Virtualizing Science to Maximize Self-Efficacy, Value, and Motivation for Tomorrow's Science Workforce

Li-Wei Peng and Cheun-Yeong Lee

Abstract

The research partnership among university faculty, information technology graduate students, and science content experts from school districts developed the Web-based two-dimensional and three-dimensional virtual reality science games. The games were implemented to engage middle school students in learning, retaining, and applying newly acquired scientific knowledge in novel settings. The quasi-experiential study investigated the impact of gender, grade levels, and educational experiences (i.e., with games vs. without games) on sixth and eighth graders' self-efficacy in learning science, value of science, motivation in science, and perceptions of virtual reality science games in science classes. A total of 255 participants' responses from four rural Appalachian middle school science classrooms in southeastern Ohio were analyzed through a three-way ANCOVA factorial pre-test and post-test data analysis with experimental and comparison groups. The results indicated that the diversity of educational experiences was a significant factor that impacted sixth and eighth graders' perceptions of science. The findings of the two short-answer questions identified the reasons why the participants liked or disliked science, as well as why the participants would or would not choose a career in science. The conclusions discussed the practices that strengthen students' attitude toward science and careers in fields of science.

Keywords: virtual reality science games, science education

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The university faculty and information technology graduate students at a Midwestern university and the science content experts from school districts developed the Web-based two-dimensional and three-dimensional virtual reality science games with Flash, the STEAMiE Educational Engine, and Second Life as middle school science curriculum supplements. The topics and contents of the games are based on the *National Science Education Standards* (http://www.nap.edu/catalog.php? record_id=4962) and the *Ohio Science Academic Content Standards* (http://education.ohio.gov/GD/Templates/Pages/ODE/ ODEDetail.aspx?page= 3&TopicRelationID=1705& ContentID=834&Content=51519). Middle school science teachers in southeastern Appalachian integrated the games into their classroom activities to engage their students in learning, retaining, and applying hard-to-teach and difficult-to-learn science concepts in novel settings. Mubireek (2003) discovered that the integration of virtual reality games into the educational environment allows students to move at their own pace and the educational process becomes more personalized for the students.

The quasi-experiential study investigated the impact of gender (male or female), grade levels (sixth grade or eighth grade), and educational experiences (engaged with virtual reality science games or not engaged with virtual reality science games) on sixth and eighth graders' self-efficacy in learning science, value of science, motivation in science, and perceptions of virtual reality science games in science classes. Studies (Jones, Howe, & Rua, 2000; Weinburgh, 2000; Baker & Leary, 1995; Hykle, 1993; Pogge, 1986; Simpson & Oliver, 1985) completed in the past two decades have demonstrated that people have different self-efficacy, values, motivations, and perceptions of science based on their gender, grade levels, and educational experiences.

The following were the three quantitative research questions for the three primary purposes of this study:

1. Are there significant differences in perceptions of science between the students engaged with virtual reality science games and the students not engaged with virtual reality science games?
2. Are there significant differences in perceptions of science between male and female students?
3. Are there significant differences in perceptions of science between sixth and eighth graders?

Literature Review

Virtual Reality Games in Science Classrooms

The growing interest in the use of games and simulations for educational purposes, particularly with regard to teaching curriculum subjects, is evidenced in the literature, as well as in recent research projects and initiatives (Freitas & Oliver, 2006).

Flash Games in Science Classrooms

Macromedia's Flash with interactive features is commonly used for developing educational games. Flash allows game developers to create two-dimensional virtual reality games with sound, videos, pictures, and animation. Students can interact with Flash games to learn science content through the process of playing games. Data collected by the STEAM project (Ohio University Vital Lab, 2008) indicated that students working in Flash two-dimensional games have improved the mean scores on content achievement tests. Flash games, in general, have a positive effect on middle school students' learning outcomes.

The STEAMiE Educational Engine Games in Science Classrooms

The STEAMiE Educational Engine (SEE) is software with multiple development tools and collaborative environment for game developers to easily and rapidly create three-dimensional immersive games containing both educational and entertaining content with little effort and training. "A motivated middle-school student, using SEE, could create a virtual world within several minutes of opening the New Module template" (Nykl et al., 2008, p. 24). Virtual reality science games developed using SEE are designed for supporting science learning in an interactive way.

Second Life Games in Science Classrooms

Linden Lab's Second Life (http://www.secondlife.com) is an online collaborative world supporting tens of thousands of online users simultaneously (Nykl et al., 2008). The growing interest in using educational content in Second Life within the classroom setting is evidenced in recent research projects and initiatives. Second Life is a virtual environment in which owners can build communities for their own purposes. Teen Life is a space in Second Life available only for individuals between the ages of 13 to 17.

SciLands is an example of using Second Life in science education. SciLands is a specialized island in Second Life with an extended network for organizations interested in shared resources, innovation, knowledge transfer, research and science education using Second Life (Les, 2008). Moreover, the local New York City ABC affiliate, WABC-TV/DT (2008), aired a piece describing the Second Life Science Class as a pilot program founded by the not-for-profit Global Kids' Online Leadership Program. This program let Second Life become part of a science class at Brooklyn High School in 2007, and this experience demonstrated that Second Life was an innovative program that allows students to experience science lessons that are out of this world, but inside any computer (WABC-TV/DT, 2008). Applying Second Life in science curriculum is a byproduct of the current rapidly expanding technological revolution of enormous proportion. Institutions researching and developing instructional materials in Second Life for science classrooms have popularized and practiced their ideas in schools.

Why Virtual Reality Science Games Work

The growing discussion for the reasons why virtual reality science games engage students and support learning is evidenced in the literature and recent research projects. Dr. Robert Ahlers and Roseemary Garris (cited by Prensky, 2001) of the Navy's NAWCTSD Submarine Lab concluded after a three-year long study why games work. Based on their theory, virtual reality game-based learning works for the following reasons:

1. Virtual reality games provide opportunities for success from the games' goals, rules, and control of one's destiny which lead to a sense of purpose;
2. Virtual reality games appeal to curiosity from surprise, complexity, mystery, and humor which leads to fascination;
3. Virtual reality games allow social reinforcement from online conversations, game chat rooms, scoreboards, and game interactions which leads to a sense of competence.

Dr. Robert Ahlers and Roseemary Garris (cited by Prensky, 2001) found that games create a self-perpetuating learning cycle of initiate–persist–succeed, as players initiate game play, adopt a role, control game play, practice skills, solve problems, persist to the end and strive to win which is considered learning, a process which then leads to re-initiation of the cycle (Pellegrino & Scott, 2004).

Prensky (2001) addressed his findings and suggested it is useful to think of virtual reality game-based learning along the two principal dimensions of why it works: engagement and learning (Figure 1). Prensky (2001) deemed that virtual reality game-based learning involves high engagement and high learning while computer-based training is basically low engagement and low learning, and pure games alone are high engagement and low learning. Prensky (2001) claims that virtual reality game-based learning blends engagement and learning with balanced emphasis on both elements. Each game in virtual reality game-based learning has a different amount of both learning and engagement that teach what is required; learners can choose games containing suitable engagement and learning based on their mood and preferences.

Figure 1

Virtual Reality Game-Based Learning

Engagement	LOW Learning	HIGH Learning
HIGH	Pure Games	Virtual Reality Game-Based Learning
LOW	Computer-Based Training	(Null – No Existence)

Note. Virtual reality game-based learning comes only when engagement and learning are both high. From "Digital Game-Based Learning," by M. Prensky, 2001, *Digital Game-Based Learning*, p. 149. Copyright 2001 by Marc Prensky. Adapted with permission of the author.

Virtual reality game-based learning also fits well with the concept of learning by doing. Many types of virtual reality science games, such as simulation games and role-play games, are examples of delivery tools for goal-based or scenario-based learning (Schank, 1996). Simulation-based virtual reality science games, "make possible 'learning by doing' because it focuses on the learner's performance outcomes in a context that mirrors the real work environment, demands more intuitive responses (judgment), is usually constrained by time, and takes into account the complexity of possible interactions across key variables" (Kindley, 2002, p. 3). The learning goals of virtual reality science games which provide artificial and heuristic opportunities for learners to increase hands-on learning focus on abstract and intuitive knowledge and skill acquisition. Virtual reality science games commonly employ instructional strategies by developing a character, asking appropriate questions, giving feedback and providing hypothetical examples. This strategy leads to a better recollection of details as well as both motivates learners and allows them to learn while doing which involves emotional and physical interaction. It also supports why virtual reality science games work.

Gender, Grade Levels, and Educational Experiences

According to Jones et al. (2000), beginning as early as elementary school, males and females have significantly different attitudes toward science in terms of earth and space sciences, life sciences, physical sciences, sciences and technologies, and scientific inquiries taught in science classes. The different perceptions of science between males and females continue to expand from middle school through high school. Even though females are more interested in school and school learning in general, males consistently hold more complimentary attitudes toward science classes than females (Keeves & Kotte, 1992). Schibeci (1984) reported that gender is a variable which has generally been shown to have a consistent influence on attitude toward science. In 1986, M. Sadker and D. Sadker indicated that gender differences are more distinct in middle school, while Weinburgh (1994) added that gender differences continue into high school and that grade level is a significant predictor of students' attitudes toward science. Weinburgh's (2000) study indicated that the positive attitudes toward science decline with each grade level.

Weinburgh (2000) further indicated that having diverse school experiences in science between males and females is one of the factors causing males and females to have unlike attitudes toward science over childhood, adolescence, and adulthood. Studies (Jones et al. 2000; Baker & Leary, 1995) pointed out that there is growing evidence that science experiences affect science career selection.

Understanding the variables and issues that most influence people in developing their attitudes toward science and how those attitudes affect their self-efficacy, values, motivations, and perceptions of science is necessary for planning appropriate instructional intervention in middle schools which will impact people in developing more positive perceptions of science.

Theoretical Framework

This study has concentrated on using the Theory of Planned Behavior model to examine sixth and eighth graders' belief structures of science with the presence of the virtual reality science games in science classrooms. The study was designed to identify virtual reality science games as a factor influencing sixth and eighth graders' intentions to prepare themselves academically for scientific occupations. Therefore, a research model capable of identifying the intentions and beliefs linked to implementation behavior was needed. Because Ajzen's (1985) Theory of Planned Behavior provides a means to identify and examine the precursors to student learning behavior (intentions and beliefs), it was selected as the framework needed to accomplish the defined research goals.

Ajzen's Theory of Planned Behavior (1985) is a theoretical research instrument for understanding and identifying science education belief factors influencing both intention and behavior. Specific to science education research, the theory has been used to understand and predict motivation to achieve in science (Allen & Crawley, 1993), secondary science students' intentions to enroll in physics (Crawley & Black, 1992), junior high and secondary students' attitude toward participating in a district science fair competition (Czerniak & Lumpe, 1996), behavioral intentions of teachers enrolled in the Institute of Physical Science (Crawley, 1989), and teacher beliefs and intentions regarding the implementation of science education reform strands (Haney et al., 1996). Very few studies have focused on examining middle school students' belief structures using the Theory of Planned Behavior model; moreover, studies specifically examining middle school students' beliefs regarding science with virtual reality science games as a variable are equally rare.

From the Theory of Planned Behavior's perspective, in order to predict and understand the virtual reality science games' impact on sixth and eighth graders' perceptions of science, the first step is to examine students' motivation and attitudes toward using the virtual reality science games as a supplement in learning science (attitude toward behavior). In general, young teens and older teens (girls and boys alike) like to play virtual reality games frequently (Lenhart et al., 2008). Sixth and eighth graders have a high motivation to engage in playing the virtual reality science games from class even in their own time after school (2007 VITAL STEAM Magazine, 2007). The research (2007 VITAL STEAM Magazine, 2007) reported that virtual reality science games attract students to approach studying science in a fun and interesting way. Virtual reality science games promote the science subject's appeal for most students. Consequently, students report a positive evaluation of engaging in studying science which is termed as attitude toward behavior. The Theory of Planned Behavior assumes that with a positive attitude toward behavior, students are likely to have high intentions to perform the behavior. The theory views intention as an immediate determinant of the behavior.

The second step to predict and understand virtual reality science games' impact on sixth and eighth graders' perceptions of science is to investigate beliefs about who would support or object to engaging in science-related studies and careers (subjective norm). According to Baker and Leavy (1995), female students' perceptions of interpersonal relationships impact their science career selections, particularly in second, fifth, eighth, and eleventh grades. The study (Baker & Leavy, 1995) reported that eighth grade female students like science in general, but they think that their friends would not be supportive of a female's career choice in science. The eleventh grade female students in the same study reported reversely. Females who accept science as a career option indicated that they have strong affective influences from their parents, teachers, or other significant individuals. Several middle school science teachers participating in the STEAM project (2007 VITAL STEAM Magazine, 2007) expressed that they were inspired by their parents or science teachers to become science teacher themselves. One of the participating teachers cited her mother and her fourth grade teacher as major influences in encouraging her to become a science teacher. Another participating teacher was inspired by her third grade teacher to become a teacher herself. The teacher stated, “Mrs. Wigton really helped me as a student and I wanted to do the same for others” (2007 VITAL STEAM Magazine, 2007, p. 8). Therefore, subjective norm influences an individual’s perception of the value of science-related studies and careers.

The third step is to evaluate students’ perceptions of abilities and controls over the resources in science-related studies and careers (perceived behavioral control). Virtual reality science games visualize difficult and abstract science concepts with virtual animation which help students have a better understanding and improve their learning outcomes. Virtual reality science games allow students to interact with information at their own skill level and pace.

In the progression of the virtual reality science games integrated with the science curriculum, students are acting as an active partner in their learning, and not simply a consumer of knowledge (Smearcheck, Franklin, Evans, & Peng, 2008). Students can build up critical thinking skills and have the ability to access information they need to explore and investigate in their education. Students learn better in science as a result of having higher confidence in their abilities and control over the resources to approach advanced science studies or careers.

In terms of further understanding the behavior in the selection of science-related studies and careers, it is necessary to identify the two basic determinants of a person’s intention: intrapersonal and interpersonal factors. An individual’s positive or negative evaluation of performing a behavior is considered to be the individual’s intention of performing the behavior (Krynowsky, 1985). This study sought to examine whether the virtual reality science games have impact on sixth and eighth graders’ evaluation of pursuing or not pursuing science-related studies and careers. If the evaluation of the behavior is positive when the virtual reality science games are presented, sixth and eighth graders' intention to choose science-related studies and careers is stronger.

The strength of attitudinal and normative factors may alter the weighed beliefs and people's opinions involved. For example, if a person has a negative attitude toward having a career in science (attitude toward behavior), he/she may still intend to get a job in science because of the person's perception that his/her loved or admired ones view the behavior positively (subjective norm). In addition, the Theory of Planned Behavior claims that a person's perceived behavioral control is the key determinant in performing actual behavior. An individual's regard of internal ability and external control for performing a behavior concludes the individual's intention of performing the behavior. Career choice and development is but one example of the power of perceived behavioral control to affect the course of life paths through choice-related processes. The higher the level of people's perceived behavioral control over a career, the greater their interest will be in it. Because of their increased interest, they will prepare themselves better academically for the occupational pursuit they choose, and their success in their pursuit will be greater (Bandura, 1994). This study sought to explore whether the virtual reality science games have an influence on sixth and eighth graders' perceptions of their internal ability and external control over their performance in science. Attitude toward behavior, subjective norm, and perceived behavioral control all work to influence people's intentions and actual behavior. To the extent that a student has a positive attitude toward devoting himself/herself to science studies and careers, that a student perceives people's opinions of having a career in science in a positive light, and that a student has the required ability, opportunities, and resources, he/she should most likely will dedicate his/her life to science.

Methods

The study adopted a 2 x 2 x 2 ANCOVA factorial pre-test and post-test data analysis with experimental and comparison groups to research the virtual reality science games' impact on capturing the interest of both male and female students in sixth and eighth grades and increasing their self-efficacy, values, motivations, and perceptions of science. The three independent variables were gender (male or female), grade levels (sixth grade or eighth grade), and educational experiences (the experimental group engaged with virtual reality science games or the comparison group not engaged with virtual reality science games). The dependent variable was sixth and eighth graders' post-test perceptions of science. The pre-survey mean scores were the covariance. Adjusted mean scores of the post-survey were applied in analyzing the data. The pre-survey mean scores of the experimental and comparison groups were moved to the same number statistically in order to adjust the mean scores of the post-survey on the dependent variable. Therefore, there was a fair starting point for the pre-survey mean scores in the experimental and comparison groups statistically. The study had assumptions that the correlation value of the pre-survey and post-survey mean scores in the two groups was close to .70 and the regression lines of the pre-survey and post-survey mean scores in the two groups were parallel.

Sixty students (thirty sixth graders and thirty eighth graders) at two middle schools, respectively, in southeastern Ohio participated in the pilot study for assessing the magnitude of the scales in the science perceptions survey, as well as "specific matters such as developing questionnaire items, estimating internal consistency reliability, estimating survey response rates, and estimating effect sizes" (Johanson & Brooks, 2008, p. 1). In Johanson and Brooks' research (2008), they suggested that using thirty as the number of participants for each instrument in a pilot study is a reasonable recommendation because it provides the researcher maximum information at minimum cost.

The survey adhered to the pencil and paper format. The demographic information section which appeared at the beginning of the survey included six items: (1) code number,

(2) grade levels, (3) age, (4) gender, (5) years of using virtual reality science games in science classes, and (6) name of science teacher. At the end, the survey concluded with two short-answer questions, inviting thoughts on the science. The main section of the survey consisted of twenty-four items with a balance of positive and negative statements and an overall item – "Overall, I like the science," at the end of the scale, on a Likert five-point scale, ranging from strongly agree to strongly disagree. The twenty-five items of the survey were constructed in the domain of perceptions of science to address factors reported to be critical indicators in Ajzen's (1985) Theory of Planned Behavior model that students' intention and behavior might perform. The items were constructed into four subscale categories to assess self-efficacy in learning science, the value of science, motivation in science, and perceptions of virtual reality science game in science classes.

A total of 255 students participated in the study. Seventy-four (thirty-five males/thirty-nine females) sixth graders in School 1 and sixty-one (thirty-one males/thirty females) eighth graders in School 2 who had played the virtual reality science games in their science classes for three months were the subjects in the experimental group. Sixty-one (thirty-one males/thirty females) sixth graders in School 3 and fifty-nine (thirty males/twenty-nine females) eighth graders in School 4 who had not played the virtual reality science games in their science classes were the subjects in the comparison group. These subjects were selected for participation in the study on the basis of comparable school systems and teacher willingness to participate.

In order to get a reliable predication equation in this study, SPSS (Statistical Package for the Social Sciences) was the software utilized to determine the sample size needed for the 2 x 2 x 2 ANCOVA factorial pre-test and post-test data analysis with experimental and comparison groups. As a result, for the two-tailed test with an alpha level of p set to .05, a medium effect size (r = .60), an f value equaled to .25, and a power of .80, the total number of the sample size (N) was expected to be at least 136. The study endeavored to keep the number of participants as equal as possible in terms of gender, grade levels, and educational experiences.

There were three sections in the research procedures: (a) pre-survey, (b) treatment, and (c) post-survey. The study conducted participant observation to ensure the research setting and to supervise the extraneous variables during the research. The participant observation notes contained the class information notes (e.g., teacher, date, start time, end time, student numbers in male and female), teacher observation notes (e.g., instructional strategies, textbook, course content, class activities, assessment methods), student engagement notes (e.g., conversations, questions), and the virtual reality science game usage notes (e.g., topics, format, usage time).

Findings

Based on the purpose of the study and the findings of the subscales' correlations and factor analysis, the perceptions of science discussed in the quantitative research questions contained the following measurements:

Main Analysis

1. Overall perceptions of science (including all the subscales),
2. Attitudes toward science (including self-efficacy in learning science, value of science, and motivation in science),
3. Perceptions of virtual reality science games in science classes.

Additional Analysis

1. Self-efficacy in learning science,
2. Value of science,
3. Motivation in science.

Findings of Research Question 1

1. Are there significant differences in perceptions of science between the students engaged with virtual reality science games and the students not engaged with virtual reality science games?

The results of the 2 x 2 x 2 ANCOVA data analysis indicated that the experimental group and comparison group significantly differed in the main analysis – attitudes toward science measurement ($p = .016$). The additional analysis presented that the experimental group and comparison group were significantly different in the measurements of value of science ($p = .001$) and motivation in science ($p = .024$). It represented that there were significant differences in the attitudes toward science, as well as value of science and motivation in science between the students engaged with virtual reality science games and the students not engaged with virtual reality science games. Table 1 reported the mean square, partial eta square, and the *p*-values of adjusted post-survey mean scores in each measurement using educational experiences as the variable.

Table 1

Each Measurement's Mean Square, Partial Eta Square, and P-Values of Adjusted Post-Survey Mean Scores using Educational Experiences as the Variable

Main Analysis Measurements	Mean Square	Partial Eta Square	Sig.
Overall perceptions of science	.215	.006	.215
Attitudes toward science	.926	.023	.016
Perceptions of virtual reality science games in sciences classes	.821	.008	.166
Additional Analysis Measurements	Mean Square	Partial Eta Square	Sig.
Self-efficacy in learning science	.282	.004	.300
Value of science	3.307	.044	.001
Motivation in science	1.209	.021	.024

Findings of Research Question 2

2. Are there significant differences in perceptions of science between male and female students?

According to the results in the data analysis, the *p*-values of all the adjusted post-survey mean scores in all the measurements considered by male and female exceeded the critical value α = .05. These results indicated that none of the adjusted mean scores of the post-survey with any measurement showed any significant differences between the gender. Specifically, there was no significant difference in the perceptions of science between male and female students. Table 2 indicated the mean square, partial eta square, and the *p*-values of adjusted post-survey mean scores in each measurement with gender as the variable.

Table 2

Each Measurement's Mean Square, Partial Eta Square, and P-Values of Adjusted Post-Survey Mean Scores using Gender as the Variable

Main Analysis Measurements	Mean Square	Partial Eta Square	Sig.
Overall perceptions of science	.165	.005	.278
Attitudes toward science	.130	.023	.366
Perceptions of virtual reality science games in sciences classes	.322	.003	.385
Additional Analysis Measurements	Mean Square	Partial Eta Square	Sig.
Self-efficacy in learning science	.737	.011	.094
Value of science	.069	.001	.627
Motivation in science	.291	.005	.266

Findings of Research Question 3

3. Are there significant differences in perceptions of science between sixth and eighth graders?

The adjusted post-survey mean scores' *p*-values in all the measurements were greater than .05. when looking at the different grade levels. These values suggested that grade levels in this study were not the variable affecting students' perceptions of science. There is no significant difference in the perceptions of science between sixth and eighth grade students. Table 3 shows the mean square, partial eta square, and the *p*-values of adjusted post-survey's mean scores in each measurement using grade levels as the variable.

Table 3

Each Measurement's Mean Square, Partial Eta Square, and P-Values of Adjusted Post-Survey Mean Scores using Grade Levels as the Variable

Main Analysis Measurements	Mean Square	Partial Eta Square	Sig.
Overall perceptions of science	.056	.002	.527
Attitudes toward science	.010	.000	.800
Perceptions of virtual reality science games in sciences classes	1.042	.010	.119
Additional Analysis Measurements	Mean Square	Partial Eta Square	Sig.
Self-efficacy in learning science	.284	.004	.298
Value of science	.912	.013	.078
Motivation in science	.526	.009	.135

Discussion

Educational Experiences' Impact on Sixth and Eighth Graders' Perceptions of Science

The results found in the 2 x 2 x 2 ANCOVA data analysis indicated that the diversity of educational experiences was a significant factor that impacted sixth and eighth graders' perceptions of science in terms of attitudes toward science, value of science, and motivation in science. The comparison group had higher adjusted post-survey mean scores in these measurements than the experimental group did. Table 4 presented the adjusted post-survey mean scores of the experimental and comparison groups in the measurements of attitudes toward science, value of science, and motivation in science.

Table 4

Experimental and Comparison Groups' Adjusted Post-Survey Mean Scores in the Three Measurements

Three Measurements	Experimental Group (N = 135) Mean	Comparison Group (N = 120) Mean	Mean Difference (Experimental-Comparison)
Attitudes toward science	3.4262	3.5498	-0.1236
Value of science	3.539	3.77	-0.231
Motivation in science	3.376	3.516	-0.14

Educational virtual reality games' rich learning environment can be highly entertaining, but literature (de Freitas, 2007; Rutter & Bryce, 2006; Van Eck, 2006; Conati & Zhao, 2004) has shown that there is a need for more empirical evidence supporting that this kind of learning environment always triggers learning or enhances students' attitudes toward science, value of science, and motivation in science because most of the research results presented are based on theoretical assumptions. For instance, action-based games may bring on behavior based on repeated practice, trial and error, but do not allow players to reflect on outcomes, not to mention enhancing learning or attitudes toward the target subjects. In addition, "the use of technology alone does not motivate students who have lived in the midst of technology all their lives" (Kiili, 2005, p. 14). The integration of educational theories and game design, teachers' pedagogical interactions, other instructional activities, and each student's differences in goals, personalities, knowledge, and meta-cognitive skills (e.g., self-explanation, self-monitoring) are essential for students to actively build the connections between educational virtual reality games and underlying domain knowledge to enhance their learning, value, motivation, and attitudes (Kiili, 2005; Conati & Zhao, 2004). "If we continue to preach only that games can be effective, we run the risk of creating the impression that *all* games are good for *all* learners and for *all* learning outcomes, which is categorically *not* the case" (Van Eck, 2006, p. 2).

The Reasons Students Like and Dislike Science

The participants were encouraged to fill out the two short-answer questions at the end of the pre-survey and post-survey, respectively. The first short-answer questions aimed to understand the participants' perceptions of the science classes they had taken prior to the research period and within the research period. The second short-answer questions sought to explore the participants' choices of scientific careers in the future and the reasons for their choices at the beginning of the research period and at the end of the research period. The two short-answer questions are as follows:

1. Please answer one of the following questions:

   If you like science – why do you like science?

   If you do NOT like science – why do you NOT like science?
2. If you were going to have a career in science, what career would you like to have? Why?

Although there were gender, grade level, and educational experience distinctions within the participants in this study, there were no significant influences on the student responses to the two short-answer questions. According to the discoveries of the two short-answer questions, the reasons why the male and female sixth grade and eighth grade participants in both experimental and comparison groups liked science were:

1. Science involved hands-on activities;
2. Science contained favorite topics;
3. Science was interesting and fun;
4. Science was easy to understand and to get good grades;
5. Science related to daily life;
6. Science would help with a future job;
7. The participants liked science by nature;

8. The participants had a nice teacher.

These findings are supported by the literature of the past decades. Shaffer (2006) stated that "the typical caricature of progressive education is that progressives believe children should be free to learn by exploring their own interests" (p. 124). In order to stir learners' interests in science and let learners be into science no matter what obstacle they encounter, learners have to be doing something relevant to their lives and something they care about (Shaffer). In Jenkins and Nelson's study (2005), they found evidence that students who reported they liked school science regarded it as interesting, as well as relevant and important in everyday life. These findings are consistent with the Institute of Electrical Engineers' (The Research Business, 1994) and the Assessment of Performance Unit's (1988) conclusions cited by Osborne et al. (2003). Osborne et al. (2003) supported that the reasons why students like science are divided into two factors: (1) innate and intrinsic interest, and (2) situational and extrinsic interest. The latter is stimulated by the factor as Sharp, Hutchison, Davis, and Keys (1996), Woolnough (1994), Myers and Fouts (1992), Piburn (1993), and Brown (1976) identified that conducting good classroom variables, such as hands-on activities (e.g., experiments, gaming), separate subjects (e.g., physics, biology), and supportive teacher-pupil interactions (e.g., teachers' patterns of communication with pupils, transmissions of teachers' expectations to pupils, the variety of teaching strategies applied in class, particular topics covered in lessons with a high level of involvement). Ebenezer and Zoller's (1993) study confirmed that the significance of the science teacher (e.g., quality of science teaching, content knowledge, enthusiasm) is the most important variable affecting students' attitudes toward science. With positive science learning experiences of activities and teacher-related comments, students may have better comprehension and achievement in science and consider science as their favorite subject. Additionally, the Institute of Electrical Engineers (The

Research Business, 1994) indicated that students who like science often believe such notions as science offers better employment prospects and is useful for jobs. There is no significant distinction between genders.

On the other hand, the male and female sixth-grade and eighth-grade participants in both experimental and comparison groups indicated that they disliked science because:

1. Science was hard;
2. The participants lacked interest in science;
3. The participants had negative perceptions of science from their science teachers;
4. Science conflicted with participants' religious beliefs.

These findings are similar with the notions of Osborne et al. (2003), Havard (1996), and Ebenezer and Zoller (1993) that students find science abstruse (physical sciences particularly) and fail to perceive its value and relevance to their everyday lives and careers in the future, arguing that they will not need to know further science and do not sustain interest in it. Nilsson (2008) stated that "many students show little interest in their studies of science and often express an active dislike of it" (p. 1). Additionally, the student response in this study can also be found in Kekelis, Ancheta, and Countryman's (2005), Sundberg, Dini, and Li's (1994), and Ebenezer and Zoller's (1993) research stating there is a chasm between science teachers and students in terms of science value and usefulness, invitation and encouragement to science courses, enrichment opportunities, and confidence to learn and do well in scientific studies or works due to the teachers' pedagogy and students' personalities and learning styles; therefore, students' appreciation of science decreases. In Miller, Scott, and Okamoto's (2006) study, it was found that students with religious beliefs who see Genesis, for example, as a true and accurate account of the Creation may supersede scientific findings or interpretations, such as evolution in genetic literacy. As a result, these students may perceive science instruction as ineffective and a waste of time, and then indicate their antipathy against science.

Some participants reported that they sometimes liked and sometimes disliked science due to the science content and activities, or they were neutral about science. This discovery is similar with Osborne and Collins' (2000) finding that students' attitudes toward school science show discrepancies with the specific science content. Hendley, S. Stables, and A. Stables (1996) concluded that, science is a love-hate subject that reduces strong feeling in students.

The Reasons Students Choose or Do Not Choose Scientific Careers

The reasons generalized from the participants why the male and female sixth-grade and eighth-grade participants in both experimental and comparison groups would choose a career in science were:

1. Interest,
2. Salary,
3. Subjective norm.

A similar finding was revealed in earlier research of Whitehead (1996) that in terms of career aspirations, there is no significant difference between males and females. Additionally, having interests in STEM-related careers is one of the significant reasons students choose a career in scientific fields. Generally speaking, students have the impression that people who work in scientific careers (such as engineers, astronauts, and doctors) have good status, recognition, and income which motivate students to prepare themselves for entering scientific careers (Whitehead, 1996). Science teachers' teaching styles, curriculum content, and encouragement from teachers, parents, and friends will lead students to positively perceive their capabilities of doing jobs in scientific fields.

In contrast, the inductive reasons why the male and female sixth grade and eighth-grade participants in both experimental and comparison groups would not consider having a career in science were:

1. Not being interested in scientific careers,
2. Having non-scientific career choices in mind,
3. Lacking self-efficacy and perceived behavioral control of science.

Some participants stated that they were not sure which scientific career they were going to have, whether they would want to have a career in science or not, or which careers involved science. Similarly, Osborne et al. (2003) concluded from literature in the 1990s and 2000s (Fielding, 1998; Munro & Elsom, 2000; Jovanovic & King, 1998) that one of the reasons students choose not to pursue a career in scientific fields is that none appeals to them. Furthermore, due to the disconnection between the decontextualized teachers and high-tech scientific society, students lack opportunities to extend their knowledge of science-related fields and careers outside of school; therefore, students may have limited scientific career options in mind. Students who regard that school science is recondite and full of challenges may reflect their declining desires to engage in scientific careers and perceive themselves to have better capabilities of doing a job in other areas.

Conclusion

The study provided information on the sixth and eighth graders' perceptions of science, as well as their intentions and potential behaviors in having a career in science associated with students' gender (male or female), grade levels (sixth grade or eighth grade), and educational experiences (the experimental group engaged with virtual reality science games or the comparison group not engaged with virtual reality science games). The study findings suggested that students' educational experiences were the significant factors impacting sixth and eighth graders' perceptions of science in terms of overall perceptions of science, attitudes toward science, self-efficacy in learning science, value of science, and motivation in science. Kekelis et al. (2005) signified that "in middle school, students choose courses and extracurricular activities that influence their academic and career paths" (p. 17). There was no general support to the view that grade levels significantly impacted students' perceptions of science, although the adjusted post-survey mean score difference in each measurement was to be noted.

In terms of middle school students' perceptions of science, the findings of the two short-answer questions on the science perceptions survey concluded that students who found that (1) science involved hands-on activities; (2) science contained favorite topics; (3) science was interesting and fun; (4) science was easy to understand and to get good grades; (5) science related to daily life; (6) science would help with a future job; (7) the participants liked science by nature; and (8) the participants had a nice teacher, showed favor toward science. In contrast, students who had impressions that (1) science was hard; (2) science was boring; (3) science teachers' pedagogy was the cause of negative perceptions of science; and (4) science was in conflict with their religion, indicated their disfavor toward science. Furthermore, the reasons students would like to have a career in science were: (1) interest, (2) salary, and (3) subjective norm. On the other hand, the reasons students would not like to have a career in science were: (1) not being interested in scientific careers, (2) having non-scientific career choices in mind, and (3) lacking self-efficacy and perceived behavioral control of science. There is no significant distinction among gender, grade levels, and educational experiences.

Ajzen's (1985) Theory of Planned Behavior argued that if a student has a positive attitude toward the behavior (i.e., value of science, motivation in science), perceived behavioral control (i.e., self-efficacy in learning science), and subjective norm (science teachers) in science, the student will intend to become involved in science. Consequently, the student will most likely devote himself/herself to science. The Theory of Planned Behavior has been successfully applied to some perceptions and behaviors found in this study; for instance, perceptions of having a career in science, confidence in capability of proceeding further study in science, and social support from families, peers, and teachers are strong determinants of student choice to pursue science voluntarily. Simpson, Koballa, Oliver, and Crawley (1994) expressed:

> The science education literature contains hundreds if not thousands of reports of interventions designed to change attitudes. Development of programs to influence the likelihood of certain science-related attitudes is important because it is assumed that changes in attitude will result in changes in behavior. (p. 223)

Zeldin, Britner, and Pajares (2008) stated that “the potential of self-efficacy and its antecedents to influence how people select or eliminate future activities has been used as a heuristic model in understanding career decisions” (p. 1037).

Ajzen’s (1985) Theory of Planned Behavior helps determine salient beliefs (e.g., computer and science gender bias) that can be reinforced or downplayed to affect relevant behavioral decisions by students. Based on the finding in this study: the experimental group had less value of science, motivation in science, and attitudes toward science (i.e., the combinations of self-efficacy in learning science, value of science, and motivation in science) than the comparison group, it is essential to further investigate the interventions – integration of educational theories and game design, teachers’ pedagogical interactions, other instructional activities, each student’s differences in goals, personalities, knowledge, and meta-cognitive skills (e.g., self-explanation, self-monitoring), and individualized support to enhance virtual reality science games’ effectiveness on students’ perceptions of science. In addition, it is critical to control the interventions (e.g., computer and science gender bias) and strengthen the connections (e.g., science role models) between intentions and behaviors according to Ajzen’s behavioral interventions based on the Theory of Planned Behavior (2006), so that virtual reality science game-based learning can achieve its full potential of enhancing students' behaviors on proceeding with the scientific workforce. As a result, the total number of Americans preparing for scientific careers may increase, regardless of gender

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