Chapter 15: Motivational Perspectives on Students' Responses to Learning in Virtual Learning Environments

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Virtual learning environments are of special interest to educators because it is the province of educators to create, select, and provide environments that encourage learning. This is true whether the educator is concerned with very young children who have a very limited range of knowledge and skills, or mature learners whose experience has equipped them with extensive knowledge and well-developed learning strategies. It is the way environments set the framework or context for experiences that make them key tools whereby educators influence the direction of learning. Learning happens with or without the educator. However, the yardstick for evaluation of any educational endeavor is the degree that learning approximates the goals and outcomes valued by learners, educators, educational institutions, and educational systems. The chapters in this volume acknowledge that throughout history humans have used a wide range of technologies to design and construct environments to encourage the development of knowledge and skills in their young. However, the power of environments to promote learning has been accentuated by electronic information technologies as they offer an ever-increasing range of digital and virtual forms. These virtual learning environments have the potential to provide opportunities for active, flexible, and increasingly individualized learning experiences. Our examination of motivational perspectives will range widely across the electronic information technologies that are used in creating virtual learning environments, from the simplest forms of computer-aided instruction through to complex virtual reality environments.

An important factor influencing the widespread interest in electronic information technologies is the seemingly limitless possibilities they provide for the construction of virtual learning environments. Each new virtual learning environment comes with its implicit assumptions, and often explicit claims offering enhanced student learning outcomes. The idea that electronically created environments will open the doors of learning for everyone has been embraced enthusiastically to the extent that it is not uncommon to read claims such as "ICT can be used to provide new, authentic, interesting, motivating and successful educational activities" (Kelleher, 2000: 37). In particular, it is the motivating power of virtual learning environments that we will examine.

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In this chapter we present a perspective that gives central place to identifying the character of the relationship or interactive process that connects learner and learning environment. More specifically our analysis will identify motivational processes that characterize how students engage with technologically based learning environments. In this way our approach will differ from other reviews of learning and virtual learning environments and will address what some have referred to as a "neglected factor in instructional design" (Spitzer, 1996). Our focus is not on any one form of virtual learning environment but rather we explore how the set of learner characteristics known as motivation might influence educational experiences and outcomes across a range of virtual learning environments. As Hartley and Bendixen (2001) have suggested the role of learner factors is likely to become more pronounced as learning environments become more open-ended.

The editors have adopted for this series a perspective that treats learning experiences as "participation in an interconnected series of learning environments". Our approach is to focus on the motivational processes that influence "participation". Motivation is about movement, energy, selectivity and direction in behavior, and so motivation is an essential component of participation. We examine how some psychological factors (e.g., curiosity, interest, goals, anxiety) influence what happens when specific objects or events within electronic environments impact students' personal information processing systems. This is one of a number of perspectives on learning in virtual learning environments that emphasize functional qualities of the interactive learning system. For example, another way to look at learning in virtual learning environments is represented in a Gibsonian perspective. As Flach and Holden (1998) note, the Gibsonian view of design principles as applied to virtual environments highlights the link between perception and action. They argue that the dynamic interplay between the environment and the learner determines the quality of the simulation and therefore the quality of the experience. In this way, the yardstick for measuring experience in virtual environments lies not in the quality of the images, but with what can be done, "the reality of experience is defined relative to functionality, rather than to appearances" (p. 94). In contrast, we address the issue of learning in virtual learning environments by considering ways that students react to and interact with (i.e., are curious about, have their interest triggered by, become anxious about, want to master, want to avoid) virtual learning environments.

We have adopted a broad conception of virtual learning environments and include computer-mediated and computer-assisted learning programs that model traditional classroom practices, as well as electronic environments that simulate real-world situations in which students can interact and influence the environment. An important characteristic of virtual learning environments is their degree of veridicality with real-world environments. As societies have developed ways of transmitting adaptive understandings of the culture to developing members of the social group, so they have constructed learning environments that are more or less veridical with the real-world environments which the developing young will need to navigate. These learning environments can also be classified according to whether learners experience them as being equivalent to the real world. Some learning environments represent the real world on a two-dimensional page. Throughout the history of education in western, literate societies, environments of this type have made up a large proportion of children's educational experiences. The critical features of real-world experience are abstracted and represented in either two- or three-dimensional form on the two-dimensional surface. At the same time there have always been educators who have argued the need for a closer match between the learning environments that make up formal schooling and the "real-world environments" for which schooling is preparing students. In the electronic age this issue is again brought into focus through the potential of computer environments to both *be* learning environments and *to simulate* real-world learning environments. Contemporary learning environments range on a continuum of immediacy. Towards one end of the continuum is the two-dimensional page or screen with its symbolic representations of the real world, abstracted from the environment and formally presented in a range of ways thought to assist learning. Currently at the other end are the virtual reality worlds created through digital means where students are active contributors to the life of the environment. The history of education shows clearly that across the full range of these learning environments students have reported experiences of being curious about, being interested in, wanting to understand, as well as being bored, being confused and frustrated, and being anxious. We will consider elements of learners' experiences within a range of these learning environments by giving special focus to what we can discover about the characteristics of students' motivational processes and how they contribute to what happens in the encounter between learner and virtual learning environment.

The specific approach we have taken to understanding learning in virtual environments can be illustrated by reference to a recent review of educational research technology. Winn (2002) identified four successive perspectives associated with the development of educational technology. The underlying theme for these perspectives has at its core the increasing sophistication of learning technologies. Early research according to Winn focused on learning content. Research questions were framed in terms of task analysis identifying effective instructional design. As more sophisticated presentation features were developed there was a shift to consideration of how format and individual student characteristics interact. Then development of media technologies that supported simulations heralded opportunities for vastly enhanced student control and more constructivist learning approaches. The latest stage has been the use of technological advances to generate learning environments that potentially can transcend limitations of time and space in what they offer to communities of learners. Seen in this way, the underlying theme associated with changes in learning environments is increasing sophistication of technology. However, learning does not take place without a learner, and although the learner is never absent in the perspectives presented by Winn, his analysis gives technological change center stage. While acknowledging the importance of the technological changes described by Winn, we will turn the spotlight onto the psychological processes, more particularly the motivational processes that color the relationship between learner and environment. In doing so we will identify how these relationships contribute to the quality of the learning outcome.

Our motivational perspective on virtual learning environments will take as its central tenet that if we wish to understand learning we need to consider the subjective experience of the learner (Hickey, 1997). Curiosity, interest, anxiety, and achievement goals are just some of the motivational processes that describe the interactive relationship between learner and learning environment. We will examine evidence on the effectiveness of virtual learning environments to identify where motivational processes are essential for the quality of learning outcomes.

1. MOTIVATION, LEARNING, AND ACHIEVEMENT

Questions about motivation arise from the selectivity of human behavior. At any given point in time every person is surrounded by a vast array of stimulation, some we notice, some we ignore, and some never impinge on our awareness. Every person also has a history that they bring with them to any new situation as a psychological organization incorporating values, interests, emotions, and attitudes. When two people are in the same situation what is novel and puzzling for one person may be familiar and valued, or familiar and trivial for others. Sometimes what is selected for attention and further investigation is a function of specific properties of the stimulus. At the simplest level this may be the brightest light, the strongest color, or maybe the loudest sound. Brightest, strongest, and loudest all imply appraisal of the selected stimulus relative to others that might have attracted attention. Sometimes what is selected and investigated is a function of personal expectation or valuing. Most people have at some time had their attention drawn away from their own conversation at a party or social event by hearing their name mentioned in a conversation across the room.

When the prominent or predictable in a virtual learning environment is ignored and a less predictable path chosen, the selectivity typical of human behavior becomes an especially critical issue invoked to understand learner behavior. Knowing how learners typically respond to particular properties of instructional experiences provides important knowledge that can be used to guide instructional design. What stimulus qualities prompt curiosity and interest, trigger specific achievement goals, or create anxiety? Of course this is only the typical pattern and individual learner characteristics can intervene and reduce the precision of predicted effects. There is also pattern within the personal factors that influence selectivity.

All of the major motivational dimensions associated with learning and achievement command a literature exploring situational triggers as well as a literature exploring individual differences. Sometimes these are framed as situational and individual perspectives and at other times as state and trait perspectives. As background to our review of the contribution of motivational processes in virtual learning environments, we will outline how both of these perspectives have been applied to some key motives associated with learning and achievement; namely curiosity, interest, achievement goals, and anxiety.

1.1. Curiosity

Curiosity refers to the motivational processes that result in a person approaching a novel situation. Probably the most well known of curiosity researchers is Berlyne, who found that the motive curiosity and its consequences, exploratory behavior, were associated with situations that were characterized by what he called *collative variability* (Berlyne, 1960; 1978). This referred to properties such as ambiguity, complexity, and incongruity. From his research findings we know that most people will approach novel situations that have high collative variability. They will then explore the situation to reduce the uncertainty generated by its ambiguity, its complexity, or its incongruity. From the perspective of individual or personal variability, a number of theorists (Beswick, 1971; Day, 1971) have proposed that there are also individual differences in the degree that people generally approach novel situations. For example, some individuals may have their curiosity aroused by a wide variety of novel situations, whereas for others there is a much narrower range of situations that arouse curiosity and result in exploratory behavior. Some may have their curiosity aroused by novel and puzzling situations that offer new knowledge and understanding, others by situations that offer new experiences and sensations (Ainley, 1987; 1998).

1.2. Interest

Interest is a related construct that has also been used to explain the impact of motivation on learning. Schiefele (1996) reviewed a number of studies that have quantified influences of interest on learning suggesting that about 10% of the variability in learning can be accounted for by interest factors. Maximize student interest in what is to be learned and typically learning will improve. The roles of both situational (Hidi, 1990; Hidi & Berndorff, 1998; Hidi & Harackiewicz, 2000) and individual interest (Krapp, 2002; Krapp et al., 1992) as they contribute to learning have been explored extensively. Recent studies have attempted to identify how both situational and individual factors together contribute to learning (Ainley et al., 2002a, b). These studies have shown that students bring to their learning well-developed individual interests and that simultaneously specific learning topics trigger different levels of interest. In addition they have explored some of the processes through which interest has its effect on learning. For example, positive effect is involved in maintaining students' engagement, thereby providing an opportunity for learning to occur.

1.3. Achievement Goals

Achievement goals refer to students' purposes in learning. Typical models refer to a range of specific purposes. On the one hand purpose can be defined as whether students want to master, to understand, or to improve competency (mastery or learning goals). Another purpose students have for their learning is to do well (performance goals). This may take the form of wanting public acknowledgement of achievement, of wanting to outperform peers, or to maintain face and "not appear dumb" in front of family or friends. At the other end of the spectrum, work avoidance goals indicate that students' purpose is to reduce learning to a minimum (Dweck, 1986; Elliot & Harackiewicz, 1996; Nicholls et al., 1985). The major emphasis in this research has been to consider the individual perspective, and achievement goals have been measured as personal orientations. Some research has adopted a situational perspective and has considered goals and purposes for learning that are salient in specific classroom environments (Ames, 1992; Ames & Archer, 1988). Most recently, research into the contribution of achievement goals to learning has expanded the focus to consider combinations of social and achievement goals represented. Every learning situation is also a social situation and so both sets of goals contribute to learning outcomes (Urdan & Maehr, 1995; Wentzel, 1992; 1999).

1.4. Anxiety

Undoubtedly the most widely known effects of motivation on learning have come from the literature on anxiety (Pekrun, 2000). The debilitating effects of anxiety on learning have been well documented. Equally well known is the inverted U-curve describing the relationship between anxiety and performance. Up to a point anxiety can improve learning. But as the level of anxiety gets higher the anxiety symptoms such as increased heart rate, or quickened breathing divert attention from the task and the quality of performance declines. When students experience a learning exercise as an easy task, anxiety focuses attention and facilitates performance. When experienced as a difficult task, anxiety is likely to interfere with performance. In the anxiety literature the situational perspective has been prominent through measurement of *state* anxiety and investigation of the relationships between state anxiety and performance. The individual perspective is represented in studies of *trait* anxiety, that is the degree to which individuals generally have a tendency to feel threat in a wide variety of situations (Spielberger & Krasner, 1988).

We have briefly sketched some prominent research directions in the study of motivation and learning. It is not exhaustive. What is critical for a consideration of the contribution of motivation in virtual learning environments is an acknowledgment that both situation and person contribute to the actual learning experience. Instructional design for virtual learning environments should be cognizant of the knowledge that has been generated from both situational and individual perspectives on motivation and learning. The learner perceives, appraises, and interacts with the virtual learning environment. In each of the processes that make up perception, appraisal, and interaction there is a contribution of both what is triggered in the person by the situation and what the selective processing of learners' personal psychological organization detects as salient.

2. STUDENT REACTIVITY TO ELECTRONIC LEARNING ENVIRONMENTS

The most common medium for accessing virtual learning environments is the personal computer. How students use computers and their attitudes toward the place of computers in education is critical to understanding student motivation and interactivity within virtual learning environments. One of the most recent studies shedding light on the extent of computer use amongst students in western industrialized countries is the OECD's Programme for International Student Assessment (PISA)[1]. Fifteen-year-old students were asked about their familiarity with computers as part of their learning environment. The questions consisted of self-assessments in response to items on interest in computers, attitudes and ability to work with computers, and use and experience with computers (OECD, 2001). Each self-report rating was made on a scale specifying response categories of "disagree", "disagree somewhat", "agree somewhat", and "agree". Summaries of these data for 16 OECD countries have been published and are informative for the insights they offer into national variations in access to computers.

While on average 60% of 15-year-olds in OECD countries use a computer at home almost every day, or at least a few times per week, there is considerable variability between countries. For example, this figure ranges from 21% in Mexico, 40% and 45% in Hungary and the Czech Republic, to more than 70% in Australia, Canada, Norway, and Sweden. In contrast, only 36% of students in this age group in OECD countries use a computer at school every day or at least a few times per week. Again there is considerable variability across countries, with proportions ranging from 15% in Germany to 55% or more in Denmark, Hungary, and the United Kingdom. Internet use across all OECD countries is high, with 42% of students on average using a computer for electronic communication almost every day or at least a few times per week, with school-related use high at 30%.

Analysis of the particular familiarity issues (interest, comfort, and perceived ability) across national samples demonstrates some of the complexity of students' responses to computers as learning environments. Patterns of familiarity are related to factors such as computer availability and school organization, and also reflect cultural beliefs and lifestyles that determine the amounts of time spent in work, school, and leisure by children and adolescents around the world (Larson & Verma, 1999).

The PISA (OECD, 2001) measure of student interest in using computers was based on responses to questions dealing with using computers for reasons of importance, fun, being interested, and involvement. Students' comfort and perceived ability with computers consisted of self-ratings on questions about specific tasks including writing a paper and taking a test. They were also asked to compare their own computer ability with what they thought to be the computer skills of the average 15-year-old. When these indices of students' responses to computers were considered in relation to measured reading achievement there was a positive association between interest in computers and reading literacy scores. The authors caution that this association does not allow interpretations of directional effects, nor does it allow for the operation of other factors such as socio-economic status. However, these data are available for closer inspection and some of the more detailed patterns within this general finding are particularly informative for understanding students' reactivity to electronically mediated learning environments. Students from Finland and from the U.S.A. demonstrated contrasting patterns. Overall, Finnish students scored lower than average across the OECD respondents for interest in computers and scored very high on the reading literacy index. For these students there was a negative association between interest in computers and literacy scores. In contrast, students from the U.S.A. reported the highest level of interest in computers coupled with a strong positive association between interest in computers and reading. Australian, New Zealand, and Canadian students whose reading levels were comparable showed only slight variations in reading literacy scores across the quartiles of interest ratings. Students from all three countries showed lower than average interest in computer scores. It is of note that for all three of these countries, the lower than average interest in computers index was coupled with high comfort and computer ability scores. Countries such as Germany, the Czech Republic, and Denmark, who also demonstrated little difference in the reading literacy scores across the four quartiles of interest in computers, showed a range from high interest (Germany), close to average interest (Czech Republic), and low interest (Denmark). Clearly the patterns of association between the various aspects of familiarity with electronically mediated learning environments and student achievements is complex and requires more understanding of how students within specific socio-cultural contexts are reacting to those learning environments. Most of the research that is reviewed in this chapter was conducted in countries where computer availability is high. Students are familiar with computers, are generally interested in them, and expect them to be part of their learning environment. The findings cannot necessarily be applied to students in countries where computer availability is low.

3. SITUATIONAL FACTORS INFLUENCING REACTIVITY TO VIRTUAL LEARNING ENVIRONMENTS

A widely used approach to evaluating the role of situational factors in virtual learning environments compares learning outcomes using some form of electronic instruction medium (e.g., CAI or Web) and traditional learning environments. A second approach directs attention to specific components within the learning environment supported by newer learning technologies and explores their effectiveness in terms of cognitive processing characteristics of the learner. Each specific component is tested for its contribution to learning in controlled experiments. A third approach focuses on the motivational conditions required for effective learning and from this perspective identifies features of virtual learning environments that optimize motivation. We will consider the contribution of each of these approaches in turn.

4. VIRTUAL AND TRADITIONAL LEARNING ENVIRONMENTS COMPARED

Virtual learning environments have commonly been evaluated by asking whether students' learning is enhanced when some form of electronic medium delivers that learning. The basic research design involves comparison of an electronic medium with some form of more traditional learning medium. Because of their longer history and the relative ease of implementing the experimental design, CAI learning environments have featured prominently in the large numbers of these studies reported over the last three decades. More recently results have been synthesized using meta-analysis. For example, one meta-analysis of studies involving secondary students (Christmann et al., 1997) indicated that overall there was a slight improvement in achievement associated with the CAI treatment groups. However, the size of this effect varied considerably. Of the studies that met their strict criteria for inclusion (i.e., a CAI treatment group compared with a traditional instruction group and the effect of the treatment on measured achievement outcomes reported), approximately half reported positive findings in favor of the CAI groups, some reported no difference, and others negative findings. Effect size varied across subject areas. The largest positive effect sizes were reported in studies concerned with science instruction and the largest negative effect sizes in studies concerned with English instruction. Two examples of this type of study will be detailed here to illustrate the findings and interpretations that are generated using this approach.

Using instructional material from a Biology course on reproduction in plants and animals, Soyibo and Hudson (2000) compared the pre- and post-instruction scores of Jamaican grade 11 students. One group of students had the typical lecture and discussion methods of instruction supplemented with access to commercially produced software called the *Virtual Body* (made by Time-life, IVI Publishing Inc., 1995). The attractive elements of this package for the teaching of animal reproduction were the attention given to issues of "learner control, feedback, interactivity, and flexibility". Other material that did not have strong interactivity features was used for the plant reproduction section of their course. At the end of the 4 weeks instructional period Soyibo and Hudson found that students in the *Vitual Body* experience group significantly outscored the control group. The outcome variable in this study was a score on a 30-item multiple-choice biology knowledge test. Studies of this general type have sometimes reported significant learning advantages for the virtual learning experience groups, sometimes no differences and sometimes negative results, although the latter might be expected to have more difficulty in getting published (Christmann et al., 1997). In other studies comparisons of learning outcomes across learning environments based on media allowing for a range of learner participation are reported. For example, Ricci and Beal (2002) compared children's story memory following use of interactive story software, narration (audio-only), and a television-like audio-visual. A second form of the interactive-computer story software consisted of a passive computer condition where the student "observed but did not control" the story. Measures of story memory following these four modes of presentation indicated that the audio-only group had the poorest performance, but there were no significant differences between memory response scores for the other three presentation modes.

In terms of the range of virtual learning environments available in the first decade of the 21st century these studies have investigated relatively simple learning environments. However, it is important to note that both studies go beyond the basic achievement findings and report aspects of students' reactivity to the learning experience. Soyibo and Hudson (2000) reported changes in students' attitudes to biology and to computer-aided instruction following their learning experience, and more importantly that the post-instruction attitudes to biology showed a "positive statistically significant but weak relationship" with the post-test biology achievement scores. Changes in students' responsiveness to both the medium of instruction and to the content of the instruction were reported. In the Ricci and Beal (2002) study, children's enjoyment ratings for the story were high and did not differ between any of the four media conditions. However, when all of the children reported their preferences across media types, there was a significant preference for computer-based media. Radio was least preferred.

The difficulty of comparing and synthesizing findings from these types of studies is compounded by a number of factors. As pointed out earlier, there are very different socio-cultural environments in which the students are located. Soyibo and Hudson's (2000) study was conducted in Jamaica in direct response to educational authority initiatives seeking to increase the low base of computer use in Jamaican primary and secondary schools. In contrast, Ricci and Beal (2002) described their school context as one where "computer access and use by children is becoming increasingly important, both at home and in school settings" (p.138). There are also complexities for interpretation and generalization of results from these studies associated with the age of the students. Ricci and Beal conducted their study with 6–7 year olds and suggested that the children were highly engaged with material no matter what the medium. Contrast this with the situation provoking a lot of studies like those of Soyibo and Hudson where the computerized instruction medium has been adopted in response to falling motivation for learning (generally dealing with adolescent/secondary or high school populations). In the latter, electronically mediated learning environments are often seen as a way of addressing issues of engagement and motivation.

On balance, comparisons between the effectiveness of learning using various forms of virtual learning environments and learning using more traditional methods have shown that virtual learning environments can produce higher learning outcomes. However, across the studies results are variable and often the interpretation of group differences has to be qualified with reference to the influence of students' interest, enjoyment, or attitudes. Motivational factors such as interest, enjoyment, and clear goals are important influences on students' responsiveness in virtual learning environments.

5. COMPONENTS OF VIRTUAL ENVIRONMENTS SUPPORTING LEARNING

A second way of assessing virtual learning environments is to focus on the key factors of the learning environment in relation to the cognitive abilities of the learner. In response to the large body of research comparing electronic and traditional learning environments, Mayer has argued that "the most important factor in producing cognitive outcomes is not the medium that is used but rather the quality of the instructional message" (Mayer, 1997: 7). Quality is determined by the way instruction is tuned to the cognitive processing capacities of student users. In this he is supported by a range of reviews directing attention to the characteristics of instructional materials as they facilitate or inhibit learning, rather than the more global approach that credits the medium *per se* as the facilitator of learning (Clark, 1994; Kozma, 1994a, b). The work of Mayer and his colleagues (Cordova & Lepper, 1996; Mautone & Mayer, 2001; Mayer, 1997; Mayer & Chandler, 2001; Mayer et al., 2002; Mayer et al., 1999; Mayer et al., 2000; Moreno & Mayer, 2002) has made a substantial contribution to this field. Their research program is built on insights from a number of contemporary theories about learning processes. For example, citing Wittrock's (1989) generative theory, Mayer argues that the learner is a constructor of knowledge, actively selecting from within the available information, building their own representation of the selected information, and then integrating it with their existing representational system. From Pavio's (1986) dual coding theory he points to the possibility that separate visual and verbal systems will be involved in the extraction of information from multimedia displays. All of this occurs within the constraints on the information processing system set by the capacity of short-term working memory (Chandler & Sweller, 1991). These and other theories of human information processing have been applied by Mayer and colleagues in their experiments evaluating the instructional potential of specific media components in multimedia learning environments.

In all Mayer's experiments, individual components of multimedia learning environments have been isolated to test their effects on two types of learning, retention and transfer. A relatively consistent picture has emerged showing that these two types of learning are differentially affected by the learner's experience with specific kinds of instructional components. The participants in many of these studies have been college-age students and they have been asked to learn concepts and principles from physical science. A number of these studies will be described in detail to illustrate the important features of this approach.

Interactivity is a key component of multimedia learning environments. Mayer and Chandler (2001) used narrated animation to assess the role of "simple interactivity" in the form of the learner being able to control the flow of the presentation. The experimental design involved narrated animation being presented to each student twice and incorporated different degrees of student control over the "pace of a narrated animation". Some students had a mixed experience. They controlled the pace for the first presentation but on the second presentation had no control over pace. For other students the order of these two experiences was reversed. Still other groups of students either controlled the pace for both presentations or had no control over the pace in either presentation. In this experiment there were two levels at which the effects of the medium of learning might operate: the actual processing of information during learning and the amount of information able to be retrieved. In terms of the processing of information, any learning exercise puts a certain level of cognitive load on students' working memory. Too much cognitive load on working memory interferes with learning. At the same time the structure of the learning exercise may facilitate or impede students' construction of a coherent mental model of the specific learning task. In many of Mayer's experiments the learning task consisted of explaining the formation of lightning (Mayer &

Chandler, 2001). Having control over the pace of the presentation promoted effective learning through matching the cognitive load of the presentation with the learner's pace of constructing their explanation of the formation of lightning. If simple user interactions lead to deeper understanding this would be indicated by higher scores on transfer tests for students who had control over the pace of presentation than those who did not. The results indicated that the order of control experiences was also important. When students controlled the pace on the first presentation and then passively viewed it on the second presentation, they performed better on the transfer test than students who controlled the pace on the second presentation after already experiencing the passive exposure.

In another experiment using similar learning material (Mayer et al., 1999), the effects of different combinations of narration and animation were tested (e.g., concurrent; narration before animation, animation after narration, narration and animation delivered in small or large bites). Here, an additional issue investigated was how the dual systems of visual and verbal materials are held and processed in limited capacity working memory. The concurrent and small successive bites groups outperformed the successive large bites group, thereby supporting a contiguity effect. These findings demonstrate how specific features of a multimedia environment influence learning (Mayer et al., 2001; Moreno & Mayer, 2002), and have contributed important principles that can be used to design effective multimedia learning environments.

The main contribution of this research has been identification of the specific cognitive processes through which components of the instructional environment impact on students' knowledge and understanding. For example, the cognitive load characteristics of the instructional contents will influence learning. Text and graphics presented together on a screen place more cognitive load on the learner than does text and narration. But the answers for effective instructional design are never simple. Although Mayer's research has demonstrated that contiguity of verbal and visual information in multimedia environments improves learning, it has also shown that individual learner characteristics matter. Students' prior knowledge of content and spatial abilities moderate the effects of the contiguity principle. When the learner has high levels of prior knowledge, contiguity is less important than when prior knowledge is low. Contiguity effects have more impact for learners who have strong spatial abilities than they do for learners who are less reliant on spatial abilities.

Alongside issues of cognitive load, Mayer draws on Wittrock's (1989) generative theory of learning which views the learner as a "knowledge constructor". This introduces into the learning equation differences in the degree that learners are able to select relevant information, and to organize and integrate it into a coherent model of the phenomenon to be explained. While all three sets of processes, selection, organization, and integration, are constrained by the cognitive abilities of the learner, motivational processes are also important.

The level of cognitive load represented by the instructional design can be set to match that of the learner, but, if the learner does not focus their attention on the computer screen, the selection will be less than optimal and the organization and integration processes that follow will be compromised. Factors that determine selectivity are clearly critical. Motivational processes such as learner interest in using computers, self-efficacy, or anxiety about using computers will influence attention and selectivity. In some of Mayer's experiments student interest has been included in the design (Mayer et al., 2000). At the end of the learning task students were asked to report how interesting they found the material. Differences in interest and learning between the experimental groups suggested that the groups reporting higher interest in the material were more likely to try to make sense of the material and to form a more coherent model.

Of special interest in this research has been the consistent finding of different outcomes according to the type of learning measure. Retention indices are not as sensitive as transfer measures. Constructivist theories of learning have been used to provide explanations for this difference in measured learning outcomes. Transfer learning requires deeper processing than retention of factual material. Deeper processing in this context represents making sense of and building a more coherent model that can be used to apply the critical concept or principle to new situations (transfer). The deeper processing that is associated with higher performance on the transfer measures of learning was also significantly related to motivational processes reflecting involvement or engagement with the learning environment (Mayer et al., 2000).

The important insight coming from all of this research is that instructional design of virtual learning environments requires a match between the design parameters and the cognitive capacities of target learners. At the same time this research points to critical role of the motivational processes, such as interest, that direct and sustain learning.

6. FEATURES OF ELECTRONIC LEARNING ENVIRONMENTS THAT OPTIMIZE MOTIVATION

A third approach to the situational factors associated with effective learning in electronic learning environments focuses on the motivational conditions required for effective learning in order to identify features that optimize motivation. A good example of this approach can be found in the research and writings of Lepper and colleagues (Cordova & Lepper, 1996; Lepper, 1985; Lepper & Gurtner, 1989).

In an early paper, Lepper (1985) defined a set of inter-related research issues that link the learner and the instructional possibilities of computer learning environments. He suggested that the design properties related to generating intrinsic motivation, the relationship between intrinsic motivation and instructional effectiveness, and identification of the different philosophies of instruction embodied in educational computer programs were key issues to be addressed. According to Lepper, the increased motivation so often claimed to be typical of students' response to educational software depended on what theorists generally referred to as intrinsic motivation. For some theorists this was described in terms of challenge, effectance, or mastery motivation. Other theories of intrinsic motivation refer to curiosity, complexity, incongruity, and discrepancy, while others refer to perceived control, self-determination, or factors such as fantasy involvement. Lepper argued that these distinct theoretical traditions could profitably work together in the context of understanding the determinants of intrinsic motivation and how this might be reflected in the design of instructional software. This direction was of course predicated on the assumption that the increased intrinsic motivation generated by new educational software would be associated with improved instructional effectiveness. Lepper argued that rather than being a necessary consequence of increased motivation, instructional effectiveness was likely to be bound up in the degree that the motivation-enhancing special effects were interdependent with the problems to be solved or the instructional content. On another occasion Lepper and Gurtner (1989) contrasted the positive expectations of computer enthusiasts with the cautious and suspicious concerns of those educators challenging the computer revolution in education. He predicted that given the variability within computer learning environments, instructional effectiveness will be as varied as the instructional programs themselves both in terms of their formal features and their incidental content. In particular, Lepper argued that the attention students pay to various aspects of the learning environment, how involved they become, and the learning strategies they use all impact on the cognitive outcomes resulting from the experience. Similarly, motivational consequences are likely to be shaped by factors such as students' learning goals, their level of intrinsic motivation, perceived competence, and self-efficacy.

These relationships have been tested in a number of experimental studies reported by Lepper and his colleagues. For example, Cordova and Lepper (1996) experimented with a number of forms of educational software designed for teaching arithmetical order-of-operation rules to fourth and fifth grade students. Specific features designed to enhance intrinsic motivation were incorporated into the separate software conditions that varied the degree to which the learning content was abstract, contextualized, or personally meaningful. The control group engaged in two unembellished computer-based learning games. For the experimental conditions, students received the same learning activities embedded in a fantasy context. The fantasy context was manipulated so that for half the students the fantasies were generic, while for the other half they were personalized on the basis of information elicited from the students at the start of the experiment.

Cordova and Lepper (1996) found significant differences in the motivation of these groups as evidenced by such indicators as their level of task involvement and the extent to which they chose more challenging versions of the game. Significantly higher learning scores were observed when the learning was embedded in the fantasy context, in the personalized context more than the generic context, and in the choice conditions more than the no-choice conditions. In a similar study, Mitchell (1993) identified how using computerized instruction in mathematics classes influenced specific motivational processes. Distinguishing between the initial reactions to the task and the continued interaction required for maximum learning, Mitchell found that the novel, electronic features of the computer presentation were effective in catching student interest. However, the instructional content needed to be involving and meaningful if it was going to maintain and hold students' attention.

Total immersion in an electronically mediated world that defines the reality within which the student can operate is a defining feature of virtual reality environments that separates these environments from other virtual learning environments. Again, issues of instructional design and learner reactivity need to be addressed when assessing the educational potential of these types of learning environments. Findings from the Project Science Space (George Mason University) help to illustrate the complexity of the interactive processes that need to be understood when using this form of virtual learning environment to achieve specific learning objectives (Salzman et al., 1999). The features of these environments that can increase motivation and contribute to greater learning include three-dimensional immersion, frames of reference (FORs) and multisensory cues (Salzman et al., 1999). Combinations of these features of virtual reality environments may also interact and add complexity to the structure of the learning environment. Specific learner characteristics that have been tested for their influence on the experience of virtual reality environments include gender, spatial ability, computer experience, concept domain experience, motion sickness history, and the individual's tolerance of the immersion experience. For example, NewtonWorld (NW) is a physics environment that has been designed to allow students to explore concepts that are often the substance of student misconceptions. One such misconception is that "motion implies force". In NW, the learner is in a corridor where they control the movement of balls of various masses. Additionally the student is able to "beam" between balls and cameras observing how the balls behave in relation to the surfaces of the room. As Salzman et al. explain:

> "In NW, we rely on sensorial immersion to enhance the saliency of important factors and relationships and to provide experiential referents against which learners can compare their intuitions. Learners can be 'inside' moving objects; this three-dimensional, egocentric frame of reference centres attention on velocity as a variable. Multisensory cues are used to further heighten the saliency of crucial factors such as force, energy and velocity.
>
> (Salzman et al., 1999: 298–299)

Observations of students' responses both to the experience in the virtual reality worlds and students' reports after their experiences indicated the importance of motivational factors. Being able to observe what was happening from multiple viewpoints (the FOR factor) as part of the learning experience was motivating for students.

In their analysis of the effects of their virtual reality environments Salzman et al. (1999) distinguish between the interaction experience (simulator sickness and usability) and the learning experience (immersion and motivation). They suggest that a positive interaction experience, a positive experience with the hardware and software interfaces is an important pre-condition for learning. These and similar experimental studies make an important contribution to an understanding of how specific design features of virtual learning environments enhance students' interest and engagement, and how they in turn are associated with stronger learning outcomes.

6.1. Virtual Learning Environments and the Experience of Flow

Another motivational variable that has recently received considerable attention from researchers working with virtual learning environments is Csikszentmihalyi's (1990) concept of "flow". Flow refers to an experience of intense emotional involvement, being completely involved in the activity for its own sake. "The ego falls away. Time flies." (Geirland, 1996). It is the state where the person feels so involved and committed to their current activity that they may not be conscious of their own level of effort and may lose all sense of time. The expanded opportunities for learner choice and control within electronically mediated environments have been interpreted as providing the ideal conditions for flow experiences. When asked about his views on the likelihood of web environments promoting flow experiences, Csikszentmihalyi contrasted a well-structured gourmet meal with cafeteria selection to highlight the need for instructional design in electronic learning environments. He is reported to have said:

> "A web site that promotes flow is like a gourmet meal. You start off with the appetizers, move on to the salads and entrees and build toward dessert. Unfortunately, most sites are built like a cafeteria. You pick whatever you want. That sounds good at first, but soon it doesn't matter what you choose to do . . . web site designers assume that the visitor already knows what to choose. That's not true".
>
> (Geirland, 1996)

In a recent study (Chen et al., 1999) web users were asked about flow experiences. Chen et al. found that the activities most likely to be associated with reports of flow experiences were information retrieval, communication, and interaction. Information retrieval activities were described as provoking challenge and providing feelings of enjoyment. Describing their experiences, students used terms such as "engrossment, exploration, excitement, timelessness" that are very similar to the experiences described in Csikszentmihalyi's (1990) work. From the questionnaire responses, Chen et al. were able to define a number of design factors associated with flow including the web user having clear goals and receiving immediate feedback. Like others using the flow framework, they reported that flow was more likely to be reported when there was a match between web-user skills and the challenges provided by the web environment. From these responses, Chen et al. suggested that design of web learning environments incorporate features that provide immediate feedback; clear rules to follow and goals to pursue; enough complexity which is not easily exhausted; creation of dynamic challenges not static ones (see Chen et al., 1999: 589).

Another study monitoring flow within a web learning environment used the experience sampling method (Csikszentmihaly & Larson, 1987) to collect students' reports of how they felt about a hypermedia learning exercise (Konradt & Sulz, 2001). At designated points in the learning exercise students reported their level of activation, affect, concentration, satisfaction, and motivation by completing experience sampling rating scales. Students were classified into four groups defined by their particular balance of challenge and skill for this task (flow: high challenge, high skills; anxiety: high challenge, low skills; apathy: low challenge, high skills; boredom: low challenge, low skills). Approximately one-third of the students met the flow criteria and this was the largest group. Clearly the hypermedia presentation had engaged a substantial number of the students. One limitation in the complex design of this study was the relatively small numbers of students for each of the hypermedia experience categories. There were only 60 students in total participating in the study. Comparisons between the learning outcomes were reported for the "flow" and the "apathy" groups. All three learning measures (content knowledge, structural knowledge, and transfer) showed higher performance for the "flow" group. Although in the predicted directions, these differences were not statistically significant.

The experience of "flow" and its contribution to learning in virtual learning environments is currently attracting researchers' interest (Pearce et al., 2005). With further refinement of measures and more robust designs this area promises to add substantially to our understanding of the processes whereby participation in virtual environments expands student learning.

6.2. Virtual Learning Environments as Social Environments

In the previous section it was argued that learner responsiveness was critical in any electronic or virtual learning environments. Much of the research we have cited has been seeking those forms of design that will maximize the likelihood that students will engage with, and be an active participant in, the learning environment. The literature on human–computer interaction makes liberal reference to "interactivity" as a major feature of technological environments that support constructivist learning. The response of one person to another person often initiates a chain of action and reaction that we call interaction or interactivity. Human responses in virtual environments can operate in a similar manner, the only difference being that the computer is taking on the role of responding partner. This is turn taking, or acting and reacting in a similar chaining sequence to what happens in human conversation or dialogue. Within the virtual environment there is some form of immediate response to the learner's action. However, for effective learning to take place the learner must discern or make connections between their own actions and the responding activity in the virtual environment (Pearce & Ainley, 2002).

Recognition of the social character of learners and the influence this can have on the level of interactivity within virtual learning environments has found expression in a range of studies exploiting the potential of electronic learning environments to incorporate social experiences designed to heighten interactivity. Avatars or animated pedagogical agents (APAs) are now part of some significant electronic instructional projects (Lester et al., 2000). When computer users are asked about their reactions to computer-mediated characters their answers clearly indicate that interactions with electronic characters are treated as social interactions (Reeves & Nass, 1996). Some of the work emanating from the Intellimedia research group will be described to indicate how this approach contributes to our knowledge of learner motivation in virtual learning environments.

The designs for the APAs in Intellimedia projects are guided by both motivational and pedagogical considerations. Within the broader set of motivational processes, emotion has been identified as a key social process and so APAs are being constructed to both display and understand emotions (Lester et al., 2000). Student and agent together operate the learning environment. Students' problem-solving activities drive the system. When the student is inactive for an extended time or when they are using poor problem-solving actions, the pedagogical agent comes in with actions and utterances designed to give direction and control of the problem-solving activities back to the student: "Engaging lifelike pedagogical agents that are visually expressive can clearly communicate problem-solving advice and simultaneously have a strong motivating effect on students" (Lester et al., 2000: 124). Early studies demonstrated that students found the agents with both animation and aural communication to be believable and reported that they found them encouraging and useful (Lester et al., 1997). Other researchers (Craig et al., 2002) have found that learning environments employing APAs with spoken narration result in better performance than where text-only or text with spoken narration are used, confirming the efficacy of realistic APAs for assisting learning. Similarly, Atkinson (2002) found that worked examples coupled with an APA programed to deliver instructions aurally was more effective at promoting learning than text-only examples without agents.

One feature of electronic learning environments that has both positive and negative implications is the wide range of possible paths that can be taken navigating that environment. The positive side has been linked with the motivating effects when students are in control and can make active decisions within the environment. The negative side of this is the possibility that students may be overwhelmed by anxiety as they experience uncertainty associated with both the range of choice available and lack of confidence in their own knowledge and abilities. Based on Vygotsky's social-constructivist approach to learning, contemporary advocates of discovery-based learning environments acknowledge the importance of providing structure or scaffolding for students' choices and decision-making. The APA provides the scaffolding by matching actions and utterances to students' current location in the problem-solving space. Experimental evaluation has shown positive effects on learning in a virtual learning environment with the support of an APA. Using a microworld called "Design-A-Plant" with its APA, Herman, the learning outcomes for students working with an APA version were compared with students having a version of the microworld with no-APA (Moreno et al., 2000). The no-APA group received text information on the screen equivalent to the content of the utterances made by Herman for the APA group. Measures of retention of factual information showed no difference between the two groups. However, both transfer and self-reports of motivation and interest showed significantly more understanding and stronger motivation and interest in the APA group. In the same set of studies it was shown that personalized dialogue was associated with higher transfer scores and stronger motivation ratings than was the same message communicated via a non-personalized monologue.

These research programs suggest that the APA is effective because it taps into motivational systems that the majority of learners bring with them to their learning. The virtual learning environment that includes some form of APA becomes a social situation thereby broadening the appeal to include social as well as cognitive processes. Numbers of students whose interest is not triggered by the cognitive content of the task, or students who are only mildly interested are still likely to respond to the "person" who is communicating directly with them. However, further research is needed to understand these social processes and how they might best be used to maximize student engagement.

Providing conditions that maximize interactivity through the use of social agents or personalization techniques taps into the motivational systems that learners bring with them to their learning. On the indication of these current findings this should be a very fruitful area for further investigation.

6.3. Virtual Learning Environments and Communities of Learners

The importance of the social context supporting learning is also a key feature of instructional programs that are designed to build communities of learners. Classrooms of students working together become communities of inquiry. This means that students are provided with a learning environment that encourages them to construct knowledge and understanding through posing questions, reacting to questions and ideas generated by other students, and reflecting on their ideas, knowledge and understanding. The central character of this process of asking questions, knowledge construction and reflection is to make thinking visible. It is the potential of virtual learning environments to facilitate making thinking visible, and to use collaborative environments to scaffold the development of shared knowledge, that has encouraged a number of researchers to investigate patterns of knowledge construction within communities of learners (Bransford et al., 1999; Koschmann, 1996). One well-known virtual learning environment developed to facilitate communities of learners is the Knowledge Forum formerly known as CSILE (Scardamalia & Bereiter, 1994). The Knowledge Forum environment involves construction of a conferencing system and database by means of networked computer software. Designed to build a reflective thinking approach to knowledge construction this system is based on principles whereby learning is modeled and scaffolded. Individual thinking is cast into the shared language of the community of inquiry and the technology provides a structure for the sharing and development of ideas. Students are encouraged to express their ideas and questions, respond to the ideas and questions of their fellow students, and to develop these experiences into shared understandings. The technology has been designed to mediate the sharing of ideas and so allows this to occur across local environments as well as across time and space. Reports of student learning in such communities describe the gains made by students as they develop skill in knowledge building processes (Goldman et al., 2003). The social character of students' experiences as a member of a community of learners provides an important source of motivation and this is reflected in their attitudes and participation, their willingness to contribute ideas. However, as was the case with our knowledge of the effectiveness of APAs, the motivational processes that are connected with these learning outcomes and attitudes are implicit in the observations made by researchers of collaborative learning communities but are yet to be researched extensively.

> For whatever reasons, the electronic venue seems to call forth more informative comments than students make in the context of face-to-face, whole-class and small-group discussions . . . Perhaps the electronic environment seems less test-like to them. Perhaps it is being part of a community engaged in the same activity. Perhaps it is the ability to see

> their own responses in relation to those of their peers. These are empirical issues that bear further investigation as we continue to explore the value of electronic environments of the KF variety.
>
> (Goldman et al., 2003: 279)

While situational factors such as features of the environment, the opportunity for social interaction and experiences of flow clearly influence reactivity to virtual learning environments, a comprehensive appreciation of the possibilities of virtual learning environments requires consideration of both person and situation. What students bring to their learning in terms of characteristic ways of responding to the mode and contents of learning environments, also needs to be the subject of close investigation so that virtual reality environments can support effective learning.

7. INDIVIDUAL FACTORS INFLUENCING REACTIVITY TO VIRTUAL LEARNING ENVIRONMENTS

Both situational and individual factors impact on learning in virtual environments. However, a significant and not yet well-understood issue concerns the complex ways these individual and situational factors interact. This has been the subject of considerable debate in a number of areas of psychological theory. For example, one of the major challenges to the use of personality theories to predict behavior has been the claim that there is insufficient cross-situational stability to justify their use (Mischel, 1973). More recently Mischel and Shoda (1995) have suggested that it is not a question of either personality or situation (cross-situational consistency or situational variability), but rather how these two perspectives play out in human behavior. They suggest a more productive approach is to view personality "as a stable system that mediates how the individual selects, construes, and processes social information and generates social behaviors" (p. 246). What the person brings to the situation in the form of their relatively enduring patterns of expectancies, goals, and plans makes it more likely that certain aspects of situations are salient. These salient aspects are in turn more likely to be selected for attention and appraised in ways consistent with those relatively enduring patterns of expectancies, goals, and plans. It is also true that situations vary in the degree that specific characteristics have immediate salience. For example, when considered from the perspectives of trait and state (person and situation), Pintrich (2000) argued that achievement goal orientations involve schema or cognitive representations of what individuals would like to achieve. These may show both intra-individual stability and contextual sensitivity. The relative strength of situational cues and the accessibility of specific goal schema will influence actual behavior. "Strong contexts can overwhelm chronically accessible traits, but in the absence of strong cues in the environment, then traits may influence behavior more." (Pintrich, 2000: 102) In this way it becomes possible simultaneously to account for the contribution of qualities of the underlying personality and the predictable variability across situations.

Mischel and Shoda (1995) were addressing issues of person and situation from the perspective of social psychological research. However, the same issues offer important insights into students' responsiveness to a variety of learning environments, including virtual learning environments. Situations may have features that by virtue of their intrinsic character are compelling for most learners. The type of research conducted by Mayer and his colleagues (Mayer, 1997; Mayer & Chandler, 2001), described in detail already, is predicated on the assumption that some characteristics of virtual learning environments will have similar impacts on most learners. Knowledge of these characteristics can then be used to inform instructional design. In addition, learners have personal motive systems and organized networks of schemas and effects that may be salient or require specific situational cues to bring them into prominence.

Some of the investigations into the effects of achievement goals on learning in virtual environments illustrate these patterns of relationships. A group of 11th and 12th grade students used the RiverWeb Water Quality Simulator (Azevedo et al., 2002) to learn about ecological systems and water quality. RiverWeb is a simulation that presents a wide range of scientific data on water systems and water quality. Students engage in a "simulated field trip through a prototypical watershed" and are able to explore the effects of a range of land uses on water quality. The exercise continued over 3 weeks. Students were randomly assigned to two instructional conditions; learner-generated goals or teacher-generated goals. In the learner-generated goals condition the broad goals of the whole learning exercise were presented and within this framework students were free to set their own specific goals. In the teacher-generated goals condition students followed a plan of goals determined by the teacher. Azevedo et al., monitored students' knowledge and understanding across the course of this curriculum exercise, and found that the performance of both groups improved. However, the group which was able to generate their own specific learning goals showed a greater shift in their mental models of how ecological systems operate. Consider what is likely to have happened in these learning environments in terms of the interaction between person and situation. In this experiment the situation has set specific limits on the goal-setting procedure. Students' purposes for their learning in the teacher-generated goal group were tightly controlled by the situation. For the learner-generated goal group the situation defined certain general purposes but within that framework students' own purposes in learning could be expressed. It might be expected that students with similar levels of mastery goals who are assigned to different conditions would be expected to have very different learning experiences and, in consequence, achieve different learning outcomes. What is especially important about the experience and learning for the learner-generated goal group is that it highlights one process whereby the personal and the situational combine. Personal achievement goals were mediated by situational affordances.

In another study (Pearce & Ainley, 2002), first year undergraduate students used a web-based instructional unit designed for exploring the physics of waves. Students' achievement goal orientations as well as some specific reactions to the learning task were recorded on-line. It was reported that after allowing for differences in prior physics knowledge, students with higher mastery goal orientation scores (wanting to understand and improve competence) were likely to report higher levels of interest in this specific topic and were more likely to choose interactive options within the program. When this was related to performance on test questions that involved application of the physics principle to a new situation, the effects of mastery goal orientation were mediated by interest in the topic. Situational cues that triggered interest brought into play students' more general purposes for their learning. The framework illustrated above for achievement goals can also be applied to other motivational constructs. In some recent work investigating dimensions of student interest through responsiveness to text materials accessed through an interactive learning task, the relationship between students' curiosity as a personal variable and interest triggered by specific popular text material was mediated by individual interest (Richardson, 2002).

Key to the connection between the situation and the person is the learner's perception of the learning situation and their perception of themselves as learners (Boekaerts, 1996). For the educator or the instructional designer this requires appreciation of the range of learners' subjective experience, their appraisals of the situation, and the specific self-schema activated or made salient by the appraisal process. The active psychological state draws on both person and context and the question is to identify within particular virtual learning environments the critical form(s) of interdependence between person and situation that occur. The quality of subjective experience is not just an outcome of personality characteristics, it is also a function of the situation as perceived and interpreted by the student.

8. GENDER AND VIRTUAL LEARNING ENVIRONMENTS

Gender is a factor that has been implicated in a wide range of educational outcomes and continues to provide important insights into educational processes (Wigfield & Eccles, 2000). Many of the investigations that have sought to understand why gender is such an important factor have suggested that gender represents critical dimensions of individual's understanding of themselves. This has been documented in terms of teachers' attitudes and perceptions of their students. Students also report differences in attitudes and behavior associated with gender and are aware of specific expectations and pressures associated with these gender differences (Holden, 2002). Patterns of attitudes and actions associated with gender can be understood in terms of the self-understandings or self-schema that have been developed through both the child's biological makeup and their social and cultural experiences (Fivush, 1998). It is not surprising to find similar gender differences when students' attitudes and behavior in virtual learning environments are considered. For example, computer games have always been consumed more avidly by boys than girls (Subrahmanyam et al., 2002).

A recent investigation into the relationship between using a home computer and students' educational use of information technology (Selwyn, 1998) with a sample of 16- to 19-year-olds reported that more positive attitudes were associated with use of a computer at home. In this sample, young men were significantly more likely to have a computer at home than were their female peers. In addition, those young women who did have a computer at home were likely to use it less frequently. Patterns of ownership and use can clearly be shown to be linked to gender. However, there is some evidence that these gender patterns may also be age related. For example, Bergin et al. (1993) reported that this gender bias is "mild or non-existent in pre-school and kindergarten" (p. 438). They argue that gender differences reported with older children represent a personal self-concept of ability focused on computers. This argument is analogous to the self-concept of ability processes that have been shown to account for gender differences in subjects such as maths and science (Dickhauser & Stiensmeier-Pelster, 2002; Wigfield & Eccles, 2000). The psychological process mechanisms here are very similar to what we have described above in terms of person and situation. The personal or self-schema concerned with self-concept of ability incorporated motivational dimensions concerned with success and failure expectations and value dimensions. These self-schema are activated in virtual learning environments and influence the specific learning behavior. A substantial part of what has been studied as computer anxiety, again often observed along gender lines, involves the expectations of failure and threat made salient by the virtual learning environment. A recent study of children from 5 to 12 years of age (Downes, 2002) involved detailed observation of the way children used computers at home and at school. Downes suggested that the development of familiarity with computers was a motivational issue, and drawing on Dewey's writings referred to his concepts of "playful seriousness and serious play". Home use of computers was more likely to show patterns of shifting focus from play to work back to play and so students were able to "complete purposeful tasks through playful means". This blurring of the lines between play and work in home use of computers was in strong contrast to the patterns of use these same children experienced within their school classrooms. Classroom computer use was generally teacher directed and the content of computer experiences predominantly directed to achieving specific criteria in what are referred to as "key learning areas". These experiences while of interest in themselves, also contribute to the development of the self-schema, or self-concept of ability that will be activated in succeeding computer experiences (Downes, 2002).

In this brief, and by no means exhaustive, review of factors influencing students' reactions to virtual learning environments, we have attempted to highlight the importance of considering the impact of both situational and individual factors. Comparisons of the learning outcomes resulting from various forms of virtual learning environments and more traditional methods have generally shown that virtual learning environments can produce higher learning outcomes. But it is also clear that motivational factors also influence learning outcomes. Research findings point to the critical role of motivational processes, such as interest, to direct and sustain learning, and demonstrate how specific design features of virtual learning environments can enhance students' interest and engagement and produce stronger learning outcomes. However, the social character of learners and the influence this can have on the level of interactivity within virtual learning environments also needs to be taken into account.

While the research findings to date allow us to paint a broad picture of the effectiveness of virtual learning environments in comparison to traditional learning situations, there is still much work to be done. Research paradigms that emphasize the real-time reactivity of students to features of the learning environment have the potential to add considerably to our understanding of students' reactions to learning environments. Just as educators have been innovative in their use of the new technologies, so too researchers are beginning to utilize the functionality available in virtual learning environments to provide important insights into learning not easily obtained in more traditional settings. Future work in this area needs to ensure that the critical role of individual and situational factors discussed in this chapter continue to be acknowledged so that the human aspect of virtual learning environments is not lost.

ENDNOTE

1. These questions were an "international option". Twenty of the 32 countries participating in PISA 2000 took this option.

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