow them to use a simple, graphical user interface to build original creations from the bottom up. Lending from constructivist theories of Piaget and the applied, self-directed learning Logo application conceived by Papart, *Flow Builder* allows learners to first choose the type of building blocks with which they are most comfortable—based on their strongest learning modalities—and begin creating. The

environment starts by having the learner combine the simplest forms, the “building blocks,” to create “units” (more complex structures made up of building blocks), and in turn use those second level structures to create even more complex structures, and so on. As Montessori suggested, the early stages of building within the environment is designed to quickly encourage feelings of mastery and efficacy. All building happens in collaboration with the software, which automatically generates a complementary match each time a student places an item on the canvas. Through this interactivity, the environment is designed to put the student in a state of flow, the euphoric state of concentration and involvement. The intention is to provide an experience that by definition matches a learner skill and interest level—not unlike Reigeluth’s elaboration theory of instruction—and allows them an environment to explore, become deeply creative, and build problem solving skills in whichever learning modality best suits them – spatial, linguistic, logical-mathematical, music, kinesthetic, intrapersonal and interpersonal. By design, the environment seeks to keep the learner in Vygotsky’s zone of proximal development thus improving the chance for cognitive development.

Though the design chooses qualities that are most engaging about video games, *Flow Builder* is different in that: there is no particular end to the game; it lacks game-ending penalties or notion of “losing”; and it does not rely on completely familiar schemas (eg. “first-person shooter”) like many games do. Though the game shares similarities with Pachet’s *Continuator*, with respect to inherently creating interactivity that matches skill and challenge, it goes beyond the music practice-tool by offering a platform to engage the learner regardless of that learners’ preferred learning modality. Further, *Flow Builder* fosters original creation through learning modalities that are best

suited to (or at a minimum chosen by) the individual, and builds skills in areas of strategy, planning, decision making, systems thinking, analytical thinking holistic thinking and understanding of interdependencies.

Flow Builder's instructional design is patterned after Gagné's conditions of learning theory, and addresses each of the nine conditions:

Condition	Instructional Element in <i>Flow Builder</i>
1. Gain attention (reception)	After a clean screen with a short message about how they will build, the start screen is one with 7 clickable, attractive icons, and no textual explanation, enticing the learner
2. Inform learners of the objective (expectancy)	After a learner chooses one of the 7 icons, a series of short, step-by-step textual and visual instructions to explain the object of the game. Enough information to get started, but not so much that the learner is overwhelmed
3. Stimulate recall of prior learning (retrieval)	Building blocks are meant to look like Legos or other physical blocks with which the learners are familiar
4. Present the stimulus (selective perception)	Instruction diagrams highlight the elements of building essential to get the process moving; namely, how to select an element, drag it to the canvas, and place it where they wish

Condition	Instructional Element in <i>Flow Builder</i>
5. Provide learning guidance (semantic encoding)	Once the learner takes a turn building a piece, the program takes a turn, and develops the creation further
6. Elicit performance (responding)	There is no waiting on the part of the learner. Though they can build at their own speed, their actions are immediately met with a response by the program.
7. Provide feedback (reinforcement)	Immediate feedback built in as the program responds to every action with a reaction, progressing the project forward
8. Assess performance (retrieval)	Once the learner “submits” a unit, they see a screen that shows their overall progress, and receives a positive message about their progress.
9. Enhance retention and transfer (generalization)	Each stage of the building is designed to build on what the learner has learned about building in the previous section. Though the “building blocks” change each stage and the variables increase, the mechanics of building are always the same

The prototype of the game (<http://www.itchyman.com/flowbuilder>) illustrates the types of screens that a learner would see at each level of the game. It is recommended that the game be constructed using Game Maker by Mark Overmars (<http://gamemaker.nl>). This game development software was evaluated and chosen based on its accessibility to novices, strong development community for trouble-shooting, flexibility in game type and design, extensibility, portability, and low cost.

Though, the design for the instruction borrows from a wide variety of research and theoretical influence, its principles are primarily built on Csikzentmihalyi's flow research, Gardner's multiple intelligences research, and instructional design approaches of Gagné, Reigeluth, Dick and Carey. It is meant to incorporate the design attributes identified in the following section.

Design Elements for Flow

Across much of the research about flow since the early 1970s, there are many consistencies and patterns that emerge time and time again. From these, as well as some of the specific drivers found in research of flow in media, human computer interaction, and learning, we can identify a discrete set of attributes that are the building blocks we will use to construct our instructional video game. Below is the list of attributes, referencing the researcher and area to which the attribute relates:

Design Attributes that Help Lead to Flow	Relating to	Researcher
Presents clear goals	general	Csikzentmihalyi
Provides immediate feedback	general	Csikzentmihalyi
Presents an equilibrium between the level of challenge and personal skill	general	Csikzentmihalyi
Promotes a merging of action and awareness	general	Csikzentmihalyi

Promotes focused concentration	general	Csikzentmihalyi
Evokes a sense of potential control	general	Csikzentmihalyi
Design Attributes that Help Lead to Flow	Relating to	Researcher
Facilitates a loss of self-consciousness	general	Csikzentmihalyi
Causes a time distortion	general	Csikzentmihalyi
Generates autotelic, or intrinsically rewarding (self-rewarding) experience	general	Csikzentmihalyi
Since people rarely get this feeling of flow when they are completely isolated, design for a social setting	general	Csikzentmihalyi
The use of incrementing levels in games (challenge and skill matched)	video games	Johnson
Player-selected levels or artificial intelligence to appropriately match the challenge with a player's skill level	video games	Johnson
Detailed worlds that require deep concentration to navigate	video games	Johnson
Clear goals as described in complex narratives (eg. <i>Ico</i>), or familiar schemas (eg. <i>Madden NFL</i>)	video games	Johnson
Immediate feedback provided in the form of point scoring or eliminating foes	video games	Johnson
Control over actions taken, as exhibited by mastery of game controllers among the best gamers	video games	Johnson
The notion that concern for self during flow is lost, sense of self after is high is exhibited by players' inhibitions in putting their avatar in dangerous situations for the euphoric feeling of success after.	video games	Johnson
A combination of pursuit of mastery, enjoyment, and deep concentration in games trigger an altered sense of duration of time, as in flow.	video games	Johnson
Since the screen in games is often taken up by the action around the task at hand, the lack of distraction and focus could lead to flow.	video games	Johnson
split-second decision making to progress the story	interactive text	Douglass
unpredictable twists in the narrative	interactive text	Douglass
Ability to read other characters' intentions	interactive text	Douglass

Design Attributes that Help Lead to Flow	Relating to	Researcher
balance of immersion and engagement (familiar schemas, but unfamiliar outcome - requires ability to call upon a number of different schemas to solve)...trajectory of the narrative is unpredictable	interactive text	Douglass
"culturally agnostic" - adjusts for cultural differences	general	Moneta
Tap intrinsic motivation + ability to block out other things (young kids have it)	education	Montessori
to engage spontaneous concentration, freedom of choice is a necessary precondition	education	Montessori
What are the five or ten most important tasks or actions to complete? Are these five or ten actions the clearest and simplest for users to access?	general	Burkin
A-ha / surprise factor, autonomy, exploration, creativity, playfulness	music	Pachet
Develops attachment behaviors (like <i>Tamagotchi</i>)	music	Pachet
By definition, a response corresponding to the skill level of the user – thinks like the user	music	Pachet
(Like the <i>Continuator</i>) Allows for a scaffolding of the complexity of the interaction – most pedagogical tools do not (which is why people are not motivated to use them to learn)	music	Pachet
Reflection in interactive systems – system’s ability to reproduce the users’ personality & each interaction with the system contributes to changing its future behavior	music	Pachet
Taps children’s “natural, deep interest in exploring oneself”	music	Pachet
Easily adjusted to skill level, gradually more difficult as play continues	video games	Sherry
The impetus to engage and persist in a learning activity is directly linked to the emotional state of the learner	education	Benchetrit & Frasson
Clearly defined task	web	Rettie

Software responds quickly to inputs	web	Rettie
Interface, selection of content is congruous to experience with medium	web	Rettie
Design Attributes that Help Lead to Flow	Relating to	Researcher
User becomes unaware of the tools of engagement (keyboard, mouse, controller)	web	Rettie
User feels in control of navigation	web	Rettie
Medium is arresting, and causes user to forget about those physically around them in real life	web	Rettie
Visualization leads to actualization	education	Benchetrit & Frasson
Content promotes positive emotional state	education	Benchetrit & Frasson
The Contact to the Instrument - optimal tactile feeling conveys a velvety, "gluey" quality...the optimal connection between the hand and the interface/instrument is experienced as "thick", "dense", firm and relaxed.	music	Burzik
Promotes the development of the sense of sound – a pleasurable feeling of being lost in one’s own sound world	music	Burzik
Promotes a feeling of effortlessness - a sensation of ‘not-doing’, of ‘not-working’	music	Burzik
Playful interaction with the medium, playing around in an improvising kind of way, evoking inner emotional participation, approaching a pleasurable body feeling	music	Burzik
Medium facilitates an easing of or relief of muscle tension during use	sport	Janson
A good controller that closes the eye/game/hand feedback loop to provide pleasure	video games	Pausch
A focus on, and lack of distraction from the major task	human computer interaction	Johnson
Medium minimizes, and to its best ability, eliminates chance for user to terminate. In other words, "errors" and "mistakes" are possible, and does not disrupt or end the experience	human computer interaction	Johnson
Reduction of many options / choices on-screen at any given time	human computer interaction	Johnson
Elimination of the mapping of several commands to a given input	human computer	Johnson

	interaction	
Help/menus are intuitive, readable, accessible/searchable, and aesthetics are downplayed	human computer interaction	Johnson
Design Attributes that Help Lead to Flow	Relating to	Researcher
Instruction does not use animation, vibrant/in-theme colors - functionality is king	human computer interaction	Johnson
Learner is part of the content rather than a context	Video games	Schott
Game takes into account a player's emissions rather than only considering immersion	Video games	Schott
Joy of discovery	Web	Csikzentmihalyi
Relevance of instruction	Education	Shernoff
Perceived control over learning experience (student controlled vs. teacher controlled)	Education	Shernoff
Authentic academic work, meaningful inquiry, real life problems	Education	Shernoff
Instructional format	Education	Shernoff
Small groups transfer control to the student	Education	Shernoff
Great teachers who are compassionate, engaging, good motivators, value intrinsic rewards, social support and ownership - drive engagement	education	Shernoff
Provide tasks that offer choice	education	Shernoff
Non-academic subjects drive engagement & positive connotation (art, even computer programming – rather than math and science)	education	Shernoff

Just as we can identify the types of attributes of media that would contribute to achieving flow, we can identify elements that media should not have – elements that detract from achieving flow:

Design Flaws to Avoid that Detract from Flow	Relates to	Researcher
Readability of menus is sacrificed for aesthetics	video games	Johnson
Animation and color used at the expense of functionality	video games	Johnson

Lead-in movie or animation on a game is too long, or so inescapable that it distracts	video games	Johnson
Long loading time for game distracts from ability to engage	video games	Johnson
Lack of online help in context	video games	Johnson
Design Flaws to Avoid that Detract from Flow	Relates to	Researcher
Forcing a user to reconfirm their options at the end of a game	video games	Johnson
Complicated game controls and a lack of an understanding of the conventions of the game engine	video games	Johnson
Game is too simple in that it allows users to guess the outcomes	video games	Johnson
Repurpose of a game engine (eg. one with embedded fantasy-genre schemas when those are not appropriate)	video games	
Educational media designed without understanding the flow experience stands to prevent engagement with the material	education	Sherry
Slow download	web	Rettie
Poor usability	web	Rettie
Confusing user interface	web	Rettie
Failure in navigation	web	Rettie
Unsuccessful searches	web	Rettie
Advertising banners (superfluous distraction)	web	Rettie
Boring, static content	web	Rettie
Medium causes fear and over-ambition in the user	music	Burzik
Medium causes impatience in the user	music	Burzik
Too passive, completely familiar schemas, does not call on user to interact	TV	Csikzentmihalyi
Environmental issues often are the problem (eg. user is hungry)	general	Sherry

Description of the Game

Learners are first presented with a clean screen that gives them a basic instruction about how they are going to build something in collaboration with the game. On the next screen, the starting screen they are presented with seven icons. The learner's only decision is to gravitate toward the one that is most appealing to them, and click on the

icon. The seven paths represent the seven sub-environments in which the learner can build, each based on one of Gardner's identified intelligences.

The reason why *Flow Builder* is designed to begin by a learner selecting one of these is twofold:

1. This self-directed approach at the entry point allows a learner to begin the instruction with their own curiosity and choice, and are meant to immediately feel in control--one of the core tenants of flow
2. The multiple intelligence doorway increases the likelihood that the game that the learner chooses is more equally matched with one of their strongest skill sets, thus engaging them early in the game and quickly beginning to find the balance between challenge and skill that is so critical to flow

It is important to note that there are "save and exit" buttons in the top right hand corner of each screen for a learner to exit the game whenever they want to, or choose an alternative path if they do not feel comfortable, or if they become bored or distracted; this feature ensures that the learner always maintains an environment conducive to finding flow. The game will remember the progress a particular learner has made on a particular path so one can always return to where they left off.

The instructional design of the tasks and the goal is simple and consistent across each of the different paths. Each path, however, has a unique theme, method of unit construction, and specific variables that appropriately increase the challenge for a learner who has chosen that specific intelligence. In each case, the learner will create a new unit and the game engine will create a complementary unit. Note that similar to the mechanics of the *Continuator*, the game engine does not produce the same unit, but produces a

complementary unit that progresses the overall construction, and at the same time provides scaffolding and instruction to help the learner. The learner and machine build something together. By definition, this will ensure that the challenge for the learner will be equally matched with the skill level of the learner, thus providing a crucial element to generating flow. Once the learner is content with the unit, they will submit the creation, completing the level, provided that the unit built is sound enough to act as a building block for the subsequent level. The learner will get a confirming screen that shows them their overall progress, provide a reinforcing message, and lead them to the next level. That unit will be carried into the next level, and the learner will start to construct a larger unit, dealing with more variables, and thus will have more complicated and interdependent choices to make.

Each subsequent unit consists of many of the units constructed in the previous level. This process continues at each level, each time consistently increasing in complexity at a complementary rate for each individual learner.

Though there is a discreet number of levels (described below) for each path, there is no explicit ending to the game. As explained, there is a minimum amount of construction that needs to be done for each unit to allow a learner to pass to the next level. There is not, however, a maximum amount of construction that can happen at each level. Therefore, it is conceivable that a particular learner could continue to build infinitely within each level. Certainly, for those experienced with the game, there is no end to how much creativity and construction can happen at the final level.

For purposes of this project, we have selected one path—spatial intelligence—to explain in detail and to prototype. The summary for each path, however, is described at a high level below:

1. *Novel Builder* (Linguistic Intelligence Path)

Learners who choose the linguistic intelligence path are tasked with building a novel.

The first step is to develop a letter, then an alphabet, then create a word, build a phrase, build a sentence, then a paragraph, then an essay, and eventually a novel.

2. *Problem Builder* (Logical-Mathematical Intelligence Path)

Learners who choose the logical-mathematical intelligence path are tasked with solving a complex problem. The first step is to develop an integer, then a set of integers, then build an expression, then develop a problem, then solve that problem.

3. *Symphony Builder* (Musical Intelligence Path)

Learners who choose the musical intelligence path are tasked with creating a symphony. The first step is to develop a note, then build a string, then create a measure, add multiple instruments, build a movement, and finally build a symphony.

4. *Body Builder* (Bodily-Kinesthetic Intelligence Path)

Learners who choose the kinesthetic intelligence path are tasked with building a house.

The learner chooses to control various tools with their mouse, their keyboard, as well the “Dance-Dance Revolution ‘Dance Pad’”, an interface that allows learners to step with their feet onto different parts of the pad, controlling the game on their screen.

They first are to dig and pour the foundation, then frame the house, then build floors, walls, electricity, water, install fixtures, and finally landscape the outside.

5. *Reflection Builder* (Intrapersonal Intelligence Path)

Learners who choose the intrapersonal intelligence path are tasked with creating a visual map of their existence in the world. The first step is to develop a list of qualities that are inherent to them, then draw relationships between those qualities, cite examples, build scenarios, identify expected outcomes, and in doing so are constructing a map of their personal existence in the world.

6. Society Builder (Interpersonal Intelligence Path)

Learners who choose the interpersonal intelligence path are tasked with collaborating in an online community, in a networked game environment, to solve real-world problems. Learners meet then choose one collaborator, are presented with issues, need to discuss and build a solution plan, and test that plan to see if it works. Learners then need to collaborate on increasingly difficult problems with an increasing number of players— 2 others, 5 others, 10 others, 100 others, and 1000 other players.

7. Universe Builder (Spatial Intelligence Path)

Learners who choose the spatial intelligence path will engage in the following experience:

Learners are tasked with building the entire universe. The learner begins by using an interface not unlike Adobe Photoshop to build a simple unit using building blocks. The learner drags and drops each building block from the palette to the canvas, and places it where he or she wishes. To combine building blocks, the learner chooses a fastener from the palette, and attaches it to a block. A complementary fastener is chosen by the game engine, and attached to the other block. Next, the learner will combine the two building blocks to form a larger structure. The learner can always erase the move that the game engine chooses, if it is not consistent with the learner's vision.

In the first level, there are only two variables: fasteners and quantity of blocks. As in all of the levels, there are rule sets associated with each of the variables, and learners must figure out the rules that govern the variables through personal inquiry, interaction with the game engine, reading of help files and diagrams, trial and error, and any other problem solving technique they wish. The minimum task a learner needs to complete is utilizing the minimum amount of blocks (4), and having them connected by matching fasteners. Once this is completed, the shape that they learner has created becomes the unit. If the learner is satisfied, they submit this unit for use in the next level. There is no limit to the size and configuration of unit that the learner can create.

In the second level, the goal of the learner is to construct a wall using many of the units that they created in the previous level. The building procedure will be the same: as the learner lays a block unit, the game engine will lay a complementary block. There are three variables for this level, and associated rule sets that govern the learner's interaction: fasteners; quantity of block units; and weight of blocks. The weight of blocks is indicated by the color; the darker colored blocks are heavier in weight while the lighter color blocks are lighter in weight. In collaboration with the game engine, learners cannot construct a wall that is too top-heavy, or it will fall down. The possible size of the wall is infinite. When the learner feels the wall is complete, it is then submitted, and the learner moves on to level three.

In level three, the learner and game engine must construct a house using the walls and blocks that they had designed in previous levels. The variables and challenges increase rapidly in this level to include: fasteners; quantity of wall units (minimum 4); and weight of walls. In addition, several other building materials are introduced: roofs;

foundations; and windows; learners must account for many other factors that mimic issues in the real world, such as structural integrity, aesthetics, and scale. Learners can reference diagrams of other houses to understand how best to build. If houses are constructed in such a way that would not be sound in the real world, for example, learners must deal with issues such as collapsing walls and roofs. In order to submit a house as a unit for use in the next level, the construction must be able to meet the minimum requirements of being a sound construction. Again, there is no limit to the type and size of house that the learner can create.

After the house is done, the learner must arrange houses on a plane in level four. They can arrange them in any way that they see fit, the goal being to form a community. Similar to the previous levels, the learner places a house, and the game engine follows with one. Additional building blocks include: roads; trees; and parks. The challenges increase again, as learner must deal with: spacing of houses; zoning within areas of the community; and placement of developments in the context of natural formations like lakes, rock beds, and mountains. Learners receive feedback when houses are too close together, and penalties or temporary destruction can occur when houses are incorrectly zoned or placed in places that compromise the natural integrity of the community. When a learner is content with his creation, he submits the community as a unit.

In level five, the learner must construct a planet. The planet is made up of many communities. In addition to the communities that the learner has submitted from the previous level, there are various other communities with different characteristics that must be used as building units for the planet. The variables that the learner must deal with at the planet level are mainly environmental: weather; plant life; animal life; and

population of human life. Placing certain communities in regions with certain weather patterns can be beneficial or harmful. For example, the learner's population allocation could be appropriate, but overpopulation will destroy a portion of the planet that the learner is constructing. Appropriate balance between plant life and wild life is crucial for ensuring the planet has longevity. Like previous levels, feedback is provided to the learner if their planet is not well-balanced. Their limits are boundless, but there is a minimum balance that needs to be stuck in order to submit the planet as a unit.

Once a planet is built, the learner moves on to the final construction, a universe in level six. The universe is made up of many distinct planets, some like the one that was created in the previous level, others with far different properties. Universes contain planets, stars, and black holes. At the universe level, learners must problem solve during their building using principles of physics. They are challenged with building a functioning universe, handling issues of star and planet alignment, relative motion, and forces like atmospheric pressure effects, magnetism, and spin dynamics—and the interplay among them. Juxtaposing planets that have opposing electro-magnetic forces, or placing rotating planets in line with static stars are examples of decisions that bring the universe out of alignment. Success at this final level is to understand the interdependencies and build a well-balanced universe in collaboration with the engine.

The inherent matching of skill and challenge that exists within Universe Builder (and in all paths of Flow Builder) is driven by not only the game engine's ability to interpret and respond to the learner while they build together, but in the learner's flexibility to submit their creation as a unit at any point that it is "in balance," or to save their work if they wish to take a break and return to the place where they left off. Since

there is no end to what a particular learner could create, the game is infinitely complex as the skill and experience of the learner increases.

Further Research

As stated in the beginning of this paper, it would seem like progress to design learning experiences that offer a flow experience, as many of flow's qualities appear to overcome considerable hurdles for learning. This project has attempted to synthesize findings from many studies of the phenomenon of flow across various disciplines, extract the attributes that contribute to an individual achieving state of flow in a media experience, then to apply that information to design a prototype of instructional media called the *Flow Builder*. *Flow Builder* attempts to create a state of flow for learners, providing them with a more engaging, challenging, and rewarding learning experience. Extensive research is needed to determine whether learners of *Flow Builder* have a higher likelihood of reaching flow compared to those who do not. If through this research, it is determined that the *Flow Builder* does not increase the likelihood of subjects reaching the flow state, this project will still be useful as a reference for attributes which elicit flow across multiple disciplines. At a minimum, we have formulated a list of design principles for instructional media from a discrete set of attributes, proven to be present during flow experiences across many disciplines, over many years of research. Given what we have learned about the effectiveness of the flow state, it is our hope that these principles will be used as a basis to create more effective, engaging instruction.

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