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Exploring Factors of Media Characteristic Influencing Flow in Learning Through Virtual Worlds

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Abstract

This study aims to find out factors of media characteristic which are considered to influence flow in learning through virtual worlds. One hundred ninety eight elementary students who are eleven to twelve years old participated in this study. After the exploratory factor analysis, to extract media characteristics of virtual worlds, seventy-eight elementary students who are eleven years old were used in the analysis of exploring relationships between factors influencing flow.

The results of this study show that distinct media characteristics of virtual worlds affecting engagement were labeled 'interactivity', 'representational fidelity', 'immediacy of communication', 'consistency', and 'persistence' after the exploratory factor analysis. Another result of this study is that the media characteristics are positively correlated: when students effectively recognize media characteristics, the level of flow is also high. In addition, virtual worlds' characteristics have a significantly consistent predictability on learners' flow, which is consistent with previous research that demonstrated media characteristics were a critical factor for influencing engagement. Lastly, factors of media characteristics such as 'immediacy of communication,' 'consistency' and 'persistence' are related to flow, but don't have an influence on causality, so it is difficult to assert that these factors predict learner's engagement. However, other factors such as 'interactivity' and 'representational fidelity' are significant factors that predict flow in learning through virtual worlds.

Key words: virtual worlds, media characteristics, learning through virtual worlds, virtual learning

1. Introduction

The development and advent of emerging technologies has greatly impacted education by motivating new learners. It has also contributed to the creation of a new instructional paradigm. Recently, three-dimensional virtual worlds, where unlimited numbers of people can interact simultaneously within network-based simulated environments, have been emerging and have become popularity. More and more educators are debating its implications for teaching and learning. According to a recent survey, the number of users of virtual worlds has exceeded more than 1.8 billion people (Kzero corp, 2011). Gartner, Inc., a leading information technology research and advisory company, have stated that virtual worlds might be adopted mainstream for education within five to ten years (Gartner, 2009).

Some researchers predict that this new media, virtual worlds, will bring major changes to the current instructional paradigm just as the Internet did in the past (Zemsky & Massy, 2004; Clarke & Dede, 2005; Aldrich, 2009). These same researchers are examining the educabilities of the emerging virtual worlds. As reflected in recent achievements, diverse research organizations such as the National Science Foundation (NSF), The New Media Consortium (NMC) and EDUCAUS have conducted several research projects associated with using virtual worlds for educational purpose. Other associations such as the AERA[1], AECT[2] and ISTE[3] have organized a special group interested specifically in virtual worlds and they are conducting and sharing research on current issues in virtual worlds.

[1] American Educational Research Association(www.aera.net)
[2] Association for Educational Communications and Technology(www.aect.org)
[3] International Society for Technology in Education(www.iste.org)

In spite of the prospects and consideration of the educability being given to virtual worlds, there is still a lack of empirical research about how learners progress within these environments (Olive & Carr, 2009; Jarmon et al., 2009). Most researchers discuss the possibility and effectiveness of using this medium as an educational tool. However, little research focuses on how people learn within this environment and specifically how certain features relate to effective learning. Many researchers are interested in the levels of engagement with which virtual worlds provide students. However, some focus their research interests on learner variables such as attitudes, skills and stimulus level (Shen and Edner, 2009), while others are interested in teaching variables such as instructional designs and methods (Omale et al., 2009; Barab et al., 2009; Wang & Hsu, 2009; Clarke & Dede, 2005). Even though virtual worlds are media with characteristics distinct from other media, these characteristics have not drawn much attention from researchers. Thus, this research seeks to determine virtual worlds' suitability as a learning environment through empirical inquiries as to how specific characteristics of virtual worlds affect student engagement. Prior to this determination, media characteristics should be identified and listed in terms of their influences on teaching and learning. Overall, this study aims to explore the media characteristics of virtual worlds influencing on engagement of residents and to determine the relationship between media characteristics and residents' engagement in learning through virtual worlds.

Research questions are as below:

> Question 1. What are the media characteristics affecting residents' engagement in learning through virtual worlds?
>
> Question 2. How are the media characteristics related to engagement in learning through virtual worlds?
>
> Question 3. What are the comparative effects of media characteristics on residents' engagement in learning through virtual worlds?

2. Possibilities and Characteristics of virtual worlds in education

Being resident in a virtual environment has already become a daily routine for today's youth (Prensky, 2001; Oblinger, 2005; Tapscott, 2009). Oblinger (2005) indicated them as 'Millenials' who have grown up with technology. Prensky (2001), also, identified them as 'Digital natives' who were born and live with digital technology. They spend much of their free time in virtual spaces including computer games, where they not only enjoy emotional satisfaction through friendships and relationships via social networking services such as Twitter, Facebook and Myspace, but also share their knowledge and communicate with one another. According to the New Media Consortium and EDUCAUSE Learning Initiative (2007), virtual lives are taking a more and more important place in the lives of both youths and adults.

Three-dimensional virtual worlds are one of the new and powerful offerings in emerging technology, which reflect users' various interests. Educators and educational researchers are paying special attention to virtual worlds as a new learning environment for new generation (Clarke & Dede, 2005; Coffman & Kinger, 2007; Annetta et al., 2008; Salmon, 2009). Annetta et al (2008) indicated that virtual worlds are becoming viable solution to meet the visual and cognitive needs of the new generation because they become more engrossed in gaming. According to Zemsky and Massy (2004), today's young generation wants to be connected, to have fun through gaming, sound and movies, and to actively express themselves in the learning process. Thus they might want to participate in a new medium such as virtual worlds rather than traditional e-learning environments.

Dede (2005) indicated three complementary interfaces of the medium as traits which exert influence on learning: "world-to-the-desktop" interface, "multi-user virtual environment" interface and the "ubiquitous computing" interface. These traits represent a variable network, virtuality and ubiquity. In sum, a powerful new medium for learning is characterized by various networks, communicating agents such as avatars and virtual reality. Dede (2005) asserted that virtual worlds have become a critical source for new millennials' learning. According to him, virtual worlds induce a strong sense of presence and the use of these technologies might be causing a shift from millennial learning styles to "neomillennial" learning styles (Clarke & Dede, 2005).

Jonassen et al. (2008) point out that meaningful learning occurs when the media constructs knowledge, helping students to better represent their ideas and to engage in collaboration. He emphasized that the use of media should support these activities as a rich learning environment. Meaningful learning occurs when the media enhances students' active, constructive, cooperative, authentic and intentional behavior. For this purpose, media should be harnessed to foster these activities. He mentions that virtual worlds, including the features of educational simulations and games, have the greatest potential to involve learners in meaningful learning.

As reviewed above, virtual worlds are educationally significant as a meaningful environment where authentic, constructive and cooperative teaching/learning strategies can be implemented according to learners' characteristics, such as their learning styles.

3. Educational implications of virtual worlds

3.1. The definition and media characteristics of virtual worlds.

There are various definitions of virtual worlds. Aldrich (2009) explained this media as HIVEs (Highly Interactive Virtual Environments); including concept of games and simulations. The term MUVEs (Multi-User Virtual Environments) is used, because multiple users can interact with others synchronously. Bell (2008) indicated that the term of virtual worlds has been used in different ways to each field of study. Thus a common definition of this medium would help avoid misunderstandings. In this regard, he defined virtual worlds as "a synchronous, persistent network of people, represented as avatars, facilitated by networked computers".

The definitions of virtual worlds are used various terms, however, there are common features among these definitions. Virtual worlds induce synchronous interaction among users within computer-based three dimensional virtual space. Conversely, virtual worlds have distinctive features compared to other media, and various types of virtual worlds exist with their own purposes. Several researchers have been defining several features of virtual worlds to distinguish one from another. These distinct characteristics suggested by many researchers are summarized as in Table 1.

Table 1. Virtual worlds' characteristics suggested by researchers

Researchers	Distinct media characteristics
Whitelock, Brna & Holland(1996)	Representational fidelity, Immediacy of control, Presence
Brna, P(1999)	Representational fidelity, Immediacy of control, Presence, Social fidelity (including social familiarity and social reality), Immediacy of discourse, Social presence
Book(2004)	Shared Space, GUI (Graphic User Interface), Immediacy, Interactivity, Persistence, Socialization/Community
Dickey(2005)	Illusion of 3-D space, Avatars, Interactive chat environment
Lehdonvirta(2006)	Numerous users, Real-time interaction, Geometric space, Avatars, Persistency

Particularly, Dalgarno and Lee (2010) list the characteristics of three dimensional learning environments that distinguish themselves from other interactive learning resources based on their literature review, as depicted in Table 2. This list groups various characteristics of virtual worlds into representational fidelity and learner interaction.

Table 2. Distinguishing characteristics of 3-D virtual learning environments

Category	Characteristics
Representational fidelity	• Realistic display of environment • Smooth display of view changes and object motion • Consistency of object behavior • User representation • Spatial audio • Kinesthetic and tactile force feedback
Learner interaction	• Embodied actions including view control, navigation and object manipulation • Embodied verbal and non-verbal communication • Control of environment attributes and behavior • Construction of objects and scripting of object behavior

As seen above, many scholars identify distinguishing characteristics of virtual worlds, which according to their own means of expression. However, several factors, such as three dimensional graphic user interface, shared space, avatar, persistence, immediacy of control, and social presence are common among all five sets of characteristics.

3.2. Virtual worlds as a learning environment

Certain universities and organizations have their presence in a virtual environment and there are some developments of virtual spaces as learning environments, for example Quest Atlantis (http://atlantis.crlt.indiana.edu/), Rivercity (http://muve.gse.harvard.edu/ rivercityproject/) and Whyville (http://www.whyville.net), among others. In addition, many studies have been conducted to identify the suitability of virtual worlds as a learning environment for developing philosophical, epistemological, ecological and psychological perspectives, far beyond using virtual worlds for teaching and learning (Dalgarno, 2002; Dickey, 2003; Cross et.al., 2005; de Jong et.al., 2005; Hayes, 2006; Peter, 2009). These studies have taken innate characteristics of virtual worlds as starting points.

Peter (2009) attempts to understand the meaning and implications of this environment as a proper space for learning. According to him, one key concept explaining the various features of virtual worlds is the use of the "avatar". Learning in virtual environments is performed by an "avatar", which is the

representative of learner. Thus, the avatar experiences learning in virtual worlds. A space where avatar plays and resides is the place where learning happens. His Deweyan view is that learning happens through individual and social interaction, based on realistic experiences. In this context, virtual worlds are deemed as meaningful spaces for learning from a philosophical perspective. In addition, virtual worlds are also a significant learning environment from a constructivist standpoint that focuses on learning environments where students' knowledge construction is fostered. There have been many studies exploring this media as an educational environment based on pedagogical points of view. In particular, several features of virtual worlds, such as three dimensional geographical space, synchronously interactive chat environment, and control of avatar, facilitate constructivist learning to support exploration and collaboration of learners in the virtual world (Dickey, 2003; Dalgarno, 2002).

Additionally, Dalgarno and Lee (2010) clarified unique media characteristics of virtual worlds and examined the meaning of learning environments from an ecological psychology perspective. They indicate that media characteristics of virtual worlds are composed of perceived information of learning that is occurring. Such features are applied to students as an affordance, an instinctive implication for the occurrence of learning. Figure 1 depicts learning affordances of virtual environments.

According to Figure 1, media characteristics such as representational fidelity and learner interaction stimulate the construction of identity, a sense of presence and co-presence. In turn, these stimulated traits result in learning benefits of spatial knowledge representation, experiential learning, engagement, contextual learning and collaborative learning through afforded learning tasks.

As implied above, virtual worlds need to be approached not only as a tool for learning, but also as an effective space originating from innate and distinctive features. Educational epistemology changes along with emerging technology. These changes, in turn, have caused a variety of learning theories and methods to arise. Thus, with the emergence of new technologies, it is necessary to assess whether these technologies are proper environments for learning. From this perspective, virtual worlds are considered as proper environments which reflect changes in leaners, technologies and learning paradigms (Dickey, 2003; Falloon, 2010; Hayes, 2006; Kluge & Riley, 2008).

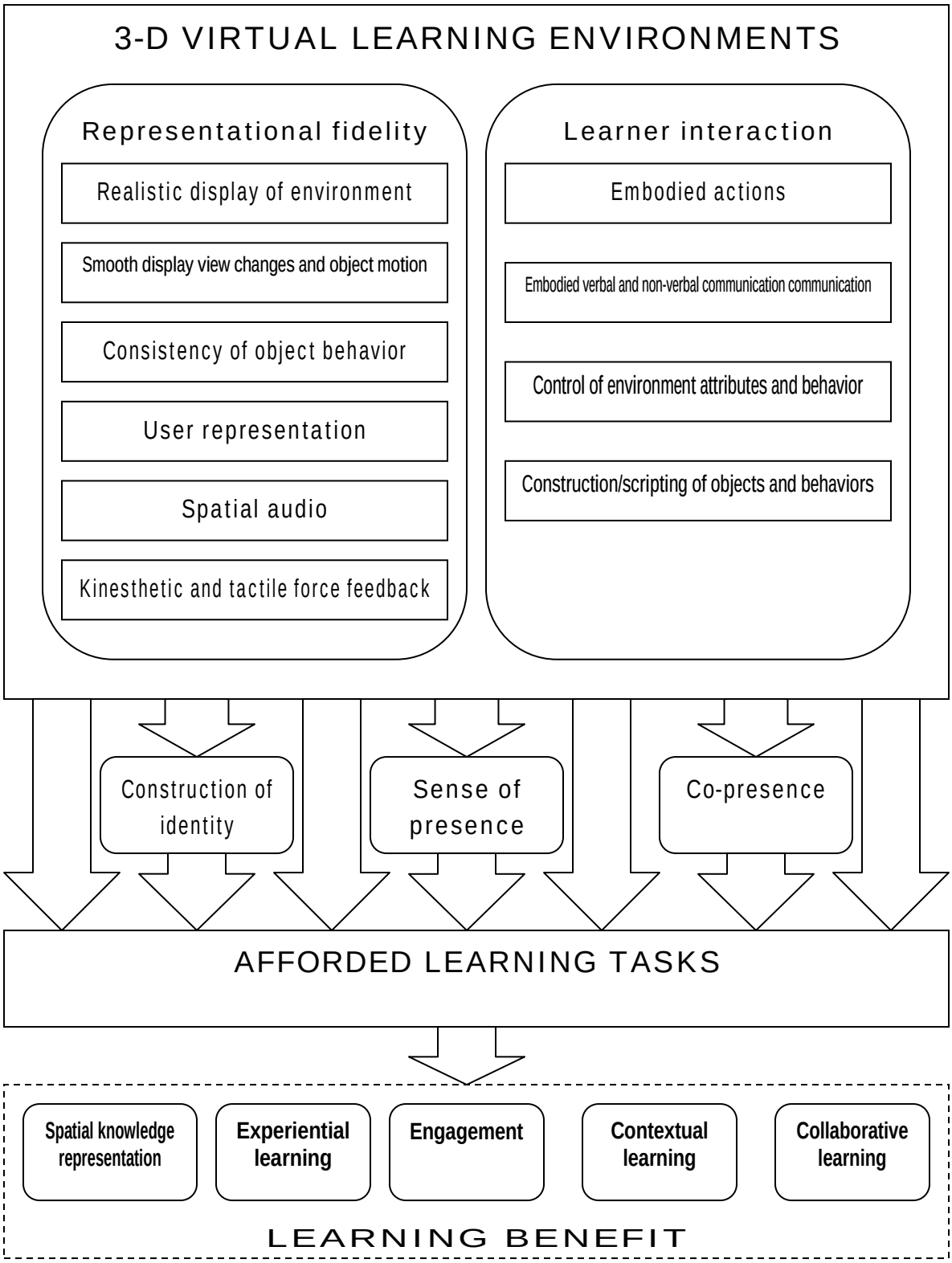

Fig. 1. Initial model of learning in 3-D VLEs (Dalgarno et al., 2010)

4. Media and flow

The theory of flow has been conducted through studies in diverse fields since Csikszentmihalyi published this concept in his 1975 article. Since then, the computer, a new technology has emerged and many researchers have tried to apply flow theory to this new technology. Webster and Trevino (1992) who define this as an interaction with media describe how, "flow characterizes the perceived interaction with CMC technologies as more or less playful and exploratory" (p. 540). Novack and Hoffman (1997) who apply the concept of flow to web users assert that "the state occurring during network navigation which is 1) characterized by a seamless sequence of responses facilitated by machine interactivity, 2) intrinsically enjoyable, 3) accompanied by a loss of self-consciousness, and 4) self-reinforcing" (p. 5).

Some researchers have examined flow experience in on-line environments based on the conceptual definition above. Chen et al. (2000) explain that flow experiences in web environments are similar to real world flow experiences: challenge, control, enjoyment are core factors related to flow in web environments. They indicate factors required to induce flow in on-line environments are those providing instant feedback, explicit objective, dynamical challenge.

Many have suggested that the above studies of flow experience in web environments should be conducted with a narrower approach to specific situations and conditions. In response, several studies of flow experience specifically examine games (Chou, & Ting, 2003; Hsu & Lu, 2003), simulations, and virtual world environments (Dickey, 2005; Wu, 2008; Omale, 2009; Sancho, 2009). According to these studies, activities within these media provide an experience as enjoyable as playing in itself. Even though these activities do not provide extrinsic rewards, these are considered as intrinsic because they can evoke students' engagement and motivation. In this context, the media and their characteristics become a critical factor that truly enhances engagement and flow experience.

5. Review of preceding studies

5.1. Effectiveness of learning in virtual worlds

Ketelhut et al. (2006) designed a scientific experiment in the virtual environment, which was called 'Rivercity', in order to identify the effectiveness of virtual worlds as learning environments (see Fig. 2). They found the same effects in a virtual environment as in a real lab. They concluded that the virtual experiment is significant in its effectiveness in terms of instructional design. Teachers and students who participated in this inquiry recognized this environment as an instructional process, not just as a changed instructional method. They showed that they could conduct scientific experimentation without laboratory materials. This analysis implies that virtual environments may harness diverse types of learning which are available for authentic learning experiences.

Shen and Eder (2009) examine students' intentions to use the virtual worlds for education, based on the Technology Acceptance Model[4] (TAM). They reconfirm the TAM process in virtual worlds, that computer self-efficacy makes learners recognize virtual worlds as a useful tool in learning and, in turn, satisfaction and behavior are affected through this process. According to the research, in order to experience enhanced learning, students should recognize the ease of use of virtual worlds and perceive the usefulness of virtual worlds in terms of TAM. In addition, students' ability to control this technology should be ensured and guidance on how to use this media when we design instruction within this environment should be provided.

[4] TAM is an information systems theory that models how users come to accept and use a technology. The model suggests that when users are presented with a new technology, a number of factors influence their decision about how, when they will use it. Davis (1989) presented that 'perceived ease-of-use (PEOU)' and 'perceived usefulness (PU)' affects users' intention to use. And users' PEOU affect PU.

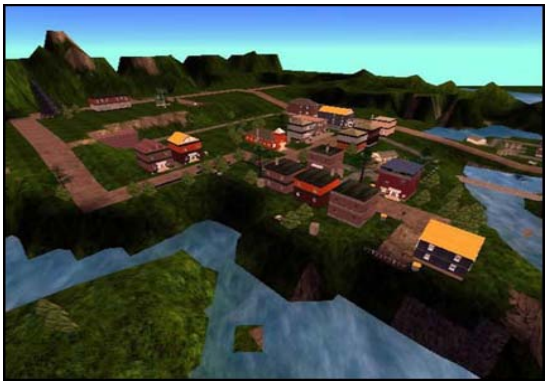

Fig. 2. A screenshot of River City (Ketelhut et al., 2006)

Barab et al. (2005) developed a virtual learning environment similar to River City, named Quest Atlantis (QA), a project-based learning environment based on various quests. The quests were designed to engage students in authentic and complicated situations to improve problem-solving ability within the virtual space. Students practiced various problem-solving strategies such as ecological, ethical and social. They focused their attention on the results, demonstrating that such three-dimensional virtual environments facilitate motivation, engagement and various learning performances. Annetta et al (2008) reported that students were satisfied with their learning in virtual worlds. Students reported that the environment was effective for distance education.

A significant body of research related to the effectiveness of using virtual worlds has been conducted on diverse topics. Such a variety of research implies that we should consider this environment as a significant learning environment and exploit this as a new learning tool.

5.2. Media characteristics of virtual worlds affecting Flow

Virtual worlds have distinct media characteristics, not only complementing web based learning environments' weaknesses but also enhancing their strengths (Hargis, 2008). Abundant previous research indicates that this media fosters students' motivation and engagement. There are diverse descriptions of virtual worlds' advantages such as motivational, engaging, fun and enjoyment, all of which converge into students' flow due to their unique characteristics.

Bricken (1991) reports that virtual environments could possibly provide learner centered interactivity with knowledge. Omale et al. (2009) contends that visually appealing, animated and interactive interfaces such as three dimensional space, avatars, and comic style bubble dialogue boxes promote students' motivation. Dickey (2005) lists three dimensional graphical user interfaces, anonymity, real-time communication, identity, interaction, and explorable spaces as virtual world media features. Shen and Eder (2008) also point out that the gamelike three-dimensional interface of virtual worlds affects learning motivation due to the playfulness of the game. Tuzan (2004) categorizes thirteen factors as motivational elements in virtual worlds. Furthermore, he points out several factors related to media characteristics: identity presentation, social interaction, immersive context, ownership, and control, which affect learners' motivation.

Wu et al (2008) focuses on the media features of online games. They conducted an empirical research on why learners are engaged in online games, which features engage learners in online games, and how they are correlated. They found that game story, graphics, length of game and control elements of game affect learners' engagement.

Most studies showed that students have experienced flow in learning through virtual worlds. Furthermore, here is a complementary assertion. Sancho et al. (2009) conducted an empirical inquiry to answer the question "Do these media really enhance motivation?" They indicate that previous researchers have represented possibilities of this media's enhancing motivation. However, those researchers have not found an explicit answer as yet. They developed NUCLEO framework which included a 3-D interface and LMS (Learning Management System), so that learners could study by facilitating motivation, self-centered learning and collaborative learning (Figure 3).

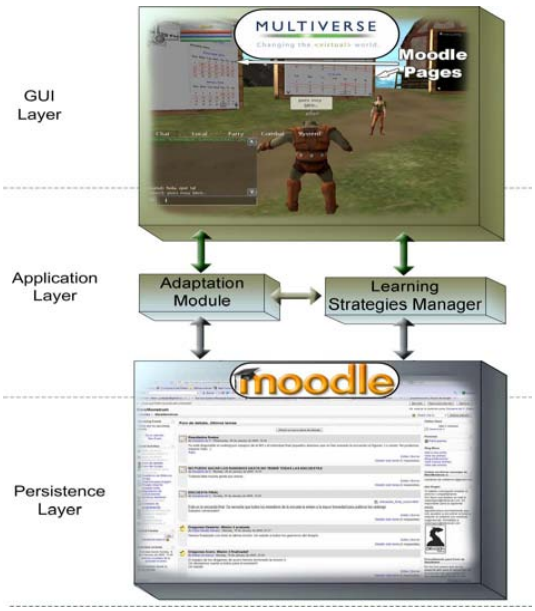

Fig. 3. Structure of NUCLEO Framework

Mare Monstrum, a virtual learning environment being developed by Sancho et al., which included a GUI, avatar, and graphic tools among the virtual worlds' features, was a research tool for confirming of impact on flow within a virtual environment based on NUCLEO framework. From this research, they found that 3D GUI and Game features significantly influenced flow, but VoIP (Voice over Internet Protocol), text-based chatting environment did not affect their learning effectively. They indicated the reason why these contrary results occurred was because the majority of students were unfamiliar with chat for educational purposes.

As shown above, virtual worlds are a meaningful medium, which can give students an optimal experience. These effects are derived from distinct media characteristics in virtual worlds. These researchers focus on the relationship between media characteristics and flow as summarized in Table 3.

Table 3. Preceding studies related between media characteristics and flow in virtual worlds

Researchers	Findings of media characteristics and flow	Virtual worlds
Tuzan(2004)	Virtual worlds' media features such as identity presentation, interaction, immersive context, and control affected motivation.	River City
Dickey(2005)	3-D GUI, anonymity, real-time communication, identity, interaction, and explorable spaces induced to motivate learning.	Active World
Shen & Eder(2008)	3-D interface of virtual worlds was related to motivation.	Second Life
Wu et al.(2008)	Game story, graphics, length, and control were related to enjoyment.	Second Life
Omale et al. (2009)	Visually appealing, animated, and interactive interfaces promoted students' motivation	Active World
Sancho et al. (2009)	3-D GUI, game features including avatar and graphic tool affected motivation.	Mare Monstrum

Implications based on this research are that media characteristics of virtual worlds should inform those who want to design instruction utilizing this media in order to maximize students' satisfaction of learning. In this sense, Nelson (2005) states that guidelines of instruction are required for learning in virtual worlds, admitting that to utilize virtual worlds as a simple tool is like using a boat without paddles on the sea. Dickey (2003) also identified that distinguishing virtual world features are 3-D space, avatars and the interactive chatting environment; these features have an 'affordance' applicable to constructivist distance learning environments. However, in terms of their applicability, she suggested that we should use support from empirical research on how to design instruction utilizing virtual worlds, and how people learn within this media. Therefore, we need to summarize research on which characteristics of virtual worlds influence students' flow experience and implement empirical research for proving these relationships. Based on such research, virtual world learning environments should be designed so that students can develop and maintain their optimal experiences in learning.

6. Methods

6.1. Participants

One hundred ninety eight elementary students who are eleven to twelve years old participated in this study. Questionnaires for analyzing data were administered to one hundred twenty participants to satisfy minimum numbers for factor analysis. Seventeen participants' responses were not relevant for analysis, so one hundred three participants' data were used for factor analysis to identify factors' validity of the relationship between media characteristics and flow. After the exploratory factor analysis, to extract media characteristics of virtual worlds, seventy-eight elementary students who are eleven years old were used in the analysis of exploring relationships between factors influencing flow. The last collected seventy-one questionnaires which were utilized for analysis.

6.2. Research Tools

'BKworld,' a virtual learning environment, was used in this study. BKworld is a three dimensional virtual learning environment based on the Second Life platform (see Fig.4). BKworld has various built-in objects and quests set up to support self-directed learning and cooperative learning. Participants can fully experience virtual worlds' media characteristics by solving quests for their learning through self-directedness and cooperation.

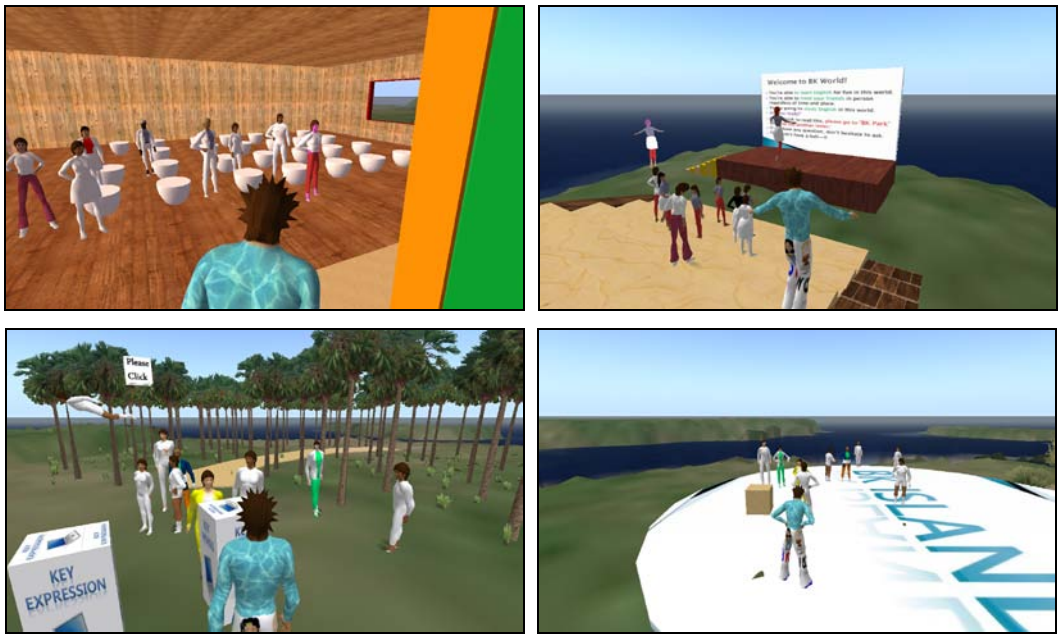

Fig. 4. A Screenshot of BKworld

Participants are obtained instructional contents and procedure by controlling a variety of objects providing in this environment. Through this activity, they are fully experienced 'control', which is one of the virtual worlds' media characteristics (see Fig. 5).

Fig. 5. Manipulate objects being provided for learning

Participants are also guided to explore various learning environments such as classroom, auditorium, park, island, garden, and other learning environments. Through this exploration, they are naturally experiencing distinct virtual worlds' media characteristics like '3D GUI', 'Shared space', 'Avatar', 'Consistency'.

Furthermore they are able to communicate with other participants via both text-based and voice chatting, and to interact immediately with a variety of objects and surroundings in virtual worlds. This was deliberately devised to experience 'Immediacy' as virtual worlds' media characteristics.

6.3. Measures

6.3.1. Media characteristics

Twenty-one items of media characteristics were used in seven areas: 3D GUI, shared space, avatar, consistency, persistence, immediacy, and control. Reviews of research performed by Dickey (2005), Omal et al. (2009), Sancho (2009) and reviews on Book (2004) and Dalgarno (2010)'s classification of media characteristics resulted in twenty six items in seven areas. The first preview of questions was done by subject matter experts, elementary school teachers who are doctoral students in educational psychology. This review resulted in the removal of five items for similar meaning. The second review for content validity was done by two Professors in educational technology. Some sentences were refined after this review. Table 4 shows the factors and their item numbers in the questionnaire.

Table 4. Factors and item number of the questionnaire

Factor	Item Number
3D GUI	1, 8, 15
Shared space	2, 9, 18
Avatar	3, 10, 17
Consistency	4, 11, 16
Persistence	5, 12, 19
Immediacy	6, 14, 21
Control	7, 13, 20

The scale for measuring media characteristics of virtual worlds was based on exploratory factor analysis. Unanswered questionnaires were excluded from the analysis, thus one hundred and three questionnaires were included in the analysis. The criterion for valid variables was decided at 1.00 of eigenvalue and factor loading above .30. In the exploratory analysis, factor loadings are generally considered to be meaningful when they exceeded .30. Table 5 shows the extracted factors and their reliabilities of media characteristics questionnaire, according to EFA (Exploratory Factor Analysis). The inter-item consistency of this questionnaire was .937 in Cronbach Alpha (α), which was proved as highly reliable.

Table 5. Reliability of the extracted factors

Factor	Item Number	Reliability
Interactivity	7, 13, 14, 20	.831
Representational fidelity	1, 2, 8, 9, 15, 18	.861
Immediacy of communication	3, 6, 10, 17, 21	.819
Consistency	4, 11, 16	.736
Persistence	5, 12, 19	.760
Overall	21	.937

6.3.2. Flow State Scale

The scale for measuring flow state in virtual worlds was the FSS (Flow State Scale) developed by Jackson and Marsh's (1996) based on the flow theory by Csikszentmihalyi (1990), which contained thirty six items measuring the nine dimension of flow described by Csikszentmihalyi: challenge-skill balance, action-awareness merging, clear goals, unambiguous feedback, concentration on task as hand, sense of control, loss of self-consciousness, transformation of time and autotelic experience. The test-retest reliability of this scale tested by the researchers was .978.

Table 6. Test-Retest reliability of Flow State Scale

Factor	Item number	Test-Retest reliability
Challenge-skill balance	F1, F10, F19, F28	.852
Action-awareness merging	F2, F11, F20, F29	.872
Clear goals	F3, F12, F21, F30	.849
Unambiguous feedback	F4, F13, F22, F31	.748
Concentration on task as hand	F5, F14, F23, F32	.867
Sense of control	F6, F15, F24, F33	.853
Loss of self-consciousness	F7, F16, F25, F34	.852
Transformation of time	F8, F17, F26, F35	.819
Autotelic experience	F9, F18, F27, F36	.918
Overall	36	.978

7. Results

7.1. Factor analysis

In order to explore factors of media characteristics influencing flow, an exploratory factor analysis was adopted. To validate the communality, the Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) and the Bartlett's test of sphericity were utilized. As a result, the KMO measure of sampling adequacy was .90, and the Bartlett's test of sphericity was .00 at significance level .001. Thus, it could be interpreted as fit for factor analysis, and that there were common factors. Kaiser criterion, scree plot and comprehensibility were considered to determine the number of factors, and principle component analysis (PCA) with varimax rotation was performed to extract factors. Table 7 shows factor loadings after varimax rotation.

Table 7. Factor loadings after varimax rotation

Item	Factor1	Factor2	Factor3	Factor4	Factor5
20	.754	.140	.241	.152	.296
13	.705	.231	.132	.205	.071
7	.701	.180	.125	.155	.069
14	.685	.221	.317	.229	.039
9	.402	.717	.182	.124	.117
2	.017	.687	.127	.261	.182
1	.371	.669	.001	.142	.155
8	.351	.553	.375	.223	.221
18	.424	.477	.212	.391	.271
15	.227	.412	.337	.344	.256
21	.190	.047	.845	.062	.166
6	.101	.519	.609	.061	.083
3	.329	.146	.541	.450	.184
17	.254	.269	.488	.403	.160
10	.396	.141	.460	.375	.203
4	.089	.248	.019	.793	.049
11	.234	.106	.125	.683	.243
16	.338	.193	.338	.625	.118
5	.009	.162	.152	.218	.856
12	.218	.214	.358	.152	.642
19	.498	.289	.024	.075	.621

Factor 1 labeled as ‘interactivity,’ which was variables of ‘control’ and ‘immediacy’ combined. This factor has been already indicated by Dickey (2005) and Dalgarno (2010). Dalgarno especially indicated text and voice based communication as an interactive feature of virtual worlds. Item 14, “I can communicate via text and voice chats immediately without reluctance.” supports this point very well.

Factor 2 was combined by variables of ‘3-D GUI’ and ‘shared space’. These items presented how students felt this environment to be the same a real word. Thus, factor 2 was labeled as ‘representational fidelity,’ which means a degree of accuracy when in imitating a real world. There are many studies associated with the effectiveness of learning, which rely on the degree of fidelity. These studies presented that fidelity was a significant factor for media characteristics influencing engagement.

Factor 3 was combined by variables of ‘immediacy’ and ‘avatar’. ‘Immediacy’ represents verbal communication which is immediately available such as text and voice chatting. The variable of ‘avatar’ presents nonverbal communication available via animated representative as shown in item 10, ‘My avatar’s behaviors are my behaviors’ and item 17, ‘Avatar represents all of my thoughts and behaviors.’ These variables denote interactive communication available via verbal as well as nonverbal means. Thus, factor 3 was labeled as ‘immediacy of communication’.

Factor 4 was combined by item 4, 'I can behave the same way tomorrow.' item 11, 'All of the surroundings in this space exist consistently.' and item 16, 'There is a consistency to studying in this space.' These items show that virtual worlds are consistent in control which means certain ways and/or environments are comparatively stable and unchangeable. Thus, factor 4 was labeled as 'consistency' as expected at the beginning of the study.

Factor 5 was combined with item 5, 'I think this space continues to exist regardless of logout', item 12, 'This space is not a static environment, but a continuous one.' and item 19, 'I feel this space has specific activities and events occurring persistently, even if I'm not here'. These variables have been already been indicated as persistence, which was named as a distinct characteristic of virtual worlds by Brna (1999), Book (2004) and Dalgarno (2004). Thus, factor 5 was labeled as 'persistence' in this study as well**.**

The result of the exploratory factor analysis is shown in table 8. The five factors of virtual worlds' media characteristics affecting flow are presented: 'interactivity', 'representational fidelity', 'immediacy of communication', 'consistency' and 'persistence'.

Table 8. Extracted factors and items determined by EFA.

Factor	Items
Interactivity	07. I can make objects and have control over them in this space. 13. I can do what I want to do in the space via text, chat and the avatar's gestures. 14. I can communicate via text and voice chats immediately without reluctance. 20. I can control surroundings, objects and behavior.
Representational fidelity	01. 3-D graphics seem like a real world. 02. This space is a place where we can speak and act together simultaneously. 08. Objects including buildings, friends and surroundings look real. 09. This space is always opened and shared by residents like a real world. 15. Graphics for learning does not disturb my learning. 18. Everyone can participate in this space if allowed.
Immediacy of communication	03. When my avatar is moving around, I feel the same. 06. I am able to speak anytime when needed. 10. My avatar's behaviors are my behaviors. 17. The Avatar represents all of my thoughts and behaviors. 21. It feels really convenient to communicate with others.
Consistency	04. I can behave the same way tomorrow. 11. All of the surroundings in this space exist consistently. 16. There is a consistency to studying in this space.
Persistence	05. I think this space continues to exist regardless of logout. 12. This space is not a static environment, but a continuous one. 19. I feel this space has specific activities and events occurring persistently, even if I'm not here.

7.2. Relationships between flow and Media characteristics

7.2.1. Correlations between flow and Media characteristics

In order to test the relationship between flow and media characteristics, a correlation analysis was performed. The results of correlation analysis are shown in Table 9.

Table 9. The correlation coefficient between flow and media characteristics (n=71)

	Flow	Interactivity	Representational fidelity	Immediacy of control	Consistency	Persistence
Flow	1	.704**	.753**	.732**	.654**	.644**
Interactivity		1	.799**	.836**	.748**	.791**
Representational fidelity			1	.861**	.784**	.796**
Immediacy of control				1	.832**	.845**
Consistency					1	.934**
Persistence						1

(**p<.01)

As shown in Table 9, the correlation coefficient between ‘Flow’ and ‘Interactivity’ is .704. The coefficient between ‘Flow’ and ‘Representational fidelity’ is .753. The coefficient between ‘Flow’ and ‘Immediacy of control’ is .732, ‘Flow’ and ‘Consistency’ is .654, and ‘Flow’ and ‘Persistence’ is .644. All correlation coefficient between flow and media characteristics variables are high, which are all significant statistically at .01 level.

7.2.2. Regressions on flow

In order to verify causal relationships between flow and media characteristics, a regression analysis was conducted. First of all, a simple regression analysis was adopted to figure out predictability of flow as a media characteristic. After that, a multiple regression analysis was conducted with flow as a dependent variable and five factors of media characteristics as independent variables. The procedure of selecting independent variables was the stepwise selection method. The result of the simple regression analysis for verifying prediction of media characteristics on flow is shown in Table 10.

Table 10. The result of simple regression analysis on flow (n=71)

Independent variable	Unstandardized Coefficients B	Standard error	Standardized Coefficients	t	p-value
Media characteristics	1.068	.112	.754	9.537	.000
R^2(adj. R^2) = .75(.57) F=90.949					

A result of a statistical significance test for the predictable equation of media characteristics affecting flow, shows that the value of F is 90.949 and p-value is .00. Media characteristics explained flow significantly with the extent of $p<.05$ ($t=9.537$, $p=.000$). Seventy five percent of the total variation, fifty seven percent by adjusted R^2 (coefficient of determination), of flow is explained by media characteristics, and predicted flow to the extent of 57% meaningfully. Based on this predictable relationship, an ANOVA procedure of the multiple regression analysis for media characteristics on flow is in Table 11.

Table 11. Anova table of regression model (n=71)

	Sum of squares	Degree of freedom	Mean square	F	p-value
regression	11.435	2	5.717	50.070	.000
residual	7.765	68	.114		
overall	19.200	70			
R^2(adj. R^2) = .596(.584)					

The result of the analysis for five independent factors of media characteristics predicting flow, as presented in Table 11, shows that the regression model predicted 59.6 % of the total variation (58.4 % in adjusted R^2) of flow with the value of F which is 50.07 and p-value is .00. However, this included two factors of interactivity and representational fidelity, excluding non-significant factors which were immediacy of communication, consistency and persistence.

Table 12. The result of multiple regression analysis on flow (n=71)

Independent variable	Unstandardized Coefficients B	Standard error	Standardized Coefficients	t	p-value
Representational fidelity	.501	.122	.527	4.107	.000
Interactivity	.272	.124	.282	2.200	.031

Results of the analysis for media characteristics' contributions on flow and their statistical significance show that independent factors affecting flow significantly are 'representational fidelity' ($t=4.107$, $p=.000$) and 'interactivity' ($t=2.200$, $p=.031$). The predictable factors on flow turned out to be, in order, 'representational fidelity' ($\beta=.527$) and 'interactivity' ($\beta=.282$).

8. Conclusions

Whenever new technologies emerge, the efforts to link them to educability have continued even before they have become generally accepted. Until recently, the core interests of media researchers have focused on the effectiveness of using media for education.

Even though studies have been conducted on effectiveness, there is a little research about for what reason these media can affect learning meaningfully, or how certain characteristics of media are related to effective learning, and how people ultimately learn through media (Oliver & Carr, 2009; Jarmon et al., 2009). This study started with media characteristics of virtual worlds, which are to be considered as an engaging learning environment for the players. Thus, this study aimed to identify distinct media characteristics which contribute to flow, and to verify the relationships between media characteristics and flow. This study also explored the correlation between media characteristics and flow, and searched for predictable factors of flow. Through this empirical verification of media characteristics predicting flow, this study advocates for instructional design of virtual worlds.

The results of this study are as follows:

First of all, many preceding researchers have revealed that students experienced motivation in virtual worlds, and acknowledged that this came from distinct media characteristics themselves. However, these researchers could not explain how these diverse characteristics affect engagement. For this purpose, distinct media characteristics of virtual worlds affecting engagement were collected through literature reviews. The suggested factors were labeled 'interactivity', 'representational fidelity', 'immediacy of communication', 'consistency', and 'persistence' after the exploratory factor analysis. These factors are supported by preceding studies in that they indicated media characteristics as a cause for engagement in learning through virtual worlds (Tuzan, 2004; Dickey, 2005; Shen & Eder, 2008; Wu, 2008; Omale, 2009; Sancho, 2009; Dalgarno & Lee, 2010).

Secondly, the correlation analysis between media characteristics and flow presented a high level of relationship (with 'interactivity' r=. 704, with 'representational fidelity' r=. 754, with 'immediacy of communication' r=. 732, with 'consistency' r=. 654 and with 'persistence' r=. 644). This result indicates that they are positively correlated: when students effectively recognize media characteristics, the level of flow is also high. Therefore, when we design instruction in virtual worlds, these media characteristics should be reflected. However, correlation does not mean causality, so we cannot conclude the media characteristics affect flow. However, since graphics and control significantly affect flow (Wu, 2008), the graphic user interface also affects learning motivation (Sancho, 2009), and media characteristics of virtual worlds can be considered to play an important role in their residents' flow.

Thirdly, the simple regression analysis shows that media characteristics explain 75% of flow significantly ($t=9.537$, $p=.000$) and 57% in adjusted R^2**.** This result implies that virtual worlds' characteristics have a significantly consistent predictability on learners' flow, which is consistent with previous research that demonstrated media characteristics were a critical factor for influencing engagement. This result also suggests that media characteristics should be considered in designing learning through virtual worlds.

Finally, the multiple regression analysis, which was performed in order to examine the relative influences of the adopted factors of 'interactivity' and 'representational fidelity' as the fitted regression model was employed to meaningfully predict flow. Factors of 'immediacy of communication,' 'consistency' and 'persistence' were excluded. Two factors predicted 59.6% of flow. In addition, the predictable factors on flow were 'representational fidelity' (β=. 527) and 'interactivity' (β=. 282), in that order. The excluded factors, 'immediacy of communication,' 'consistency' and 'persistence' did not explain causality of flow. This result supported the research of Sancho et al (2009) in that media characteristics of immediacy, such as instant messaging and chat, did not influence motivation. Excluded factors are unchangeable and fixed in nature, as compared to changeable and manipulatable features of 'representational fidelity' and 'interactivity'. Thus, factors of media characteristics such as 'immediacy of communication,' 'consistency' and 'persistence' are related to flow, but don't have an influence on causality, so it is difficult to assert that these factors predict learner's engagement. However, other factors such as 'interactivity' and 'representational fidelity' are significant factors that predict flow in learning through

virtual worlds. Therefore, when we consider instructional design in order to maximize learners' engagement through virtual worlds, changeable features and characteristics, such as 'representational fidelity' and 'interactivity', should be prioritized, so that these characteristics can be maximized to elicit learners' positive feelings toward real world and active manipulation.

Virtual worlds need to be recognized as a meaningful learning environment in K-12 settings. The efforts of using virtual worlds in teaching and learning were conducted by corporations, higher education institutes and private organizations. They view this medium as an effective, efficient and appealing environment. However, there are still teachers who have negative attitudes toward media such as games, the Internet and virtual worlds, and other computer-based learning environments. There are ethical issues related to anonymity and unstable identity caused by interacting via an avatar. However, for current learners who are familiar with these media, there is no doubt on their meaningfulness for learning as well as for enjoyment.

In light of our findings, certain limitations should be considered. First, although we focused on virtual worlds' media characteristics as a latent factor influencing flow, there exist more factors to consider such as learner factors, instructional factors. These factors are recommended to be considered in future studies to make sure virtual world is a meaningful learning environment. Second, the virtual world adopted in this study was the Second Life platform. A further study needs to be done on other virtual worlds to ensure study consistency so that distinct features of virtual worlds can be verified.

There were various environments derived from the Web, but common features of the Web such as networks and hyperlinks, have caused a shift in learning. Likewise, although various virtual worlds exist, there are common features which should be recognized as distinct media characteristics of virtual worlds. The analysis of these features can provide, explain and predict new paradigms of learning, satisfying future learners using changing and evolving media.

Appendix A. Flow State Scale

Please circle a score from the scale 1 (disagree strongly) to 5 (agree strongly) below which most closely corresponds with how you perceive with studying in virtual world.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
(F1) competent to meet demands	1	2	3	4	5
(F2) things happened automatically	1	2	3	4	5
(F3) knew what I wanted to do	1	2	3	4	5
(F4) knew how well I was doing by the way I was performing	1	2	3	4	5
(F5) total concentration	1	2	3	4	5
(F6) in total control of body	1	2	3	4	5
(F7) not concerned with others	1	2	3	4	5
(F8) time different from normal	1	2	3	4	5
(F9) experience was extremely rewarding	1	2	3	4	5
(F10) abilities matched challenge	1	2	3	4	5
(F11) spontaneous and automatic	1	2	3	4	5
(F12) strong sense of what I wanted to do	1	2	3	4	5
(F13) clearly doing well	1	2	3	4	5
(F14) completely focused on task	1	2	3	4	5
(F15) I could control what I was doing	1	2	3	4	5
(F16) not worried about others	1	2	3	4	5
(F17) altered time	1	2	3	4	5
(F18) enjoyed experience	1	2	3	4	5
(F19) challenge and skills equally high	1	2	3	4	5
(F20) performed automatically	1	2	3	4	5
(F21) knew what I wanted to achieve	1	2	3	4	5
(F22) knew how well I was doing while performing	1	2	3	4	5
(F23) attention focussed	1	2	3	4	5
(F24) feeling of total control	1	2	3	4	5
(F25) not concerned with presentation	1	2	3	4	5
(F26) slow motion	1	2	3	4	5
(F27) wanted to recapture the feeling	1	2	3	4	5
(F28) skills met challenge	1	2	3	4	5
(F29) correct movements without thinking	1	2	3	4	5
(F30) clearly defined goals	1	2	3	4	5
(F31) aware of how well I was performing	1	2	3	4	5
(F32) kept my mind on what was happening	1	2	3	4	5
(F33) in total control	1	2	3	4	5
(F34) not worried about performance	1	2	3	4	5
(F35) time stopped	1	2	3	4	5
(F36) experience left me feeling great	1	2	3	4	5

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