5-1-2010

` You know I hate it when people half ass things': a case study of a high school science student and the role of pre-instructional activities, goal orientation, and self-efficacy in learning with simulations

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'YOU KNOW I HATE IT WHEN PEOPLE HALF ASS THINGS': A CASE STUDY OF A HIGH SCHOOL SCIENCE STUDENT AND THE ROLE OF PRE-INSTRUCTIONAL ACTIVITIES, GOAL ORIENTATION, AND SELF-EFFICACY IN LEARNING WITH SIMULATIONS

A Dissertation Submitted in Partial Fulfillment
of the Requirements for the Degree of
Doctor of Philosophy

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College of Education and Behavioral Sciences
School of Applied Psychology and Counselor Education
Program of Educational Technology

May, 2010

This Dissertation by: Samuel Helms

Entitled: '*You Know I Hate it When People Half Ass Things'*: *A Case Study of a High School Science Student and the Role of Pre-instructional Activities, Goal Orientation, and Self-Efficacy in Learning with Simulations*

has been approved as meeting the requirement for the Degree of Doctor of Philosophy in the College of Education and Behavioral Sciences in the School of Educational Research, Leadership, and Technology, Program of Educational Technology

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ABSTRACT

Helms, Samuel Arthur. *'You Know I Hate it When People Half Ass Things': A Case Study of a High School Science Student and the Role of Pre-instructional Activities, Goal Orientation, and Self-Efficacy in Learning With Simulations.* Published Doctor of Philosophy dissertation, University of Northern Colorado, 2010.

This single subject case study followed a high school student and his use of a simulation of marine ecosystems. The study examined his metaworld, motivation, and learning before, during and after using the simulation. A briefing was conceptualized based on the literature on pre-instructional activities, advance organizers, and performance objectives. The briefing was a series of formal lessons before the participant began to use the simulation for the purposes of learning. The research questions focused on how the briefing influenced the participant's metaworld, self-efficacy, goal orientation, prerequisite knowledge, and the themes that emerged from the data, which helped explain how the briefing influenced the participant's learning.

Results centered on four themes: (a) unanticipated or desired goal orientation; (b) perceptions of self-efficacy; (c) perceptions of quality work; and (d) lack of responsiveness. The literature on goal orientation and self-efficacy was used to explain and unite the themes. The data suggested that the participant's performance-avoidance goal mediated between his high self-efficacy and low performance. Also, in cases where the participant has a performance-avoidance goal, the briefing may have no influence on

learning with a simulation. Lastly, the briefing may be defined in two ways: informal and formal.

Future research could examine how metaworld can be formed outside of a formal briefing, and how prior experiences influence the formation of metaworld, goal orientation, and self-efficacy when learning with simulations. Researchers could also examine ways to strengthen a weak metaworld that does not inspire the learner to explore the simulation. Another area for future research is how goal orientation and self-efficacy influence the formation of metaworld.

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CHAPTER 1

STATEMENT OF THE PROBLEM

Introduction to the Problem

Simulations are “evolving case studies of a particular social or physical reality” (Gredler, 2002, p. 834). They are created by adapting a real situation or process to a predefined context and medium. For example, a flight simulator adapts the real processes of flying a plane to a computer platform. The real context for a simulation is called the reference system and is what the simulation attempts to mimic (Asakawa, & Gilbert, 2003; Jacobs & Dempsey, 1993; Peters, Visser, & Heijne, 1998).

Researchers have not agreed on a single universal definition of “simulation.” Despite this, one can draw some similarities. First, it is generally agreed that simulations are a type of interactive learning environment (de Jong, 1991; Edwards, 1995; Papert, 1980; Reiber, 2004). The interactivity comes from the user’s ability to have dynamic, immediate, and interpretable feedback from the simulation (Edwards, 1995). This feedback then helps guide the user’s next action, leading to more feedback from the simulation. Second, the environment of a simulation should be rich enough to allow learners to become immersed in the dynamics of the learning experience (Gredler, 1996, 2002; Papert, 1980). Learners should be able to freely explore the simulation’s

environment, with or without guidance, interacting with numerous variables and situations. How rich an environment needs to be before it is considered a simulation varies from author to author. For example, Papert's (1980) definition implies a free space learners can explore at will with few limitations.

Several benefits of simulations as educational tools have been identified. Improved problem solving abilities is one of the more intriguing benefits of simulations (de Jong & van Joolingen, 1998; Gredler, 1996, 2002). Also, simulations engender a sense of curiosity in learners by providing a problem with context and sometimes a background story.

Some research argues that by providing a context and allowing learners to explore a complex system, simulations help users learn to diagnose and manage difficult problems (Gredler, 1996, 2002). The catch, as identified by de Jong and van Joolingen (1998), is that providing learners who do not have well-developed self-regulation strategies for managing complex learning environments, will quickly result in cognitive overload. However, not providing learners with a rich, dynamic environment in which to test hypotheses (whether it be by trial-and-error or a scientific approach) does not provide a flexible enough environment for using problem-solving skills (de Jong & van Joolingen, 1998).

Much of the research on simulations focuses on the technology and methods needed to create an environment rich enough for immersive exploration, but user-friendly enough to avoid overloading the learner with information. The literature regarding the development of simulations typically focuses on technology, such as programming tools. For example, Chittaro and Ranon (2007) discuss the potential use of Web3D technologies

such as VRML and X3D to create educational virtual environments (EVEs). Reviewing prior research into simulations, Gredler (1996, 2002) focuses primarily on the characteristics of simulation design (i.e. number of variables, learner's interaction with the variables). While research into these areas is important for developing simulations as an educational tool, it does not represent the full context of simulations in education. Specifically, how activities used in addition to simulations influence students' interaction with the simulation, and how simulations are positioned in the lesson, is not well understood.

Several studies have called for more research regarding the context that should surround simulations. Other authors have mentioned too much time is spent discussing technology dependant aspects such as fidelity and not enough discussing the best practices of simulations (viz., Dickey, 2005a; Gredler, 1996, 2002; Jacobs & Dempsey, 1993). Despite this, the discussions of how such a context might look are anecdotal observations ancillary to the main thrust of research. In much of the literature examined in the next chapter, authors focus on the technology of simulations.

In the classroom, simulations are not used in a vacuum. They are part of a larger lesson plan and curriculum and are used to reach specified objectives, as are other instructional tools. For example, a video on exploring the deep sea might be preceded by a lecture regarding the abyssal plane, Mariana Trench, and continental shelves. Thus, how simulations are contextualized in a lesson is an important consideration. The context surrounding the use of simulations in the classroom has at least two parts: before the simulation and after the simulation. There is an extensive amount of research regarding the debriefing, or activities following simulation engagement. Several authors have

proposed models and frameworks for the debriefing (Lederman, 1992; Petranek, 2000; Petranek, Corey, & Black, 1992; Steinwachs, 1992), and now it is understood that a proper debriefing is critical to learning with simulations (Petranek, 2000).

Several researchers provide excellent debriefing models, identifying how each aspect of the debriefing affects learning. It is clear, for example, that the debriefing should occur immediately after students finish using a simulation so that the experience is still fresh in their minds (Petranek, 2000). The facilitator then directs the conversation from descriptions to analysis and finally to situations other than those presented in the simulation (Steinwachs, 1992). Thus, students' learning context progressively develops from surface descriptions of their own actions (knowledge), to analogy and analysis of their and others' actions, and finally to a synthesis and evaluation of diverse contexts. However, there is less research on what activities should take place before learners use the simulation.

For the purposes of clarification, the context provided before the use of a simulation, including other instructional activities, explanations, interactions, and other activities used to introduce students to the simulation, will be referred to as the briefing. This implies a connection to debriefing and provides a narrative frame. What exactly comprises the briefing is hinted at in the literature and will be examined here; however, a specific model does not exist. There are anecdotal reports from several authors indicating how simulations are presented to students, can make a significant difference in how students learn. Limited research has been done to date (quantitative or qualitative) specifically addressing this issue. Nevertheless, a few authors have mentioned the need to examine events preceding the use of a simulation.

Several early studies have noted the need to clarify the instructional activities preceding the use of a simulation. Bredemeier & Greenblat (1981) present a review of the literature and illustrate many of the early views of simulations and games in education. They argue for a very rigid structure of using simulations in education by controlling the variables in the world and comparing simulations with other types of learning. However, the authors also note that "how a game is run and who runs it appear to make a difference" in the learning outcomes, as well as an "introduction" to the game used before students play (p. 310). This introduction is the brainstorm leading to the development of the briefing phase.

Barnett (1984) is one of the earlier authors citing a need to refine "game theory to identify which aspects of the technique [of using games and simulations in education] are likely to influence specific types of learning," and cites the need to state learning objectives during the construction of the simulation (p. 168). As with Bredemeier & Greenblat (1981), the author identifies the need for a thorough description of the briefing, in this case suggesting it should include a stated list of learning objectives.

Butler (2005) presents anecdotal evidence that how the simulation is presented to learners can greatly enhance motivation. Using a simulation of American colonial life, he was able to demonstrate that by having characters in the simulation, the students experienced the passing of taxes as colonists, rather than simply as students. This encouraged the students to do their own research during the simulation to prepare for future taxes. Butler's (2005) study illustrates the importance of encouraging motivation before using a simulation.

Additionally, Gagné and Briggs (1979) identify three key steps before "presenting the stimulus material" (the simulation) to the learners (p. 157). They are "gaining attention, informing the learner of the objective, [and] stimulating recall of prerequisite learnings" (p. 157). Although the authors were not referring to simulations specifically in their writing, it is reasonable to expect that the same three steps apply to simulations as they would to other learning material. However, it has not been examined how these first three steps may change when simulations are used.

The calls of Bredemeier & Greenblat (1981) and Barnett (1984) for more research regarding how events before using a simulation influence learning have only partial answers; however, two interesting trends appear in the literature. First, Bredemeier & Greenblat (1981) identify how a simulation is presented to the learners and how learners perceive the simulation, influence how engaged and motivated learners will be while using the simulation. Second, Elshout and Veenman (1992) note that domain knowledge given before using a simulation can influence how learners problem-solve while using the simulation. Thus, there are at least two components of a briefing: building learners' perceptions of the simulation to establish motivation, and delivery of domain specific knowledge.

To better classify these two categories of influence, some new terminology is needed. Borrowing from Edwards' (2004) discussion of text based role-playing games, the learners' perceptions and understandings of the simulation before engagement are called learners' metaworlds. Metaworld is formed by everything learners encounter about a simulation before engagement with the simulation itself.

All the skills, knowledge, and understanding learners need to successfully engage the simulation will be called prerequisite knowledge. Prerequisite knowledge includes simulation-specific information, such as reading the directions, and domain-specific information. Elshout and Veenman (1992) identify several sources of prerequisite knowledge. Domain-specific information about heat exchange and temperature might have, according to the authors, helped low-intelligence students practice better problem solving strategies. Also, before using the simulation the authors provided all subjects with a 'short instruction about operating the Macintosh computer" (p. 136). Under the definition presented, this instruction would also be considered prerequisite knowledge, since learners could not have used the simulation without first knowing how to use its medium (the computer).

Prerequisite knowledge summarizes the facts, concepts, and other intellectual learnings the student has of the domain before using the simulation. Metaworld, on the other hand, summarizes a student's attitudes, beliefs, and perceptions of the simulation. For example, the rules of the simulation would be prerequisite knowledge since the student will need these rules to successfully engage the simulation. Whether or not the student believes the simulation will be fun is a matter of metaworld. Metaworld is more attitude-based and prerequisite knowledge is more fact-based.

Metaworld and prerequisite knowledge are two key aspects of the briefing. Anecdotal observations by Barnett (1984) and Butler (2005) have indicated these three components might play a significant role in how students learn using simulations. However, there have been no studies conducted to specifically address this issue.

As indicated earlier, this is a huge gap in our understanding and in research regarding how simulations can be used most effectively as educational tools.

In part to answer the calls of Bredemeier & Greenblat (1981) and Barnett (1984), and in part to continue examining the phenomena described by Butler (2005), the purpose of this study is to examine how metaworld and prerequisite knowledge formed in a briefing affect the participant's learning with a simulation.

Research Questions

Q1 How does the briefing affect the participant's metaworld, prerequisite knowledge, and subsequent use of the simulation?

Q2 What are the themes that emerge in interviews and the participant's comments regarding his metaworld, prerequisite knowledge, and use of the simulation?

Definition of Terms

Briefing: All context provided to learners before the educational engagement, such as instructional activities, discussions, advertisements, and other media (Asakawa & Gilbert, 2003; Barnett, 1984; Dwyer & Lopez, 2001). In the present study, the briefing was the first four weeks of the study and ended when animals were added to the simulation.

Engagement: The moment when learners begin to use the simulation for learning. In this study, engagement began when animals were added to the simulation.

Metaworld: Learners' perceptions of and attitudes towards the simulation before engagement (Butler, 2005; Edwards, 2004).

Prerequisite knowledge: All facts and skills learners need to successfully engage the simulation, including the mechanics and any domain-specific information. Prerequisite knowledge is identified and listed by the facilitators (teachers) during

the construction of the simulation (Elshout and Veenman, 1992). Some examples of prerequisite knowledge used in this study are the nitrogen cycle, ideal values for calcium, magnesium, nitrate, nitrite, ammonia, and salinity.

Reference system: The real-world scenario being simulated (Peters et al., 1998). In this study, the reference system is coral reef ecosystems simulated by a saltwater aquarium.

Summary

In an effort to help clarify the best context to use simulations as educational tools, this study will attempt to address how a briefing affects a user's learning with simulations. The briefing, as defined for this study, is all information provided to the learner before he engaged the simulation. By understanding how the briefing affects learning, educators will be more equipped to use simulations as effective educational tools.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

A review of the literature relevant to this study crosses several lines of research. To begin with, the concept of a briefing, or some formalized introduction to the lesson to prepare students for the learning materials to come, is not new. In much of the literature, pre-instructional activities, such as explicit performance objectives and advance organizers, are the tools used during this phase. In this chapter, literature related to pre-instructional activities and the use of educational simulations is presented.

Pre-instructional Activities

The Events of Instruction

Gagné and Briggs (1979) describe nine events of instruction based on cognitivist theories of learning. All of the events are designed to support the cognitive principles of attention, selective perception, rehearsal, semantic encoding, retrieval, response organization, feedback, and executive control processes. Attention refers to any stimulus upon which a learner focuses while selective perception "transforms this stimulation into the form of object-features, for storage in short-term memory" (p. 154). Rehearsal keeps information in short term memory and semantic encoding prepares it for storage in long-term memory. To get information from long-term memory back into short-term memory, the process of retrieval is employed. Response organization "selects and organizes

performance" and feedback reinforces these performances (p. 155). Finally, executive control processes are involved in the management of all other processes.

Although the learner can perform all these operations independently, Gagné and Briggs (1979) suggest explicitly prompting them via the nine events of instruction:

1. Gaining attention
2. Informing learner of the objective
3. Stimulating recall of prerequisite learnings
4. Presenting the stimulus material
5. Providing "learning guidance"
6. Eliciting the performance
7. Providing feedback about performance corrections
8. Assessing the performance
9. Enhancing retention and transfer. (Gagné & Briggs, 1979, p. 157)

One application of the instruction events would be to consider the simulation as the stimulus, much like other instructional tools such as textbooks, movies, lectures, etc. In other cases, simulations might be used to gain attention by providing a context for the material to be learned. This is not the deliberate use of simulations to "support the internal processes of learning" and as such, they are not considered simulations for instruction (p. 155). In the present study, only simulations deliberately used for instructional purposes are considered.

The first three events could comprise a briefing when the simulation is considered the stimulus material. Therefore, the briefing should: (a) gain learners' attentions; (b) inform learners of the objectives; and (c) stimulate the recall of prerequisite learning. These first three events link to critical processes in the cognitivist model of learning, specifically to retention, executive control, and retrieval.

When using complex simulations, gaining the learner's attention in the briefing is critical for the establishment of continuing motivation (Rieber, 1996). Learners will need

this motivation to remain engaged with the simulation and work through complex problems. Related to this is the second event, informing the learner of the objective. The objective "will be used as an indication that learning has, in fact, been accomplished" (Gagné & Briggs, 1979, p. 158). Gagné and Briggs (1979) make the point that sometimes the objectives may be obvious. For example, the participants may quickly conclude the learning objective is to establish a reef tank. However, it is "probably best not to take the chance of assuming that the student knows what the objective of the lesson is" (p. 158). In this study, explicit learning objectives were provided.

Stimulating the recall of prerequisite learning, the last event of the briefing, links the simulation to known concepts, knowledge, and understanding. This last event "may be critical for the essential event of learning" (Gagné & Briggs, 1979, p. 159). In addition to combining the material being manipulated in the simulation with prior learning, this event would include the prerequisite knowledge needed to successfully engage the simulation. Prerequisite knowledge includes learning the mechanics of the simulation and may actually involve some pre-engagement with the simulation itself.

Martin, Klein, and Sullivan (2004) examined the individual effects of Gagné's nine events of instruction by systematically removing one at a time from a learning experience. Specifically, the authors measured the relative effects on learning and attitudes when practice, examples, or the presentation of objectives prior to learning was removed. They found the greatest significant difference in both learning and attitudes when the opportunity to practice was removed. Subjects had an average post-test score 2.63 points below the full program. Removing examples and not stating learning objectives before instruction did not yield significant results.

Martin et al., (2004) cited prior research supporting "when computer-based instruction is systematically designed, the presence of objectives for students may not increase their achievement" (p. 637), and their well-organized instruction might have masked the effects of removing stated learning objectives. Additionally, students' attitudes toward the lesson were more favorable when the objectives were *not* stated in the beginning. The authors speculate "students may be unaware of the absence of objectives when other elements such as practice are included in the program" (p. 637). From these findings, the authors conclude that when using well-structured instruction with practice and examples, stating learning objectives in the beginning as a pre-instructional activity is not beneficial.

There are three types of pre-instructional activities described in the cognitivist research that may benefit the briefing for educational simulations. These are often studied together. They are performance objectives, advance organizers, and overviews (Duchastel & Brown, 1974; Duchastel & Merrill, 1973; Hannafin, 1987; Klein, 1994; Mayer, 1977; Rothkopf & Kaplan, 1972). Often, one goal of these studies is to test whether or not students' post-test scores actually benefit when the students are informed of the objectives. Another common goal in the research is to examine how these performance objectives should be written and presented to the students.

The second type of pre-instructional activity is an advance organizer. Ausubel (1960) describes the use of advance organizers, which are high-concept descriptions of the learning material. An advance organizer should provide the "initial anchorage" for the new concepts to be learned (Ausubel, 1963, p.143). Anchors of this kind are the "primary prerequisite for subsequent learning, and, by definition, for sequential transfer" (p. 143).

Thus, an advance organizer should "insure that relevantly anchoring ideas will be available" to the learner when encountering new concepts (p. 145). These anchors may be unknown by the learner, or if known, may not be understood to be relevant to the new concepts. In the research, advance organizers typically take the form of verbal information presented as a short passage or outline. When advance organizers are displayed in a graphic format, they typically are referred to as concept maps (Anju, 1991; Willerman & Harg, 1991). The research regarding concept maps will be addressed separately from verbal advance organizers since many studies directly compare the two methods.

Structured overviews, the third type of pre-instructional activity, are at the same level of generality and abstraction as the material itself, but frequently are called advance organizers in some of the literature (Chung & Huang, 1998; Fordham, Wellman, Sandmann, 2002). It is not clear to the reader whether what the authors claim as an advance organizer meets Ausubel's original descriptions or not (1960, 1963). This makes analyzing the research difficult and may explain some of the discrepancies between the studies. In this literature review, structured overviews are presented as improperly defined advance organizers.

Performance Objectives

The effectiveness of presenting the learners with the objectives has been extensively examined in the literature. For the present study only those given to the learners before the stimulus material will be considered.

Performance objectives and learning. Duchastel and Merrill (1973) identify three functions of behavioral objectives: (a) direction in teaching; (b) guidance in evaluation; and (c) facilitation of learning. Of these three functions, their article focuses on research in the facilitation effects of behavioral objectives (i.e. objectives in pre-instructional activities). The first set of studies addressed whether showing students objectives before the lesson had a positive effect on learning. The authors concluded there is insufficient evidence to support any conclusion due to inconsistent results. Some of their studies found presenting objectives before a lesson was beneficial, while others found no effect or even a negative effect.

The second set of studies "sought interactions between type of learning and availability of objectives", to distinguish knowledge from other types of learning, although these categories are frequently ill defined (Duchastel & Merrill, 1973, p. 57). Overall, the studies showed no interaction effect between type of learning and objectives. The third set of studies investigating a relationship between learner characteristics and objectives yielded similar conclusions.

The last group of studies presented by Duchastel and Merrill (1973) examined whether objectives would reduce the time necessary for subjects to learn the material. These studies were more consistent and suggested presenting learners with objectives did reduce the time it took to complete a lesson by encouraging learners to spend more time on task.

Despite the inconsistent nature of the findings in this article, Duchastel and Merrill (1973) conclude there is enough evidence to suggest using behavioral objectives prior to a lesson. Their argument for this conclusion is although many studies found no

statistical differences between groups, “those that *have* found such an effect have usually favored the presentation of objectives” (p. 63, emphasis in original).

In a related study, Mayer (1977) summarized the implications of a series of three experiments by suggesting that an unintentional advance organizer “provided subjects with a way of assimilating new information to an integrated set of past experiences” (p. 545). Other groups who were given performance objectives demonstrated a potential limitation of this pre-instructional activity. The performance objectives may have caused the subjects to ignore the “underlying *cognitive objectives*” of the lesson (p. 545, emphasis in original).

Hannafin (1987) examined effects of orienting activities on learning when students used computer-based instruction. Behavioral and cognitive orienting activities were presented as introductory slides to a computer-based lesson. The behavioral activity contained two performance objectives, while the cognitive activity presented two high-level concepts. The researcher found significant interactive effects, using a between orienting activity and cueing, and a between orienting activity and practice. Cueing techniques proved to be more effective with the behavioral activity, and practice improved post-test scores more when paired with the cognitive activity. Hannafin (1987) did not find a significant effect for orienting activities themselves. The author speculates that the effects of orienting activities may be greatest in “less powerful or poorly organized lessons” (p. 51).

Klein (1994) found groups of students who were given objectives before a lesson spent more time on task than groups given advance organizers, or a control group given no pre-instructional activities. The effects on learning of performance objectives and

advance organizers where overshadowed by the type of practice in which the groups engaged. The author speculated that students have more experience with performance objectives and knew to direct their behavior to meet the objectives.

Incidental learning. In one of the earlier studies on performance objectives, Rothkopf and Kaplan (1972) examined the effects of dense performance objectives on both intentional and incidental learning. The authors defined density as the number of sentences in the learning objectives "empirically determined to be relevant to one of the objectives" (p. 296). They used a four-group comparison to examine the effects of density on intentional and incidental learning. The research suggested "specific objectives resulted in higher performance on intentional items than general objectives" (p. 298). Specific objectives, however, did not have any significant effect on incidental learning. Objective density and number of items recalled on a post-test were inversely related; the denser the objectives, the fewer items recalled correctly.

Duchastel and Brown (1974) investigated "various reasons why objectives could possibly be helpful to students" (p. 481). One issue, which persists in later research as well, is whether giving students performance objectives as a pre-instructional activity limits their incidental learning. Another issue, which the authors cite as a reason for their study, is the inconsistent data on whether performance objectives aid learning at all. The authors suggest that if students do not know that the "post-test which they will be taking is directly referenced to the objectives presented to them," the positive effects of this activity may not be realized (p. 482). In a sense, the students may see the list of objectives more as guidelines for reading rather than actual objectives.

To test performance objectives' effects on purposeful and incidental learning, the authors first controlled for subjects' understanding of what these objectives were. This was accomplished by having the subjects take four other tests on material presented with performance objectives. This ensured "that the students were fully aware, during the experiment, of the role played by objectives in learning" (Duchastel & Brown, 1974, p. 482). The authors used 58 college students in a control-group experimental design. One group was presented 24 objectives, and the other was not. Results suggested "that relevant learning was enhanced by the availability of objectives" (Duchastel & Brown, 1974, p. 483). As well, incidental learning was lower for the group receiving the objectives than the control group. Subjects given objectives performed better on post-test questions relating directly to the objectives, but poorly on questions not related to the objectives. Subjects in the control group performed equally well on both sets of questions. Based on these data, the researchers suggest performance objectives do increase learning on questions relating to the objectives, but reduce incidental learning.

Conclusions. There is enough evidence in the literature to support using performance objectives as pre-instructional activities in a briefing for this study. However, the most prevalent implication for the present study is that stating performance objectives may reduce incidental learning (Duchastel & Brown, 1974; Hannafin, 1987; Klein & Cavalier, 1999; Mayer, 1977).

Advance Organizers

Introduction: defining advance organizers. Before moving into the literature on advance organizers specifically, it is necessary to present a standard definition. Because the concept of advance organizers can be rather mercurial, not only might these activities

be difficult for the reader to visualize, but also many researchers have come up with their own definitions, some of which veer quite far from Ausubel's (1963) original idea, while others lament the lack of a concrete definition (Weisberg, 1970).

An important distinction needs to be made between Ausubellian advance organizers and overviews. Overviews present the main ideas of the new material and "largely achieve their effect by repetition and simplification" (Ausubel, 1963, p. 165). In contrast, advance organizers are "presented at a higher level of abstraction, generality, and inclusiveness" than the material to be learned (p. 165). Mayer (1979) gives five distinct characteristics of advance organizers, following Ausubel's (1963) original definition:

1. A short set of verbal or visual information;
2. Presented prior to learning a larger body of to-be-learned information;
3. Containing no specific content from the to-be-learned information;
4. Providing a means of generating the logical relationships among the elements in the to-be-learned information;
5. Influencing the learner's encoding process. (p. 382)

The characteristic of shortness generally is adhered to in the literature, but is itself not enough to differentiate advance organizers from overviews. That an advance organizer is presented before the actual presentation of the content to be learned is excepted, and sets an advance organizer as a tool within the first three events of instruction described by Gagné (1965). However, introductions and overviews also are presented before the lesson.

That advance organizers not contain any specific information to be presented in the lesson is a distinguishing factor (the third listed above). Overviews and introductions list the main points or key facts of the lesson; facts that may very well be on a post-test. Advance organizers, in contrast, do not contain specific information that would help a

learner on a later examination for specific knowledge-based content (Ausubel, 1960). This key distinguishing characteristic will be used to critically evaluate the literature on advance organizers as pre-instructional tools. Some authors do not adhere to this characteristic.

Advance organizers in learning models. Several authors included advance organizers and concept maps, a visual advance organizer, in their models. Hung and Chao (2007) proposed a model of "Matrix-Aided Performance Systems" (MAPS) to aid in the use of electronic performance systems (EPSS). Part of the MAPS model makes use of advance organizers that present "an overall structure of a knowledge domain [by] building on what users already know to help them bridge the gap from already-mastered knowledge" to the new information presented in the EPSS (p. 184). Their use of advance organizers in this context is consistent with Mayer's (1979) characteristics above, and with Ausubel's (1960) description.

Additionally, advance organizers and concept maps play a key role in Coffey and Cañas' (2002-2003) proposal of a Learning Environment Organizer (LEO). The central function of LEO is to provide "the learner with a graphical advance organizer" for the entire set of course material (p. 276). The organizer is itself a graphical concept map that "presents non-linear representations of information and knowledge to be learned" (p. 278). Their use of concept maps in this light is consistent with Ausubel's (1960) and Mayer's (1979) definitions.

Early Research. Ausubel (1960) examined the effect of an advance organizer in a two-group controlled experiment. The assumption of the study was that presenting learners with "appropriate and relevant subsuming concepts (organizers)" before "the

learning of unfamiliar academic material" should enhance recall and retention of the material (p. 267). To examine this claim, the author used 120 undergraduate students to create two groups: an experimental group given an advance organizer followed by a 2,500-word passage, and a control group given the main passage and an introductory passage containing historical information. The advance organizer was "introductory passage," text based, containing "background material for the learning passage which was presented at a much higher level of abstraction, generality, and inclusiveness than the" main text passage (p. 128), and "provided not direct advantage in answering the [post-]test items" (p. 270).

The experimental group's average test score was 16.7 while the control group's score was 14.1. Although not statistically significant, the author used the results to argue for the inclusion of advance organizers in textbooks and lessons introducing unfamiliar material to students. Additionally, the author claims the "retention of the learning material was tested 3 days later" and these results "unequivocally supported the hypothesis," although no data or analysis are given (Ausubel, 1960, p. 271).

One of the concerns with using advance organizers to compare previously learned material with new material is the risk that the two topics will not be discriminable to the learner. For example, Ausubel and Fitzgerald (1961) theorize:

> It is assumed, in other words, that only discriminable categorical variants of previously learned concepts have long-term retention potentialities. Thus, if a *comparative* type of organizer could first delineate clearly, precisely, and explicitly the principle similarities and differences between the new learning passage (Buddhism) and existing, related concepts in cognitive structure (Christianity), it seems reasonable to suppose that the more detailed Buddhist ideas would be grasped later with fewer ambiguities, fewer competing meanings, and fewer misconceptions…. (p. 266, emphasis in original)

It follows that the more an advance organizer can discriminate between the learner's prior knowledge and the new material, the more it would facilitate learning of the new ideas. However, this is predicated on the amount of prior knowledge the learner has. To use the authors' example, a comparative organizer on the similarities and differences between Christianity (the prior knowledge) and Buddhism (the new material) is of little value if the learner does not know much about Christianity in the first place (Ausubel & Fitzgerald, 1961).

To gather some empirical data regarding these theories, Ausubel and Fitzgerald (1961) compare the effects of a historical introduction (control), a comparative advance organizer (indicating direct comparisons between Christianity and Buddhism), and an expository advance organizer (describing Buddhism in an abstract way) on subjects' post-test scores. In all of these pre-instructional activities, "no information was included…that could constitute a direct advantage in answering" post-test questions on Buddhism (p. 268). This is a key characteristic Mayer (1979) picks up later for his definition of advance organizers.

The data suggested the comparative organizer increased retention of the Buddhism material more than the other two conditions after a three-day interval. In addition, subjects who already knew a lot about Christianity benefited little from the comparative organizer. These subjects would already have the prerequisite knowledge about Christianity to form their own mental organizer. After a ten-day interval, both of the advance organizer groups retained more material than the historical passage/control group. These results reinforce the importance of prior knowledge in discriminating and forming comparative mental organizers.

In a follow-up study, Ausubel and Fitzgerald (1962) used a text completely unfamiliar to the subjects. Using a two-group comparison with verbal ability as a covariate, the authors presented a passage on pubescence. They first used a pre-test to exclude subjects who already had advanced knowledge of the material, and used the verbal section of the School and College Ability Test (SCAT) to establish verbal ability. As well, each group was given two related passages, but only one pre-instructional activity (historical control or advance organizer) before the first passage.

Results suggested subjects with a lower verbal ability benefited more from the advance organizer than higher ability students did. On the sequential learning from one passage to the next, using SCAT as a covariate, the advance organizer did not help learning from the second passage any more than the control condition. The authors suggest "for organizers to be really effective in enhancing sequential learning and retention, it would probably be necessary to use another organizer prior to the second passage" (Ausubel & Fitzgerald, 1962, p. 248).

Returning to the Christianity and Buddhism topics from earlier, Ausubel and Youssef (1963) further examined the effects of advance organizers on discriminability. They hypothesized that prior understanding of Christianity would have the most benefit on learning Buddhism if it is clear and stable. Also, they theorized that an advance organizer would increase aid in the discrimination between prior learning and the new material, "particularly in those subjects who either have less verbal ability or who find the new material less discriminable" due to their lesser knowledge of Christianity (p. 332). Affirming the results from the previous two studies (Ausubel & Fitzgerald, 1961,

1962), subjects who had greater knowledge of Christianity performed better than those with little prior knowledge did.

Furthermore, advance organizers helped the learning of the Buddhism passage more than a historical introduction, when both verbal and prior knowledge of Christianity were held constant as covariates. However, there was no interaction effect between knowledge of Christianity and the advance organizer condition, refuting the findings from Ausubel and Fitzgerald (1962). The interaction between verbal ability and the advance organizer treatment, however, was significant and supported the earlier findings.

Scandura and Wells (1967) used a game of mathematics "called 'play-like,' which required the subjects to pretend that they were ants. The basic idea was to present certain topological facts about lines, curves, arcs, and networks" on an abstract and generalized level (p. 297). Using four groups, the authors examined the effects of games as advance organizers. Two groups were presented historical introductions as a control and two were given the advance organizer games.

Results indicated the two advance organizer groups performed better than the control groups on post-tests. An additional finding of interest is that none of the groups differed significantly "in mean time spent on the organizers, lesson, and tests" (Scandura & Wells, 1967, p. 298). Based on these results, the authors suggest "the organizer may have made it easier to interpret the abstract statements given in the lesson by providing concrete referents" (p. 300). On the other hand, the organizers may have included information that directly helped the subjects' performances on the post-test, although an honest attempt was made to preclude this.

Debating advance organizer effectiveness. In an influential review of the early literature on advance organizers, Barnes and Clawson (1975) set off a controversy regarding the empirical research on advance organizers. After reviewing the results of 32 studies, the authors concluded there was not enough empirical evidence to support the claims of advance organizers' benefits to learning. Their review was not a statistical meta-analysis. Rather, their conclusions were based on sorting the studies into two columns: ones that supported the use of advance organizers, and those that did not. One problem with this method, as the authors themselves indicate, is "Ausubel has not operationally defined the advance organizer" (p. 653). As a note, Weisberg (1970) made a similar claim earlier.

The lack of a clear definition for advance organizers is Barnes and Clawson's (1975) overall issue with the prior research, even research into visual advance organizers, or concept maps. Additionally, the authors claimed far more research was needed which examined the value of advance organizers for increasing higher-order learning, rather than simple knowledge acquisition. The lack of an operational definition causes problems in the research even after Barnes and Clawson's (1975) article.

In reply to Barnes and Clawson's (1975) review of advance organizer research, Lawton and Wanska (1977) bring up several important points relevant for the present study. One of the primary concerns raised in Barnes and Clawson's article, is the lack of an operational definition for advance organizers. Lawton and Wanska (1977) reply by detailing the functions and uses of advance organizers as described by Ausubel (1960, 1963). Additionally, they point out the futility of comparing studies if no agreed-upon definition yet exists.

Because Barnes and Clawson's (1975) review was not a statistical meta-analysis, differences in "subjects' age or ability level, length of the treatment, or subject matter taught" were not controlled (Lawton & Wanska, 1977, p. 236). Thus, direct comparisons between the studies are not appropriate. In addition, because many of the prior studies do not give an example of what they consider an advance organizer to be, versus an introductory summary for a control group, one cannot assume they are all the same. For instance, the verbal advance organizer may actually be quite similar to an introductory statement in some studies, yielding no significant differences between treatment and control groups.

Lawton and Wanska (1977) try to provide some concreteness to Ausubel's (1960, 1963) idea of an advance organizer, even though they never give a precise definition or example. "Advance organizers usually consist of verbally expressed 'propositions' [that] involve some reconstruction of the meanings of individual concepts" (p. 239). However, if learners already have the prerequisite knowledge for assimilating the new material, then presenting them with an advance organizer will have no beneficial effect. To control for this, the authors assert future studies should incorporate a pre-test to examine how much prior knowledge learners have of the subject matter. Therefore, advance organizers may have the greatest effects for subjects who do "not have a relevant 'ideational scaffolding' to which *potentially* meaningful new knowledge *may* be related," and for those who need "reorganization, clarification, or extension of existing, relevant high-order ideas" (p. 240, emphasis in original). A properly constructed advance organizer as a pre-instructional activity may help ensure all learners have the same "ideational scaffolding".

Finally, Lawton and Wanska (1977) give several stages for using and developing advance organizers. Their recommendations in their entirety are presented here for comparison purposes later.

1. Learners should be pre-tested to establish the presence or absence of relevant subsumers.
2. Depending upon the learners' naiveté regarding subject matter and/or "process" concepts, or depending on the status of relevant subsumers possessed by the learner, the appropriate type of organizer to use should then be determined.
3. Subject matter and/or problems should be analyzed to establish high-level concepts and/or high-order skills (which may also be expressed as problem solving strategies).
4. Construction of the advance organizers should proceed according to a potentially valid sequence of intended presentation.
5. In constructing the organizer, the number of concrete props needed to exemplify subject concepts/process concepts/strategies should be determined, according to the naiveté, age, or expected competency of the learners.
6. Related learning activities (in classroom settings), subsequent tasks (in research design), or both should be constructed so they provide relevant particular information, which, if assimilated, leads, by subsumption to the extension of interrelated concepts in cognitive structure…
7. Subsequent tests (formative or summative) should attempt to assess (a) superordinate/subordinate conceptual relationships; (b) propositional learning; and (c) problem solving strategy learning…
8. In research studies, subjects passing the pre-test should be excluded. Only in this way is it possible to achieve non-trivial post-test data.
9. Post-tests that merely assess concept-definition recall or recognition are open to rote-learning contamination.
10. A delayed post-test should also be included to determine learning retention. (pp. 242-243).

Mayer's (1976b) article cited a test in which a random versus an organized order of the frames in the learning material, had no effect on post-test data. If the organizer provides the necessary framework for learning the material, whether they are in the same order or not, may not matter as much as the authors suggest.

In an extensive review of the early literature on advance organizers, and partly in response to Barnes and Clawson's (1975) article, Mayer (1979) asks "In what contexts do

advance organizers seem to work," and "How do they work in these contexts?" (p. 372). To ground the review, the author posits interpreting the results of prior research in the context of Assimilation Encoding Theory (AET). Two of the key predictions of this theory regarding advance organizers are: (a) the new concepts to be learned will be better linked to prior knowledge, thus leading to greater far transfer, called conceptual anchoring; and (b) individual facts and details may be lost in favor of the big picture, called obliterative subsumption.

Furthermore, AET predicts there will be conditions under which advance organizers have little or no effect on learning. First, if the "content and instructional procedure already contained the needed prerequisite concepts" advance organizers would be redundant and not contribute any new structure for the learner (Mayer, 1979, p. 375). Second, an effective advance organizer cannot be created for a set of isolated facts "that lack any systematic overall structure" (p. 375). Third, and most important for evaluating later research, advance organizers that do not "provide an assimilative context" will not be effective, "examples include using a list of key terms or a summary as an advance organizer" (p. 376). Last, learners possessing a wide base of knowledge and understanding in the material to be learned will have no need of an advance organizer, as they already have the prior conceptual anchors to relate the new material. Thus, advance organizers may be more effective for novices than for professionals.

The first set of studies the author examined evaluated the effects of advance organizers on far transfer. In the first study (Mayer, 1979), results supported AET's obliterative subsumption proposition by indicating participants presented with an advance organizer "performed better on far transfer problems but about the same on near transfer

problems" (p. 377). These results were confirmed in the second study; the advance organizer group scored higher on far transfer post-test items. Also, the author notes for both studies that the advance organizers were "designed to add no new content that would be necessary in answering [post-test] questions," a key characteristic differentiating advance organizers from overviews and summaries (p. 377).

AET predicts advance organizers presented before the lesson should help learners link the new information with prior learning and experience, and "they would be expected to recall more idea units concerning general concepts" and to make "inferences and intrusions about related ideas" (Mayer, 1979, p. 378). Conversely, an advance organizer presented after the lesson would not help learners connect the new material with past concepts, and the learners in this case would likely "focus on recalling the technical idea units," or specific bits of knowledge, with "more vague connectives and vague summaries" uniting these bits (p. 378). Mayer (1979) tested this hypothesis using a discriminate analysis which was able to "correctly classify over 76% of the protocols on the basis of these features," supporting the predictions of AET (p. 378).

Higher-ability learners and those with prior knowledge of the material may already have internal advance organizers, and presenting an external one would be ancillary to them. Low-ability learners and those without prior knowledge of the material would not have these pre-created advance organizers, and one would predict researcher-created advance organizers to have a greater effect on these learners. Mayer (1979) tested this hypothesis with SAT scores in math to categorize participants as high-ability or low-ability. Results supported the prediction with a significant interaction effect between ability and advance organizer.

Mayer (1979) also manipulated the organization of the learning material to test the effects of advance organizers on well-organized text and poorly organized text. As hypothesized by Ausubel and Robinson (1969), advance organizers should have the greatest effect on poorly organized text, because a well-organized structure may already contain built-in organizers. Mayer's study provided empirical support of this hypothesis. "Results indicated that the advance organizer resulted in better performance when the text was in random order but not when it was in logical order" (Mayer, 1979, p. 379). As we shall see, these results have important implications for the briefing in general and for advance organizers as pre-instructional tools in learning with simulations.

In another set of research, Mayer (1979) examined the effects of advance organizers and overviews on discovery learning. An advance organizer "that provides the prerequisite concepts" should result in learners acquiring a "broader outcome in which the rule is connected to other aspects of the learner's experience" (p. 379). An overview that presents a formula for learners to use during the discovery process, on the other hand, likely will result in subjects acquiring "a narrow outcome consisting mainly of the algorithm for solution" (p. 379). In other words, providing the formula will result in learners simply plugging it in where needed, without processing the concepts behind the formula. Mayer, Stiehl, and Greeno (1975) conducted a series of studies to examine these predictions. Overall, results supported the predictions above. Groups given the advance organizer of general concepts and prerequisite skills, "excelled on far transfer tasks while the group given the formula introduction excelled on near transfer tasks" (p. 380).

Finally, Mayer (1976b) conducted a series of studies to examine how advance organizers affect higher-order learning. In the first study, subjects presented an advance

organizer before the lesson "acquired a high order algorithm that could be extended to new situations," while the control group acquired a "chain of lower order rules" that were difficult to transfer (Mayer, 1979, p. 380). Similarly, Mayer (1979) found advance organizers to help subjects solve "problems requiring long chains of inference" (p. 380). These results indicate advance organizers support higher order reasoning.

In support of advance organizers. Snapp and Glover (1990) researched the hypothesis that advance organizers should not only aid in the recall of knowledge, but should also aid higher-order thinking such as analysis. To test this, the researchers conducted a series of four studies (one pilot study and three main studies). The pilot study and the first main experiment were identical in structure. In a control-group comparison, subjects were given either a text-based advance organizer or nothing. They then read a passage and took a post-test designed to measure recall of specific knowledge facts. The results showed the experimental group performed better than the control group on the post-test. Using the same materials with different subjects, the researchers changed the post-test to analysis questions that were "far more complex than the knowledge-level questions used" in the first experiment (p. 268). Again, results indicated that an advance organizer enhanced subjects' performances on the post-test. A third experiment repeated the second one with a different group of subjects and found the same results. The results of this series of studies suggest advance organizers help both with simple knowledge recall and with analysis.

Summarizing Ausubel (1963), DaRos and Onwuegbuzie (1999) define an advance organizer as "a set of instructional materials which is related to new material that is presented on a higher level of abstraction, inclusiveness, and generality than the more

detailed and differentiated material to be learned" (p. 4). As such, advance organizers "can be used to provide ideational scaffolding for new ideas and to discern similarities and differences" between prior knowledge and the new concepts to be learned. Typically, an advance organizer is text-based, but many now use images or graphs as well, which others identify as concept maps.

The authors conducted a study comparing several graduate-level classes in a control-group comparison (one group with advance organizers, the other without). Their data yielded a significant difference favoring the advance organizer group.

Duphorne and Gunawardena (2005) tested an advance organizer's effect on critical thinking skills when used with nursing students. Using a variety of statistical tests, the researchers found no significant differences in critical thinking skills between groups using an advance organizer versus those that did not (p = .843). One group using advanced organizers actually had lower scores, though not significantly so, than the other control groups. The researchers suggest the other groups using advance organizers, which did not have a lower critical thinking score than the control groups, "used the organizer as a strategy to assist them in the discussions" (p. 46). These findings suggest advance organizers may have limited use for lessons involving critical thinking.

Supporting higher learning. Mayer (1976a) included advance organizers in a study on the randomization of frames of information. In the first experiment, subjects presented with an advance organizer before the instruction and "allowed to use it during acquisition" performed better on a post-test than a control group (p. 146). Specifically, the groups performed better on items of transfer but performed worse or equally as well as the control group on knowledge acquisition items.

In the second experiment, Mayer (1976a) found that a sequential or random order of the frames had no significant effect on learning. However, “there was an overall superiority of subjects who received pertaining [i.e. the advance organizer] with the model over subjects who did not” (p. 148). The author interprets these results as indicating how the subjects learned the new material. Those presented with the advance organizer “developed outcomes with rich external connections between new material and existing knowledge” whereas those who were not given an advance organizer “added the isolated new information to memory” (p. 149).

Kintsch (1994) presented a summary of a series of experiments on advance organizer’s effects on memory and learning. The author cites earlier research as evidence that advance organizers often facilitate learning of the material in a general sense. For example, subjects in an earlier study who were presented with an advance organizer were better able to make inferences from the material than a control group. However, the control group performed better on items taken directly from the text passage. The author theorizes the advance organizer better connects the background information with the new, and “when a reader needs to use this information productively for inferencing and problem solving, relevant material is more likely to be accessed” (Kintsch, 1994, p. 297).

Kahle and Nordland (1975) failed to find significant differences between an advance organizer treatment group and a control group. The authors measured 38 different post-test variables, and found no significant differences in any of them. However, the authors note that it was difficult to determine which effect was due to which variable.

Comparing types. Pella and Triezenberg (1969) examined the effects of advance organizers on learning physics using "the conceptual scheme of equilibrium as advance 'organizer'" (p. 12). The researchers used three different presentations of this organizer to the students. Group 1 used a verbal organizer. Group 2 used visual sketches and verbal explanations, while Group 3 used mechanical models. The to-be-learned information was presented in nine videos. Statistical analysis of the post-test data indicated that Group 3, using the model, scored higher than the other two groups. However, on post-test questions measuring knowledge or application, the didactic verbal presentation of the organizer was superior.

In another early study directly comparing verbal advance organizers with visual organizers, Weisberg (1970) measured the effects of an advance organizer in three different formats: a graph, a map, and a verbal text passage. Along with an historical introduction control group, the author used a stratified random sample to select subjects for the four groups. Results indicated the greatest significant difference was between the control group and the group using the concept maps as advance organizers. Additionally, the three different organizers formed a statistically significant order in terms of which yielded the highest post-test scores: concept maps, graphs, and verbal. The authors suggest these results "raise serious questions as to the value and use of verbal organizers; especially when other, more fruitful materials are available" (p. 164).

Alexander, Frankiewicz, and Williams (1979) compared the effects of visual and oral advance organizers on elementary school students. In a pilot study, the authors employed 18 subjects, five different instruments, and one cultural-specific instrument to construct the organizer, material, and post-test questions. The authors concede their

methods were exceedingly conservative but cited the delimitations on the study from the elementary school environment.

Along with a control group, the main study had a visual organizer before the learning material, a visual organizer after the material, an oral organizer before, and an oral organizer after. The organizer groups had higher significant retention scores versus the control group. Furthermore, the visual organizer groups scored slightly higher than the other groups, although the scores did not reach statistical significance. Similar findings found in favor of the advance organizers versus the post organizers.

Glover, Bullock, and Dietzer (1990) tested two hypotheses, examining what learners were doing in the time between seeing an advance organizer and seeing the new material. One hypothesis suggested learners were rehearsing the advance organizer during this interval. The second hypothesis tested the theory that a period of cognitive rest between the organizer and the material would allow “time for text-relevant information to become inactive” and then enable the learner to approach the to-be-learned material with “full encoding processes” (p. 292).

To examine these two hypotheses, Glover et al., (1990) randomly assigned 45 subjects to one of three groups: (a) control; (b) advance organizer immediately followed by the text passage; (c) a 10-minute delay between the advance organizer and text passage. The results indicated subjects in Group (c) recalled more than the other two groups on a post-test, and that Group (b) recalled more than the control group. These results supported the delay hypothesis, but could not indicate if subjects were rehearsing the advance organizer during this delay or not.

To clarify the cognitive purpose of the 10-minute delay, Glover et al., (1990) conducted a second experiment using five groups: (a) control; (b) advance organizer immediately followed by the passage; (c) 10-minute unsupervised delay; (d) 10-minute delay where the advance organizer was rehearsed; and (e) 10-minute delay of distraction (math problems). Post-test data analysis indicated no significant differences between groups (c) and (e) or between groups (b) and (c). However, groups (c) and (e) both performed significantly better than all the other groups, which supports the delay but not the rehearsal hypothesis. Advance organizers had a greater effect when the content was allowed to become inactive, while rehearsing the advance organizer produced no advantages.

In a final experiment, the authors tried to replicate the first two experiments "in an actual school setting in which students read typical course materials" as opposed to a controlled laboratory setting (Glover et al., 1990, p. 294). Four groups were composed of randomly selected seventh-grade students: (a) control; (b) no delay; (c) rehearsal; and (d) math problem distraction. The results supported the findings of the first two experiments. Subjects in Group (d) performed better than the other groups.

Based on the data from these three studies, Glover et al., (1990) suggest advance organizers assist in the formation of an "organizer schema," which then needs a slight delay to become fully processed and encoded (p. 295). The schema "then allows readers to more effectively relate text information to knowledge already in memory" as predicted by AET (p. 295).

Kiewra et al., (1997) expanded on Mayer's (1983) study by including different formats of advance organizers and subtopic information. One advance organizer was

presented in an outline form listing the "major steps in the radar process…without description" or definitions of these steps (Kiewra et al., 1997, p. 147). The second organizer presented the same information in a 5 x 2 matrix. The post-test "asked participants to recall all that they could about each step" but gave the steps on the test (p. 147). Therefore, the advance organizers did not contain specific information that would help subjects on the post-test.

Results indicated that "students who read the conventional organizer [the outline] recalled more ideas" than the other groups (Kiewra et al., 1997, p. 148). Similarly, students who were presented the matrix organizer scored higher on test items asking them to relate items. These results led the authors to conclude that students recall the type of information presented in the organizer. Because the outline advance organizer presented an overview of the information, learners were better able to recall items relating to radar in general. The matrix organizer drew comparisons between the old and new methods of using radar, and learners who used this performed better when asked to compare and contrast the two methods. The authors speculate that the matrix organizer "restricted learning to relational information," whereas the broader outline organizer "facilitated the recall of general ideas" (p. 149).

Concept maps. The previously reviewed literature has examined the effects of verbal organizers on learning. Another line of related studies used Ausubel's (1963) concept of advance organizers to construct maps, graphs, or other visual aids to present a high-level, abstract overview of the learning material. These are called concept maps.

Anju (1991) used concept maps to test three hypotheses, similar to those examined in studies using verbal advance organizers. Using 48 fifth-grade students, the

researcher administered a pre-test to gauge the subjects' prior knowledge of fungi, the to-be-learned material. This test indicated the subjects had enough prior knowledge of fungi to warrant a comparative concept map. Using a repeated-measures factorial design, subjects were in three groups: those presented with the concept map followed by the material, those presented the material followed by the concept map, or those presented the material only. Results were not significant for any of the groups. The author suggests that because the material was well organized and logical, the concept maps had little benefit.

Willerman and Harg (1991) used eighth-graders to create a two-group comparative study. The authors predicted the group using concept maps as advance organizers would have higher post-test scores than the control group. The experimental group was presented a blank concept map with "arrows showing the linkage between the concepts" and filled in the blanks "by copying the teacher's example" (p. 708). The control group was given an introduction to the lesson. The lesson itself consisted of a lecture, "note taking sessions, lab sessions, and teacher demonstrations" (p. 708). A t-test on the post-test scores indicated a significant difference favoring the experimental group.

Griffin, Malone, and Kameenui (1995) examined concept maps, or "graphic organizers," as they call them, albeit in a different type of experiment. In most of the research, concept maps are presented to students where all or most of the mapping (i.e. the terms and links between the terms) have already been completed. In their study, however, Griffin et al., (1995) had the subjects create their own organizers during the experiment. Using four intact groups, the authors presented two of these groups with "detailed instructions for identifying important information within the text and

constructing graphic organizers" (p. 101). These two treatment groups received this instruction for five days, while the two control groups identified the main ideas of the passages but did not construct the concept maps.

Using tabulated qualitative data, statistical analysis revealed a significant result. Using follow-up univariate statistics, the data showed no significant difference between the groups on immediate recall items, but did suggest students who "received traditional basal instruction…performed significantly better" than those in the treatment groups (Griffin et al*.,* 1995, p. 104). On a measure of transfer, both the concept map and no-concept map groups performed better than the basal instruction control group.

These results do not overwhelmingly support the beneficial effects of concept maps, and the authors' concluding remarks explain why this may be. Reviewing the non-tabulated descriptive data from the groups, the authors note that the subjects in the concept map treatment groups "were required to learn not only the content but also the procedures associated with graphic organizer construction" (Griffin et al*.,* 1995, p. 105). This suggests students may derive more benefit from pre-written concept maps than from constructing their own.

Advance organizers for simulations. Most of the studies reviewed used a text passage to present the to-be-learned material. A text passage is not a simulation. Thus, one should use caution when extrapolating the results of the advance organizer studies to learning with simulations.

One study used advance organizers as pre-instructional activities for a simulation. Mayer, Mautone, and Prothero (2002) report three experiments examining the use of modeling, pictorial, and strategic scaffolding in preparing students to use a geology

simulation. The authors used cognitive apprenticeship and cognitive load theory to guide the structure of their experiments. "Cognitive load theory predicts that free discovery in the Profile Game may not lead to meaningful learning, because the learner's cognitive system can become overloaded" (p. 173). Thus, the authors reasoned that providing advanced scaffolding for students before using a simulation would aid their learning, speed of use, and transfer. In the first experiment, the authors compared the performance effects of modeling how to use the simulation, to allowing the students to figure it out on their own. The results from the data analysis of this first experiment yielded no significant differences.

Arguing that modeling how to use the simulation software did not provide the students with any strategic understanding of the simulation, the authors then compared the effects of using pictorial scaffolding, strategic scaffolding (text-based with some pictures), both, and neither on learning with the simulation. Before the students used the simulation, they were presented the scaffolds, with the exception of the control group. Results indicated the group who received pictorial scaffolding did significantly better on post-tests than groups that did not have pictorial scaffolding. The scaffolding alone, however, did not produce significant results. The group receiving both aids did significantly better than the group receiving no aids.

Lastly, the authors checked the use of pictorial scaffolding on transfer. Using a similar design as the last study, the post-test was a pencil-and-paper test using images and features from the simulation. Results indicated the pictorial-scaffolding group "correctly solved more problems than students who did not receive pictorial scaffolding" (Mayer et

al., 2002). Additionally, “students in the pictorial-scaffolding group correctly solved more transfer problems than students in the control group” (Mayer et al., 2002, p. 180).

From these studies, the authors concluded adding pictorial scaffolding to the simulation would significantly improve learning and transfer with the simulation. They posit that pictorial scaffolding was more effective than modeling since the former is visual, while the latter is verbal.

Advance Organizers Improperly Defined

Several studies, while claiming to investigate the effects of advance organizers to some degree, do not use the same definition of these tools as Ausubel (1960) and Mayer (1979). Although the details vary somewhat between the studies, the general issue lies with Mayer’s (1979) third characteristic of advance organizers: that they contain “no specific content from the to-be-learned information” (p. 382). Many authors describe and define the advance organizers they use as summaries of the main body of material (Chun & Plass, 1996; Hanley, Herron, & Cole, 1995; Herron, 1994; Herron, Hanley, & Cole, 1995; Herron, York, Cole, & Linden, 1998)

Chun and Plass (1996) investigated the effects of a video as an advanced organizer to a text in German, a foreign language for the subjects. The study was designed to answer, among other things, whether reading comprehension would be “facilitated by a dynamic visual advance organizer in the form of a video preview” (p. 508). The video itself was an “abstract, artistic overview of the story” and provided information about the character, mood, and setting (p. 509). Their quantitative results of their first study were inconclusive, but provided a formative review for developing the next study. In the second study, the researchers found that when propositions were

included in the advance organizer, subjects recalled more of these than when they were not included.

However, the authors in this study violated one of the characteristics of an advance organizer as presented by Mayer (1979). An advance organizer should “contain no specific content from the to-be-learned information” (p. 382). Chun and Plass (1996) clearly state that their video advance organizer contained “idea units” and “recall protocols” (p. 512). Therefore, the results of this study might better be applied to the effects of overviews and introductions than to advance organizers.

Chung and Huang (1998) compared three types of advance organizers on learners’ understandings of a foreign language film. The first organizer consisted of descriptions of the main characters, the second definitions of the vocabulary words, and the third both the descriptions and the vocabulary. A post-test asked learners to recall facts presented in the video. Results indicated that subjects using the vocabulary-advanced organizer performed better than the other two did. The authors speculate that the vocabulary plus main character advance organizer was too long to retain learners’ attentions, and go on to emphasize that advance organizers should be concise.

There are several points to make about this study in the context of the earlier literature. First, the advance organizers containing information about the main characters would not help learners connect the new material with prerequisite knowledge or skills. This is a key characteristic of advance organizers (Mayer, 1979). The advance organizers contained information on the character such as, “Philip: a pediatrician” in the student’s native language, which does not require prerequisite knowledge. Second, although vocabulary was not examined on the post-test, and therefore the advance organizer met

Mayer's (1979) third characteristic described above, the vocabulary also was not linked to prior knowledge. Taken together, these two points cast some doubt on the results of this study as it pertains to the larger body of research on advance organizers.

Chung and Huang's (1998) study is one in a series of related articles investigating the effects of advance organizers on learning foreign languages; several researchers follow a similar pattern defining advance organizers as summaries of main ideas, or a presentation of the characters in a video (Hanley et al., 1995; Herron, 1994; Herron et al., 1998). Additionally, many of the advance organizers in these studies do not have the learner recall prerequisite information and link it to the new material. Results of using advance organizers in these studies vary, but their incorrect definition of an advanced organizer cannot be ignored. Because of this, these articles will not be reviewed in the present study.

Advance Organizers: Conclusions

The studies on advance organizers and concept maps reviewed above yield some implications for the present study. Although the results are not always uniform, there are several suggestions that can be directly applied to learning with simulations. Advance organizers appear to benefit the transfer of learning to diverse and more complex situations, which is a critical aspect of learning with simulations (Mayer, 1979; Mayer, 1975). Advance organizers may also benefit poorly organized or complex material by providing a framework for the learner (Anju, 1991; Lawton & Wanska, 1977; Mayer, 1976a; Mayer, 1979). They also appear to be most beneficial for low-ability learners (Ausubel & Fitzgerald, 1962; Ausubel & Youssef, 1963; Lawton & Wanska, 1977;

Mayer, 1979). Lastly, some research suggests advance organizers encourage high-order learning.

Several studies suggest strategies for using advance organizers as pre-instructional activities in the classroom. For example, several authors posit using a pre-test to determine the prior knowledge of the learners to construct the best advance organizers (Ausubel & Fitzgerald, 1961; Barnes & Clawson, 1975; Lawton & Wanska, 1977; Griffin et al., 1995). Mayer (1976b) also allowed subjects in one study to use the organizer during the stimulus material.

The results generally support advance organizers' benefits for learning and, more specifically, increased transfer when subjects were given advance organizers as a pre-instructional activity (Ausubel, 1960; Ausubel & Fitzgerald, 1961; Alexander et al., 1979; Griffin et al., 1995; Mayer, 1979; Mayer, 1975). In the case of simulations, the ability for learners to transfer the skills gleaned in the simulation to the real-world situation is critical. Without transfer, one can argue that students just learned how to manipulate the simulation in its isolated context. For instance, the present study may teach the students how to maintain an aquarium (the simulation) but nothing about marine ecosystems (the reference system transfer target). The data from the advance organizer studies suggest advance organizers as a pre-instructional activity will increase the likelihood students will transfer knowledge from the simulation to the reference system.

Another important implication of advance organizer studies is the activities' possible benefit to poorly organized learning material (Anju, 1991; Lawton & Wanska, 1977; Mayer, 1976b; Mayer, 1979). These studies have demonstrated an advance

organizer's ability to help students through material that is presented in a disorganized or random fashion. The simulation that will be employed in this study involves dozens of interacting variables. For instance, students cannot effectively maintain their pH levels without also knowing how light, carbon dioxide, oxygen, carbonate hardness, calcium, and magnesium affect this single variable. The research on advance organizers as pre-instructional activities suggests that they may provide some structure, which would help students manage the simulation.

Related to structure, research suggests advance organizers help low-ability learners and novices to the material (Ausubel & Fitzgerald, 1962; Ausubel & Youssef, 1963; Lawton & Wanska, 1977; Mayer, 1979). Providing a pretext for the simulation using advance organizers should provide the necessary anchoring concepts students will need to engage the simulation effectively.

Additionally, these anchors provided during pre-instruction should help students learn at a deeper level and acquire higher-order skills (Kiewra et al., 1997; Kintsch, 1994; Lawton & Wanska, 1977; Mayer, 1976a, 1976b, 1979; Mayer, Stiehl, & Greeno, 1975; Scandura & Wells, 1967; Snapp & Glover, 1990). The research cited here illustrates the importance of pre-instructional activities' roles in establishing a foundation on which students can build higher-order learning skills.

Studies also suggest using a pre-test to help develop the advance organizers and pre-instructional activities (Ausubel & Fitzgerald, 1961; Barnes & Clawson, 1975; Griffin et al., 1995; Lawton & Wanska, 1977). According to Barnes and Clawson (1975) and Lawton and Wanska (1977), the pre-test will communicate what prior anchoring and subsuming concepts the students already possess. With this information, pre-instructional

activities can be developed that will more efficiently link students' prior learning and concepts to the new material.

Mayer (1976b) was the only researcher to allow subjects to continue using the advance organizer while engaged with the to-be-learned material. Additionally, Helms (2009) examined how students learned from a simulation in a science classroom. Results indicated students would return to the pre-instructional material frequently during what was technically engagement with the material. Mayer's (1976b) and Helms' (2009) studies, when taken together, suggest students should be allowed to access the pre-instructional activities during the simulation.

Comparing Advance Organizers and Performance Objectives.

Several authors used advance organizers and performance objectives as variables in the same study. While most of these studies seem to support performance objectives over advance organizers, it should be noted that many of the authors reviewed below do not define, or give examples of, their advance organizers. Thus, it is not possible to verify whether they followed Ausubel's (1960, 1963) original concept.

Bassoppo-Moyo (1996) examined the effects of advanced organizers, performance objectives, and structured overviews on learning. The author argues "organization is the hallmark of good instructional materials" and that pre-instructional activities present learners "with a useful perspective of what will subsequently be encountered" (p. 44). Using Gagné's (1965) nine events of instruction as a guide, the author indicates the first three events, gaining attention, stating the learning objectives, and reminding learners of prerequisite skills, as falling under the general category of pre-

instructional activities. The author then sets out to test three of these activities: advanced organizers, performance objectives, and structured overviews.

Using 674 students from two Zimbabwean colleges in a four-group comparison, the author found some interesting results. Of the three experimental conditions, the effect of advanced organizers "was of no practical importance," failing to yield statistically significant results with a miniscule effect size (p. 49). The effects of performance objectives and structured overviews had the most benefit on test scores, with performance objectives yielding the greatest average score and effect size. However, the author does not discount advanced organizers entirely, and speculates the results may be "more pronounced on higher level learning than simple factual recall" (p. 50).

In a follow up study, Bassoppo-Moyo (1997) used a basic control group methodology to examine the effects of structured overviews, advance organizers, and performance objectives on learning using written passages. Using an ANOVA to analyze post-test data, the results indicated the most beneficial effect was from performance objectives. Structured overviews were second, followed by advance organizers. The author suggests advance organizers may not have had much effect in the present study due to the rote nature of the knowledge being tested. They may be more beneficial and "have more impact on higher level learning than on factual recall and recognition" (p. 246).

Klein and Cavalier (1999) examined the use of advance organizers on cooperative and individual computer based instruction (CBI) activities. Using a CBI program created for the study, the researchers constructed three group-variations among orienting activities. The first group contained instructional objectives, the second advance

organizers, and the third had no orienting activities before the CBI units. All of the groups, however, presented four "introductory section" screens: "identification information…, motivational information, navigation information, [and] cooperative or individual instructions" (p. 64).

The results suggested "students who received instructional objectives through the program performed significantly better on intentional post-test items than" the advance organizer group or the no-orienting-activities group (Klein & Cavalier, 1999, p. 68). No data analyses were reported regarding incidental learning and objectives.

Advance organizers did not have a significant effect on intentional or incidental learning in the study (Klein & Cavalier, 1999, p. 68). The authors posit this was due to the organization of the CBI itself, citing Mayer's (1977, 1979) assertion that advance organizers "promote learning when new content is not well organized" (Mayer, 1977, p. 68). Objectives as a pre-instructional activity did increase a group's time-on-task. The authors speculate that the objectives "provided dyads with a clear goal to accomplish" (Klein & Cavalier, 1999, p. 68).

Lim and Chai (2004) reported on how orienting activities (advance organizers, objectives, and overviews) were used to support information and communication technologies (ICT) in the classroom. The authors defined an advance organizer as an "overview of topics to be covered" (p. 227) but not on a higher level of abstraction than the material presented to the students, a key characteristic of advance organizers according to Ausubel (1963).

In addition to the pre-written activities, "some teachers highlighted and demonstrated the key features and the navigation buttons" of the computer program.

Although not given as a type of orienting activity, presenting the mechanics of a simulation is part of the briefing as defined in the present study. Lim and Chai (2004) report that "when students knew how to use the ICT tools, they were more likely to be motivated and engaged" than students who did not know how to use the tools, who were found to "display off-task behaviors" (p. 226). This is one of the unique aspects of simulations where the mechanics of using the learning tool may be unfamiliar to the students, and, as the authors point out, students will need an overview of these mechanics before they begin to use the tool.

The research comparing advance organizers and performance objectives largely supports the latter. However, as evidenced by Lim and Chai's (2004) study, how the authors define advance organizers may not have been congruent with Ausubel (1963) nor under the guidelines given by Mayer (1979) above. Because of this, it is difficult to draw a conclusion for the present study. Based on the research regarding performance objectives and advance organizers in general, it is arguable that both would be appropriate pre-instructional activities for a briefing.

Simulation Research

When it comes to simulations as learning tools, the majority of the research discusses various aspects of how to design simulations. Many studies focus on how technology may influence learning from a simulation or a game. In a related line of research, other studies focus on a simulation's fidelity, or realism, and how greater fidelity may enhance or detract learning. Finally, another set of research works to explain and categorize simulations and games.

When combined with the research on pre-instructional activities, a good framework for a briefing emerges. The research on performance objectives, advance organizers, and concept maps provides specific educational tools to use, but does not discuss the unique features of the briefing as conceptualized for this study. Recall that the briefing serves two main functions: (a) to establish metaworld; and (b) provide all the necessary knowledge, skills, and learning for the students to successfully engage the simulation (the prerequisite knowledge). The metaworld should provide a solid foundation of both motivation and prerequisite knowledge; or to use advance organizer terminology, of motivation and the necessary subsumers to assimilate the to-be-learned material. The metaworld helps establish continuing motivation, which students will need to solve the complex problems presented in the simulation (Rieber, 1996).

It is important to note that “there is a general consensus that learning with interactive environments such as games, simulations, and adventures is not effective when no instructional measures or support are added” (Leemkuil, de Jong, & Ootes, 2000, p. i). Because simulations are instructional tools, presenting them alone and without any sort of instructional facilitation will typically result in unmanageably high cognitive load and frustration on the part of learners (Rieber, 1996). However, what instructional measures and support should be used is not well understood, particularly to prepare learners to use a simulation (Gredler, 2002).

Simulation Design

The majority of articles on simulations does not focus on pre-instructional activities or the briefing, but instead concentrate on technology and design. Many of the

articles address specific aspects of technology, such as three dimensional worlds, fidelity (realism), and specific programs such as Second Life.

Livingston and Kidder (1973) conducted an experiment to examine the relationship of roles and rules in the game *Democracy*. The researchers used five groups totaling 218 students to examine this question. In the first group, all references to the political aspects of the game (the roles) were removed. Subjects were identified simply as being part of a team where all references to "politics and legislation" were removed (p. 133). In the second group, the scoring was removed by replacing the "constituency scores" with "profile cards" (p. 134). The third group played *Democracy* without the structure of the game, allowing subjects to advance through it at their own pace. The fourth group played the full game of *Democracy* while the fifth group, the control, played an unrelated game. Using uni and multivariate statistical analysis, the authors concluded that both "the game structure and the role identification in the *Democracy* game contribute" to the game effectiveness of teaching log-rolling in politics (Livingston & Kidder, 1973, p. 137).

Allen, Jackson, Ross, and White (1978) discuss how variations of the *Equations* game influence which aspects of the game the learner focuses on during play. The study consisted of 37 junior high students who played two versions of *Equations*. The control group used a game in which they could not earn bonus points, and the experimental group used the "snuffing" version of the game that awarded points based on challenging other player's solutions. The results suggested that by adding the possibility of gaining four bonus points, students learned more mathematical concepts by using the game. The authors posit these results from students having to spend more time proving their

solutions while even the smallest change in game design can have a profound effect on learning.

Jacobs and Dempsey's (1993) book chapter first dissuades researchers from using the term "simulation game" to refer to both simulations and games. The authors define games as "any training format that involves competition and is rule-guided" in order to differentiate them from simulations, which typically lack internal competition (p. 201). Competition, however, does not have to be a player versus player scenario, and instead can encourage learners to compete against themselves; for example, by trying to beat one's previous score in the game. Games present aspects of challenge, fantasy, and curiosity to the learners by presenting goals with an uncertain outcome, some amount of randomness, and feedback "presented in a way that minimizes the possibility of damage to a learner's self-esteem" (p. 203). Curiosity can be created using sensory objects such as lights and sounds, but "cognitive curiosity" will lead to more in-depth learning (p. 203). Similarly, using fantasy that builds on the learners' skills as the simulation progresses creates additional learning.

The authors go on to discuss the differences between content and construct validity. Content validity is the degree to which the simulation "captures critical aspects" of the reference system "through careful construction of stimulus items" (Jacobs & Dempsey, 1993, p. 206). However, a simulation can have construct validity based on the degree to which it engenders the necessary skills by the learners. Increasing content validity has a tendency to make the simulation more general and less skill-specific, thereby reducing construct validity. Rather than strive for a balance, the authors take the stand that it is "more desirable for the simulation to foster general skills and

abilities…that are useful in a wide range of situations" than to teach specific skills unique to limited situations (p. 206).

Discussions of fidelity and design dominate the second third of the chapter. The authors discuss the research on fidelity, or realism, in simulations and how fidelity relates to learning. They find mixed results from research. In theory, making a simulation more realistic should increase transfer and learning, but the authors note that high-fidelity simulations can lead to cognitive overload and thus decreased motivation and learning. Based on the literature, a trend of "designing simulations based predominantly on physical fidelity" is likely misguided (Jacobs & Dempsey, 1993, p. 210).

Pulos and Sneider (1994) present a model for developing and evaluating educational simulations and games. They argue that it is "essential to have a conceptual framework for development, evaluation, and research" into educational simulations and games (p. 24). Their model begins with an analysis of the concept to be taught: identifying key concepts, observing a successful teacher, and a literature review. The second step is to identify the teaching methods that will be used in the simulations or games itself, based on the concepts from the first step. The authors argue this second step should be grounded in learning theories and not vaguely stated. The third step is to analyze the learner in the context of the educational concept to be taught by the simulations or games. Fourth, the developer should design a game to be fun for the learner, which means having a cultural understanding of the learner and carefully observing what the learner finds to be fun. The fifth step is to develop the simulation or game itself, integrating the data from the first four steps and running some beta tests. Observe the learner while playing, see what the learner ignores and identify possible methods to integrate ignored components

more. Lastly, the authors argue for a combined qualitative and quantitative evaluation of learning. They do not promote comparing the simulation or game with another teaching method, as they "are most likely to be used as an integrated part of the curriculum and not as a replacement" (p. 27).

Swaak, van Joolingen, and de Jong (1998) examine the effects of assignments in simulations on learners' cognitive loads and planning behaviors. The simulation used in the study had four instructional support measures: model progression, assignments, explanations, and a hypothesis scratchpad (p. 238). Model progression is the practice of presenting less complex models first, then increasing the complexity as the learner's proficiency increases. "Assignments direct the learner in what to find out of the simulation model" (p. 238). Explanations allow learners to view the underlying mathematical model of the simulation. Finally, the hypothesis scratchpad is an internal tool to assist learners' development of structured hypotheses about the simulation. The authors used a classic two-group comparison study where the experimental group received introductory paragraphs directing the learners toward specific discoveries.

Results suggested assignments increased learning as measured using pre- and post-tests measuring "intuitive understanding of the subject matter" (de Jong et al., 1996, p. 17). However, assignments did not increase transfer or learners' understanding of the simulation's structure. Assignments increased learner motivation to finish the simulation and the control group, which did not receive assignments, "had to be specifically motivated to go on and not to give up too early" (p. 24). Cognitive load and time spent in the simulation were not significantly affected by assignments. Finally, the authors note "practically all participants stopped their work when the last assignment was finished"

rather than continuing to explore the simulation (p. 25) and this could be a negative consequence of using assignments.

Gredler (1996) illustrates the research regarding games and simulations until 1995. The author indicates several major weaknesses in the research, including the lack of a “comprehensive design paradigm derived from learning principles,” “well-designed research studies,” and a tendency to use media comparison studies to evaluate games and simulations (p. 110). The author gives a methodology for classifying games and simulations based on their deep structures. Games and simulations, according to the author, differ in three ways: (a) “games are competitive exercises in which the objective is to excel by winning”; (b) games are linear whereas simulations are more dynamic and nonlinear; and (c) games have strict rules governing player behavior whereas simulations are a “dynamic set of relationships among several variables” (pp. 522-523).

The author further divides simulations into experiential and symbolic categories. Experiential simulations are like a dynamic case study in which the learner can participate. Learners take on a role and a dynamic problem unfolds with “multiple plausible paths through the experience” (Gredler, 1996, p. 523). Some subsets of experiential simulations are themes focused on data management, diagnostic, crisis management, and social-processes. In symbolic simulations, the “learner is not a functional element” and instead tries to “discover scientific relationships or principles, explain or predict events” (p. 523). The author divides symbolic simulations into subsets of data universe, system, process, and laboratory research simulations. The subsets for both experiential and symbolic simulations focus on different problem solving strategies and different ways of representing the simulation.

Based on prior research, de Jong and van Joolingen (1998) indicate that "learners have problems with discovery learning" and set out in this article to identify these problems and "design simulation environments that support learners in overcoming these problems" (p. 180). By reviewing articles describing an experimental study using simulations, the authors identified four categories of problems learners have when engaged in discovery learning: "hypothesis generation, design of experiments, interpretation of data, and regulation of learning" (p. 183).

To alleviate these problems, the authors make several recommendations in the use and design of simulations for discovery learning. First, they suggest that "learners should know something beforehand if discovery learning is to be fruitful" when using simulations (de Jong & van Joolingen, 1998, p. 187). They call this "direct access to domain knowledge" and indicate research suggesting students should have access to the knowledge during the simulation itself (p. 187). However, they cite research suggesting that domain-specific information provided before the simulation (i.e. prerequisite knowledge) does not improve learning outcomes. The next two recommendations are supporting students' understandings of hypothesis generation and experimental design.

The authors make a strong recommendation for the use of model progression in the simulation's design. "In model progression the model is introduced gradually..." allowing the student time to learn the basics before encountering the model's full complexity (de Jong & van Joolingen, 1998, p. 189). Additionally, using assignments that prompt the student to search for or work toward a specified goal can help direct what might otherwise be an unorganized experimental strategy.

In a follow-up book chapter to her earlier work, Gredler (2002) discusses the use of games and simulations, reinforcing her earlier chapter on the subject while including new research and ideas. Games and simulations are defined the same way, where games are "competitive exercises in which the objective is to win," and simulations "are open-ended evolving situations with many interacting variables" (p. 571). Despite some overlap between the definitions (i.e. games can be open-ended and have many variables as well), the key difference is that games deliberately include competition and a winning condition.

As in the author's earlier article, most of the chapter focuses on the design of games and simulations for learning. The author's design criteria for games include: (a) random chance should not contribute to learning; (b) the game should address important content, not trivia; (c) the game should not have too many "bells and whistles"; (d) the game should not take away points for wrong answers; and (e) games should not be zero-sum (Gredler, 2002, p. 572). The potential for learning using games, according to the author, consists mostly of knowledge acquisition with a single mention of developing "new relationships among concepts and principles" but no direct mention of problem solving (p. 572).

Gredler (2002) spends the majority of the article discussing simulations. Using the same breakdown of experiential and symbolic simulations as in the 1996 article, the author elaborates on the characteristics of the deep structure of simulations. First, simulations should be as high fidelity (realistic) as possible and "reflect authentic causal or relational processes" (Gredler, 2002, p. 573). Second, ill-defined problems should be the type of situations presented to learners. Third, the simulation should immediately

respond to learners' actions with "changes in the status of the problem and/or reactions of other participants" (p. 573).

The author's discussion of past research into games and simulations includes a minimal amount on games and much more material on simulations. The author's review of games focuses on the uses of a few published games in particular settings, but does not discuss how these games were used. Research into the learning benefits of simulations also discusses specific published simulations, but includes findings that are more general. For example, the author identifies improvements in problem solving skills as being a commonly reported finding in research. Most of the author's discussion regarding the research focuses on studies comparing levels of fidelity, graphics in particular, and finding few significant results. The author states that it is the method, not the media that will determine how well simulations and games work for teaching.

Using 20 male and 20 female volunteers, Dempsey, Haynes, Lucassen, and Casey (2002) conducted a qualitative survey of 40 computer games including "simulations, puzzles, adventure games, board games, card games, arcade games, word games, and miscellaneous games" (p. 160). After playing all the games, the participants indicated some potential uses of computer games for education. Men appeared to be more motivated by "successful completion of simulations," and often approached simulations with confidence of success (p. 162). Participants indicated the desire for "clear, concise instructions," challenge, and "control over many gaming options such as speed, degree of difficulty, timing, sound effects, and feedback" (p. 163). The authors also observed participants learning the rules of the games by trial-and-error play, not by reading the instructions. Participants, however, would refer to written instructions when trial-and-

error was insufficient. The participants identified much educational potential for the games; among their ideas were problem solving, history, planning, decision-making, drill and practice, writing, economics, and logic. The authors concluded that a "framing strategy" would greatly benefit the use of computer games in the classroom, where this framework would provide a context for the game in the lesson and "maximize the players' opportunities for success" (p. 166).

In a series of three experiments, Moreno and Mayer (2005) examined how guidance, reflection, and interactivity increased learning and transfer in games. The authors used a game where participants had to create plants from a variety of parts (roots, stems, leaves, etc.) to survive on alien worlds. The game taught students the differences and purposes of various plant types. Based on prior research, the authors speculated guidance would help learners "by providing explanatory feedback" based on the learner's choices and preventing students from becoming "lost and frustrated" during the discovery process (p. 118).

In the first experiment, 105 undergraduate students played one of four versions of the plant game. In two games, learners were asked to "explain the answer they selected" (Moreno & Mayer, 2005, p. 119). In addition, in two games, "some learners received an explanation of the answer after being told whether they were correct" (p. 119). Measurements of retention, near transfer, and far transfer were taken after the game. Results indicated that guidance did not affect retention; however, guidance increased near transfer and far transfer scores. Also, asking learners to explain their answers did not affect scores. The authors concluded from this study that guidance helped learners organize information during the game.

However, the interactivity of the game masked the effects of the reflections. The next two studies in the article confirmed that reflections were not necessary in interactive games and simulations. From these later experiments, the authors concluded that “adding reflection to an interactive environment does not significantly improve” learning because “interactivity already primes the cognitive process of organizing” (Moreno & Mayer, 2005, p. 127).

Dickey (2005a) discusses techniques and concepts used in commercial video games and how they could be used in educational games. The author first describes a psychological distance video games create between learners and the game, allowing learners to take risks and actions they would not take otherwise. Motivation to play video games arises from the inclusion of a “clear task or goal,” “progressive balance…of skills and challenge,” and “immediate feedback” (p. 69). When motivation to play educational games fails, according to the author, the cause is likely a misapplication of one of these three factors. Epistemologically, games typically fall into a constructivist framework; however, “although key components of engaged learning have been identified, few models and exemplars for achieving these components have been presented in the literature about engaged learning” (p. 78). Such research implies an educational framework for using games and simulations in education based on a constructivist epistemology.

Learning With Simulations

Another prevalent theme in the literature examining how simulations influence learning, is theorizing how simulations may affect learning. Again, it is a common characteristic of these studies to ignore the role of pre-instructional activities.

Greenblat (1973) reviews the claims of practitioners and the results of research regarding simulations and games in teaching sociology. The interest in such a discussion arises from several points given in the article. Among them are, (a) “The view that the mind is an instrument to be developed rather than a receptacle to be filled”; and (b) “the idea that students learn not because learning is a goal in and of itself, but because learning leads to goal achievement” (p. 64). Summarizing the learning from past research, the author concludes simulations can increase motivation, enhance cognitive learning, alter affective states, change how students approach later course work, and alter the social dynamics of the classroom.

Bredemeier and Greenblat (1981) present a review of the literature and illustrate many of the early views of simulations and games in education. They argue for a very rigid structure for using simulations in education by controlling the variables in the world and comparing simulations with other types of learning. However, the authors also note that “how a game is run and who runs it appear to make a difference” in the learning outcomes, as well as an “introduction” to the game used before students play (p. 310). This introduction, although only briefly discussed in the article, is the brainstorm leading to the development of the briefing. The authors also discuss group dynamics and the lack of an apparent relationship between game ability and academic ability.

Bredemeier and Greenblat (1981) also review research regarding learning with simulations along several subject areas: cognitive subject matter, transfer, affective subjects, self-learning, and motivation. Using mostly media-comparison studies, prior research overwhelmingly found no differences between “traditional” teaching methods versus simulations and games. The only solid evidence in support of simulations was

with the retention and transfer of what is learned (pp. 320-322). Simulations' effectiveness in changing attitudes and affects was dubious; various authors reported different results, resulting in no clear recommendations. Research supports the use of simulations for "tension release, receipt of valuable affective feedback from others…, increased self-awareness, and greater sense of personal power" but only when the player wins the game (p. 324). Lastly, simulations did increase motivation among participants in most of the studies reviewed, but little is given as to why this is the case.

De Jong (1991) defines "instructional use of computer simulations" as having five key characteristics (p. 218). First, the simulation must have a "formalized, manipulable underlying model" (p. 218). Second, the simulation should be used in the "presence of learning goals" that clearly define the behavioral and learning outcomes the learners should demonstrate at the end of the simulation (p. 219). "Third, and this is a cardinal characteristic, the simulation must be used to invoke specific *learning processes*" such as hypothesis generation, problem solving, planning, and monitoring (p. 219 emphasis in original). Fourth, the learner must be active and be able to manipulate the simulation. Lastly, the learner needs to have direct control over the simulation's underlying model. These five characteristics can place a high load on the learner and the author calls for the need for some type of facilitation, either by a person or the computer, during the simulation process but not before, which would place it in the briefing.

Elshout and Veenman (1992) conduct two experiments to measure the effects of a simulation's structure on learning. The authors argue that imposing a learning structure on high-intelligence students capable of self-regulation may inhibit their learning. However, allowing low-intelligence students unable to manage their problem solving

skills might overwhelm students and relegate them to trial-and-error behavior (p. 135). In the first experiment, the authors categorized subjects into high- or low-intelligence using “a series of ability tests, representing several components of the Structure of Intellect model” (p. 135; the authors do not give the names of the specific tests in the article). Four high-intelligence and four low-intelligence subjects then were assigned to either a structured or an unstructured simulation on heat.

In a meta-analysis of the research, Hayes, Jacobs, Prince, and Salas (1992) first identify some outstanding research gaps regarding the effectiveness of flight simulator training. First, they concur with prior research for a need to identify “specific training system requirements” and how these system elements affect learning (p. 63). The authors’ methodology consisted of gathering all research “involved in training with a simulator and transfer to operational equipment” (p. 65). Of an initial pool of 247 experiments, 26 were used in this study after coding each using the point-biserial correlation coefficient. All of the studies involved were media-comparison type studies using a control group and experimental group. The analysis resulted in several findings.

First, simulator training was far more effective when used for a specific task, such as takeoff and landing. Second, the use of high-resolution computer graphics imagery did not have any detectable effect on transfer. Third, the use of pneumatic motion and G-suits to simulate gravity did not have a detectable effect on simulator training effectiveness for jets; however, this result may be due to the “lack of periodic calibration of the motion cuing systems” during the original experiments (p. 71). Fourth, allowing trainees to proceed to more advanced simulated experiences based on the individual’s demonstrated proficiency “was greater than that for training programs where

all trainees proceeded at the same pace" (p. 72). Based on these results, the authors conclude that flight simulators are effective training tools.

Christensen et al., (2001) discuss the differences, uses, and research into simple and complex macrosimulators and microsimulators. According to the authors, simple simulations "teach simple algorithms or procedures with only a few aspects involved" whereas complex simulations include several variables (p. 251). Macrosimulators, which are more common in the medical field, "provide a chance to perform manual procedures" in situated environments emphasizing realistic settings (p. 254). "Microsimulators provide autonomous, cognitive training" where the key differentiating factor between macro and micro simulations is the medium of delivery (p. 254). The authors also discuss the use of debriefing, "the heart of all simulation," in medical simulations but base their recommendations for using simple and complex micro and macro simulations on the appropriateness of the medium for the learning material (p. 255). They do not discuss how to contextualize simulations in the lesson.

Dickey (2005b) presents two case studies of learning with virtual worlds. The author argues that "3D interactive environments provide support for constructivist-based learning activities by allowing learners to interact directly with information from a first-person perspective" (p. 440). In the first study, students taking Business Computing Skills 1000 at the University of Colorado-Boulder used BCOR, a three dimensional world designed in ActiveWorlds Educational Universe (AWEDU). The study revealed that BCOR created a learning environment with a "sense of place, presence, and community for spatially distant learners," where students felt as if they were "'at school' or 'in school' or 'actually there'" while providing a sense of anonymity (p. 445). The

second case study focused on an Intro to RWX Modeling class held in AWEDU. The author chose to use situated learning theory as a framework for interpretation and concluded learning about 3d modeling with RWX scripts was enhanced by using a three dimensional world. Lastly, the author concludes, pulling from prior research as well as the two case studies, that "immersive environments allow learners to interact with data or knowledge representations that are not possible to replicate in a traditional classroom setting" (p. 449).

Conclusions. Although there is a plethora of research recommending how educators should design simulations, and speculation as to how design characteristics may influence learning, none of the reviewed studies discusses how to implement simulations in classrooms. There are some, however, that discuss debriefings and hint at the value of a briefing. While design may influence usability and classification, some authors, such as Petranek (1994), argue that the implementation of simulations is of greater importance. For instance, after the simulation ends, the learners should pause to reflect on the experience (Baker, Jensen, & Kolb, 1997). This step is typically termed a debriefing and needs to be examined for concepts that could be applied to a briefing.

Debriefing Simulations

Research on the debriefing of a simulation, or guiding the learners to apply lessons in the simulation to the reference system, is also well-established and makes some clear recommendations. In particular, several authors have suggested frameworks and precise, research-guided methodologies for conducting a successful debriefing.

Baker et al., (1997) suggest the word "conversation" for describing the type of interactions during a debriefing (p. 7). The primary focus of this article is the oral, or

conversational, debriefing. The authors lay out a format to follow during debriefings and roles for the facilitator and learners. The facilitator should adopt values and goals for the debriefing session that will encourage a reflective and thoughtful space. These values include respect for students, including all learners in the conversation, respecting silence and the right of learners to listen, and an "openness to surprise and the unanticipated" (p. 9). With these values in hand, the facilitator should not direct the conversation, but approach the other learners as "a more wide-awake participant" (p. 8).

Lederman (1992) proposes a model for structuring and assessing debriefings. After examining how debriefings are used in military and experimental settings, the author describes seven elements of debriefings: "the guide/debriefer, the participants, the experience, the impact of that experience, the recollection of it, the mechanisms for the reporting out on the experience and the time to process it" (p. 149). Using these seven elements, the author proposes three phases of debriefing. The first phase introduces the "participants to a systematic self-reflective process about the experience through which they have just come" (p. 152). This first phase asks the participants to describe, recount, and recollect the experience in their own words. The second phase focuses the "participants' reflections onto their own individual experiences and the meanings they have for them" (p. 152). These reflections can focus on the emotional or cognitive sides of the experience. In the last phase, the participants are asked to "go from the individual's experience to the broader applications and implications of that experience" (p. 152). In this last phase, participants identify patterns, processes, and principles used in the simulation experience.

When assessing a debriefing experience, the author poses a series of variables to be considered by the reviewer. First, the reviewer should examine the learning objectives of the exercise and how well they were met in the debriefing. Second, examine whether the situational context of the debriefing detracted from the experience at all. For example, assessing whether or not there was adequate time and resources for the debriefing would be part of the context. Third, the review should note what types of debriefing strategy was used (written, oral, how long after the simulation, etc.). Fourth, how well was the strategy implemented? Last, evaluate any quantified data gathered during the debriefing and how well the participants did in each of the previous phases.

Within this context, several researchers have proposed steps or stages for the conversational debriefing process. Lederman (1992) presents a three stage model: "introduction to systematic reflection and analysis"—"intensification of personalization"—generalization (p. 151). Steinwachs' (1992) model also has three stages: description—analogy/analysis—application, and her titles will be used for the stages presented here, while combining her descriptions with Lederman's (1992). Lastly, Petranek (1994) uses the "Six E's of Debriefing, *events, emotions, empathy, explanations, everyday,* and *employment*" (p. 519, emphasis in original). These E's will be combined and discussed in the three stages of the authors above.

In the first stage termed description by Steinwachs (1992), students "gradually emerge from the game world" into the conversational debriefing (p. 187). This step should take place immediately after engagement with the simulation to allow for the greatest amount of recall (Steinwachs, 1992). This is a stage of recall and self-reflection about each student's experience in the simulation. Included here are the first three E's

(events, emotions, and empathy) proposed by Petranek (1994). The purpose is to expose students to the decisions, emotions, and experiences of the other students (Lederman, 1992; Steinwachs, 1992).

In the second stage of the debriefing process, analogy/analysis, the learners are asked to explain their actions and the actions of others—this is the fourth E, explanations, of Petranek (1994). Learners should personalize their explanations to their own actions, and hypothesize as to the reasons for other learner actions (Lederman, 1992). Thus, learners analyze their behavior and the behaviors of others, as well as analogize their own behaviors to hypothetical situations in the simulation (Steinwachs, 1992). The second stage of conversational debriefing accomplishes two things. First, it encourages players to rationalize their actions in the simulation and, it sets up the more extrinsic considerations of the third stage.

In the third stage, application, learners generalize their collective experience to the reference system (Lederman, 1992; Steinwachs, 1992). This stage takes learners "from their own individual experience to the broader applications and implications of that experience" (Lederman, 1992, p. 152). Learners relate their actions in the simulation from the first stage, and the explanations of those actions in the second phase, to how they might behave in the reference system. The relationship should be practical and relate to the everyday experiences of the learners (Steinwachs, 1992). This stage encompasses Petranek's (1994) everyday and employment.

Throughout the three stages, (description, analogy/analysis, and application), the facilitator has a role more akin to a participant. Facilitators should not come into the conversation with an agenda or plan for the conversation (Baker et al., 1997). In short,

the facilitator is responsible for setting up the context and beginning the conversation, but is not responsible for "facilitating." Baker et al., (1997) describe the facilitator as a "more wide-awake participant" with attention to the entire picture (i.e. the three stages) as well as the specific conversation (p. 8). The facilitator should "avoid telling players what you think they should have learned" and instead let the learning evolve from the conversation (Steinwachs, 1992, p. 188).

A conversational debriefing has been demonstrated to be a vital phase in learning with simulations (Baker et al., 1997; Christensen, Heffernan, & Barach, 2001; Ertmer & Russell, 1995; Lederman, 1992; Petranek et al., 1992; Steinwachs, 1992). During this phase, learners have the opportunity to exercise skills in debate, persuasion, and listening as they declare their opinions, leaving them open to scrutiny by their peers. The conversational process therefore helps develop interpersonal communication by requiring students to engage their listening and oral persuasion skills as well as moral and ethical virtues such as humility and personal confidence (Ertmer & Russell, 1995). These skills and virtues are then personalized for each learner in the written debriefing.

After a conversational debriefing following the three stages proposed (description, analogy/analysis, and application), some sort of a written debriefing should take place. Although there is a gap in the research identifying stages, steps, or models for written debriefings, some authors provide ideas. One method of written debriefing is to have the learners keep journals during the simulation and the conversational debriefing. Learners submit these journals to the facilitator for feedback, but learners do not read each other's journals. Another idea is to use written concepts (Petranek, 2000). Similar to journal

writing, the written concept technique focuses learners' writings towards important concepts discussed in the conversational debriefing.

Journal writing "forces the student to organize the material on a personal basis" after the group experience from the conversational debriefing (Petranek et al., 1992, p. 180). Students should be asked to write about their experiences during the simulation. The facilitator provides feedback on the journal entries as frequently and as practically possible (Petranek et al., 1992, Petranek, 2000). In the briefing phase, students' journal entries will help identify their metaworlds (their concepts of the simulation before using the simulation), and if they have the required prerequisite knowledge. The constant feedback provided by the facilitator increases student-facilitator contact through private communication (Petranek et al., 1992).

The written concept technique, developed by Petranek (2000), is similar to journal writing, except that it takes place only once (during the debriefing phase) and focuses students' attentions to pre-established themes. During the conversational debriefing, students will develop themes or concepts about play. For example, a simulation exploring racial stereotypes might elicit themes of discrimination, politics, public education, and other broad concepts. After identifying them, the facilitator compiles a list of about 20 concepts and asks each student to write a few paragraphs on each one (Petranek, 2000).

Conclusions. The research regarding the importance, structure, and methodology of the debriefing, as presented here, illustrates the importance of this phase for using simulations as learning tools. Additionally, many researchers agree that the debriefing is required for meaningful learning (Baker et al., 1997; Christensen et al., 2001; Ertmer & Russell, 1995; Lederman, 1992; Petranek et al., 1992; Steinwachs, 1992). However, these

same qualifications and research do not translate to the briefing. Some of the literature hints at the value of a briefing, which will be examined next.

Studies Suggesting the Value of a Briefing

Some studies have mentioned, directly or indirectly, the need to present pre-instructional activities to students before they engage the simulation. These studies provide a picture of how the briefing concepts of metaworld affect motivation and learning. Combined with the research on pre-instructional activities and Gagné and Briggs' (1975) first three events of instruction, the basis for the present study can be formed.

To examine, in part, how direct instruction offered before using a simulation stimulated "student interest as well as build basic knowledge," Roberts, Blakeslee, and Barowy (1996) set up a qualitative study using an aquatic ecosystem simulation (p. 41). The authors used two initial phases to establish a baseline of knowledge for the students and a "teaching experiment on equilibrium in aquatic populations" (p. 42). These first two phases were designed to establish skills, based on earlier research, needed by students to purposefully use a science simulation. These skills include "isolating variables, testing limits, examining interrelationships between parameters, …controlling parameters, …an appreciation of the issues of internal model validity" and looking for patterns and consistency in model behavior (p. 44). One of their findings was consistent with prior research that teachers can give too much structure before the simulation. Relating their findings to this prior research, the authors state that "the student needs to be both shown the way and then left to learn by doing" (p. 48).

The authors also concluded that “students who could relate what they saw on the screen [of the simulation] to a previous experience” were more likely to be successful with the simulation (Roberts et al., 1996, p. 50). Conversely, students who could not relate the simulation experience to prior knowledge or experiences were “completely uninterested” (p. 50).

Jackson (1997) examined how a class of earth science students used a video simulation, documenting problems and concerns for future studies. The author presented the simulation to three different classes taught by teachers of various experience levels. The author acted as an observer for each of these classes. The results yielded several findings pertinent to the present study. One factor was small variations in the simulation material that were glossed over by the teachers, but “often proved to be highly frustrating or grossly misleading” to students when using the simulation (p. 130). In addition, students often did not have the prerequisite knowledge about the subject matter, “language and communication skills, cultural references, and/or motivation to make sense” of the simulation as it was played (p. 132).

Windschitl and Andre (1996) used a biology simulation to investigate the effect students’ pre-conceptions of knowledge had on learning from an exploratory simulation. The results suggested students with a “more sophisticated” understanding of learning performed better in an exploratory simulation. Concurrently, students with a less sophisticated understanding of learning performed better in a confirmatory simulation. The authors posit these results are further evidence that students’ prior conceptions of the learning process influence how they perform in a constructivist environment.

Barnett (1984) reviewed the literature on games and simulations in learning environments. The author compiled a list of five different areas of potential research into games and simulations including increasing motivation, "altering the attitudes held by students," as a tool for delivering factual and conceptual knowledge, improving social skills, and providing an environment to practice social skills (pp. 165-166). As well, the author identifies some reasons to use simulations and games in the classroom, stating that they are motivating, cooperative, "promote moral development in pupils," improve social skills, and "enable the *teacher* to learn about the children's concept of reality" (p. 166, emphasis in original). The author cites a need to refine "game theory to identify which aspects of the technique [of using games and simulations in education] are likely to influence specific types of learning," and states the need to affirm learning objectives during the construction of the game (p. 168).

Elshout and Veenman (1992) conducted two studies examining the role of structure on high- and low-intelligence students learning of heat from a simulation. The studies reveal two interesting points regarding learners' prior domain knowledge before using the simulation. In the first experiment, the authors noticed a background of basic thermodynamic principles does not compensate for lack of knowledge and that these explanations had no affect on learning for either low- or high-intelligence subjects (p. 138). However, the domain knowledge was not structured when delivered to the learners, and the authors note "by presenting the subject matter in a still more structured way…the conceptual difficulties of the weaker students could be relieved" (p. 138).

In the second study, Elshout and Veenman (1992) noticed a difference in how domain knowledge influenced the problem solving strategies of low-intelligence and

high-intelligence subjects. "Novices, who are lacking domain knowledge, possibly do not have such faculty, deep models" and such subjects are not able to make constructive, hypothesis-driven decisions in the simulation (p. 139). By providing prior domain knowledge, the authors suggest low-intelligence students would be better able to avoid making a choice only when forced to by the simulation.

Dwyer and Lopez (2001) conducted a case study using a computer simulation of a river ecosystem. Following the exploration, invention, and expansion framework posited by Sunal and Sunal (2000), the researchers first presented a group of elementary school students with a variety of activities. The researchers arranged their lessons into four learning cycles. The first cycle "allowed the students to develop understanding of the concepts before using the simulations" (p. 8). This first cycle is similar to the briefing phase in that the researchers used other instructional tools and strategies to support the simulation. In this case, they used KWL charts (what I know, what I want to know, what I learned), and several undefined classroom activities focused on helping students "develop working, or operational, definitions of the concepts" used in the simulation (p. 8).

The authors' conclusions were based primarily on how students with a variety of learning disabilities faired in the simulation. While many students struggled with the pre-instructional activities such as reading, they "thrived in working with the CD simulations" (p. 11). Thus, the authors' surmise, the strategy of using the exploration, invention, and expansion framework with simulations is a success.

Asakawa and Gilbert (2003) present a summary of characteristics and features of internet-mediated educational, business, and policy games. The authors' primary focus is

on describing common design characteristics such as objectives, role-play, synchronicity, facilitation, and communication tools. It is, however, one of the few articles to mention the importance of a briefing, albeit they only use this time to describe the rules of the game.

More recently, and providing the best anecdotal evidence to date, Butler (2005) describes a case study in which the author developed and used a role-playing game about American colonial behavior just prior to the Revolutionary War. Before beginning the game, the author/teacher has the students write backgrounds for their characters (their roles in the game) including “details about their family makeup, history, skills, and reasons for coming to the New World” (p. 66). The students then shared their characters’ histories with the rest of the class. During the game itself, students took on this character and traded goods, branched into new enterprises “including fish, lumber, rum, tobacco, indigo, and cotton,” and dealt with random events such as fires (p. 66). The author took on the role of England and periodically announced the actions of the mother country such as the Sugar Act, Stamp Act, and Townshend Act.

By announcing England’s Acts to the class, the author noticed appropriate responses from the students based on their characters. Those who exported rum, and therefore needed to import sugar, were indignant and angry by the passage of the Sugar Act, while learners whose characters were not involved with sugar didn’t care or “felt that ‘the [rum-producing colonists] deserve it because they’re getting too rich’” (p. 66). Butler then directed the learners’ enthusiasms to their history textbooks to review what taxes they could expect England to pass next.

The learners' reactions to the acts as they were passed resulted in a realistic group dynamic. "Not only did the students understand this idea of regional individualism among the colonies, they were experiencing it for themselves" as they bickered and argued amongst each other (p. 66). In short, the learners reacted as their characters would have in the situation. However, the author chooses to focus on computer technology, rather than the importance of the characters, and introduction to the simulation for the learners.

Conclusions. There is enough anecdotal evidence to justify a closer look at pre-instructional activities and orienting strategies in simulations (Asakawa & Gilbert, 2003; Barnett, 1984). The reviewed research presents tantalizing clues regarding the importance of pre-instructional activities to establish a context for learning (Dwyer & Lopez, 2001; Elshout & Veenman, 1992; Roberts, Blakeslee, & Barowy, 1996, Windschitl & Andre, 1996), prerequisite knowledge (Jackson, 1997), and structuring these activities in a meaningful way (Elshout and Veenman, 1992). Additionally, Butler (2005) provides evidence that a motivating metaworld can be used to encourage continuous motivation throughout the simulation.

Simulation Research: Conclusions

Jackson's (1997) findings suggest the need for a briefing. The inaccuracies in the simulation leading to frustrations were often solved by allowing the students to learn "the mechanics of the software" (p. 132). A briefing would include this step as a pre-instructional activity. Jacobs and Dempsey (1993) had a similar finding with computer games: Allowing the students a chance to interact with the simulation before the pressure

of assessment is applied, helps the mechanics become more transparent, reduces cognitive load, and helps students focus on the simulated tasks.

Jackson's (1997) second finding, that students often lacked the necessary prerequisite knowledge to use the simulation effectively, is exactly what a briefing should provide. Students need a framework of domain knowledge to guide them through the simulation process. This framework can be provided by the pre-instructional activities of the briefing.

The findings presented by Roberts et al., (1996) have several important impacts on the present study. First, the authors' report that too much structure can detract from the simulation experience implies that it might be possible to give too much information in the briefing. The pre-instructional methods used during the briefing may hinder learning if used while students are engaging the simulation. After the briefing, students should be left to explore the simulation's environment until they find they need more help. This follows Collins' (1990) description of a cognitive apprenticeship, in which students are given help and then left to explore on their own.

Second, the last two conclusions summarized above support the premise of having a briefing phase before engagement with a simulation. Roberts et al., (1996) note that students need some basic skills to get the most meaningful learning from using scientific simulations, and that prior knowledge and experience helps motivate students while using the simulation. Both of these conditions can be met during the briefing. Lessons can be given to establish students during the briefing to teach the necessary skills mentioned by the authors. Also, the briefing should provide, as previously mentioned, the foundational knowledge needed by students to engage the simulation (prerequisite knowledge).

Prerequisite knowledge would provide the prior knowledge and experiences mentioned by the authors to encourage motivation.

The two experiments by Elshout and Veenman (1992) suggest well-structured domain knowledge provided to learners before using a simulation might help some of them make use of better problem solving strategies. However, learners had access to the same domain knowledge during the simulation, which adds a further layer of complexity. It is possible that simply providing knowledge beforehand and not allowing learners access to this knowledge when using the simulation does not have a great learning benefit. The ideal method, based on the article, might be to provide learners with well-structured domain knowledge before the simulation and allow them to access this information during engagement. The authors, however, do not address this distinction.

By having the students create a background history of their roles before using the simulation, Butler (2005) established a briefing for the learners. The backgrounds motivated the learners by framing the game in a personally relevant context for each student. Further, the author allowed learners to refer to their textbooks and access prerequisite knowledge during engagement. This article is an excellent anecdotal illustration of the importance of the briefing phase when using simulations, but fails to discuss how the exercises before the simulation positively influenced learning.

Moreno and Mayer's (2005) findings regarding guidance are of particular interest to the present study. The briefing phase provides learners with the tools they need to successfully engage the simulation, which would include guidance in the form of advance organizers and other techniques. If the learners are able to access the information given in the briefing during engagement with the simulation, Moreno and Mayer's (2005) findings

suggest this guidance will help learners cope with a complex discovery process. One would therefore expect learners to return to these materials for guidance of their own volition.

Overall Conclusions

The research on pre-instructional events, performance objectives, and advance organizers provides a foundation on which to build the current study. Many questions remain about the use of pre-instructional activities, specifically with simulations. Generally, the research supports the use of pre-instructional activities for learning and in particular the value of informing learners of the objectives and reminding them of the prerequisite learning.

Extrapolating this research, one would expect Gagné's (1965) pre-instructional events to have similar benefits when utilized before a simulation, as they seem to have when used with other learning materials. Anecdotal evidence from some prior simulation research suggests briefing activities can positively influence learning with simulations (Asakawa & Gilbert, 2003; Barnett, 1984; Bredemeier & Greenblat, 1981; Butler, 2005; Elshout & Veenman, 1992; Jackson, 1997).

However, the concept of the briefing for this study consists of more than just pre-instructional activities. Learners' metaworlds, their real world reasons for engaging the simulation, and their prerequisite knowledge, that is, what they know about the reference system and the mechanics of the simulation beforehand, are also hypothesized to play a vital role in learning. Butler (2005) provides intriguing anecdotal evidence about using a simulation to teach fifth-graders about the American Revolution. The students'

metaworlds were strong enough to hold their engagement and support continuing motivation throughout the simulation.

Most of the studies cited above were quantitative experiments or meta-analyses. In contrast, the present study is qualitative and non-experimental (i.e., this is a case study). There are several reasons for a qualitative study at this point. First, although performance objectives and advance organizers are theorized to be effective pre-instructional activities and can be used as part of a briefing for a simulation, how they work with simulations is not well understood. Second, this study is a macro view of pre-instructional activities in support of complex learning tasks not a micro view of pre-instructional activities as a part of a more simple instructional experience.

Qualitative research "can reveal how all the parts work together to form a whole" (Merriam, 1998, p. 6). Since there is so little precise research regarding pre-instructional activities and simulations, a general understanding of the phenomena needs to be formed before more specific experimental research can begin. The present study will help form this general understanding using a qualitative methodology. When more of the how is answered with regard to pre-instructional activities and simulations, researchers can then begin to look at what activities have the most beneficial effects for the learners during a briefing.

Summary

The present study primarily asks how pre-instructional activities (orienting activities) affect learning with a simulation. Therefore, the literature in this chapter focuses on two areas, pre-instructional activities and simulations. Pre-instructional activities are defined in the context of Gagné and Briggs' (1979) first three events of

instruction. They posit the educator should (a) gain the learner's attention; (b) inform the learner of the performance objectives; and (c) stimulate recall of prerequisite learning. Research in this area suggests two tools for accomplishing these tasks: advance organizers and performance objectives.

There is sufficient evidence in the literature regarding advance organizers and performance objectives to include them in any research on pre-instructional activities. The evidence suggests these activities help orient learners for the stimulus material to come, remind them of prerequisite knowledge, and act as aids for poorly organized and complex material. Although there is some evidence that performance objectives reduce incidental learning, the research supports similar advantages for providing these to learners.

Although much of the research on simulations as learning tools discusses design characteristics, several authors provide intriguing results suggesting the need for some orienting activities to prepare learners to effectively use the simulation. In the present study, these orienting activities are termed a briefing, to place it in context with a debriefing, an already established phase in simulation research.

The reviewed literature also provides some suggestions for how to construct the simulation and how to gather data to answer research questions. These suggestions are examined in the next chapter.

CHAPTER 3

METHODOLOGY

This qualitative study employed a case study methodology. A description of the theoretical framework, researcher stance, methodology, methods, procedure, and data analysis follows.

Theoretical Framework

To conduct a successful qualitative study, the researcher must identify the theoretical perspective, epistemology, methodology, and methods used (Crotty, 1998). The theoretical perspective is the broad philosophy providing a context for the study. The epistemology is the general theory of knowledge used. The methodology describes the strategy underlying the particular methods used and is influenced by both the theoretical perspective and epistemology. Finally, the methods are the specific data gathering tools to be used in the study.

The theoretical perspective used in this study was post-positivism. Post-positivists believe that “research outcomes are neither totally objective nor unquestionably certain” regardless of how “faithfully the scientists adheres to the scientific method” or the recommended methodologies of the field (Crotty, 1998, p. 40). However, I can claim a higher degree of objectivity, albeit never perfectly, based on the quality of the methodology itself. In other words, in the post-positivist framework, research may not be

entirely objective, but research done using the proper methodology is more objective than sloppy or haphazard research.

Post positivism allows for a degree of objectivity while acknowledging the influence of subjectivity. Using this perspective is mostly a personal choice; it is what I believe personally. Constructivism, where any claim of objectivity is suspect, assumes all data gathered are subjective regardless of the methodology. Positivism assumes the researcher can conduct purely objective research; something I do not personally believe is possible. Post positivism is a middle ground whereby I can create a robust methodology to yield as close to objective research as is possible.

Researcher Stance and Research Design

Epistemology

I consider myself a post-positivist. I believe in an absolute Truth but also believe that personal biases and subjectivity prevent a full description of Truth by any one individual. It is this belief that drives a focus on the methodology of research, to try to be as objective as is humanly possible, realizing that it will never be perfect (Crotty, 1998). I acknowledge that, inevitably, some subjectivity is likely but will work toward letting the data speak for itself without biasing interpretation.

From this perspective, I define Truth in the scientific framework of this study to be the absolute objective fact of a thing or event. In this case, the phenomenon I observe is a fact in of itself; however, I do not believe it possible to observe this pure fact without some degree of subjectivity. Thus, pure scientific Truth exists on its own, but the observation of that Truth is always tainted.

When observing the absolute scientific Truth, I believe it is possible to reduce the subjectivity one brings to the facts with careful methodology. The essential underlying factor is to acknowledge the biases one is likely to bring to the observation. With the biases in mind, one can at least acknowledge them and admit that the observation is not perfect. That is what I attempt in this study.

Researcher History

I have been interested in games and simulations for educational purposes since high school. I wrote a text-based role-playing game called *WindSpeaker* while finishing middle school with the help of my brother and two of our friends (all of whom became players after it was written). The game (Sernett, 2006) is a fantasy role-playing game in the same genre as *Dungeons and Dragons* although it is based on original mythology (set in an American colonial era timeframe). *WindSpeaker* is a project that is never truly finished, and I have been working on it from middle school to the present.

It is difficult to overstate the influence creating and playing *WindSpeaker* has had on my personal life and my career. It is the reason I became interested in studying games and simulations for education. While playing, I observed what I thought was a tremendous growth of problem-solving abilities in the players and in myself. I have always been curious if what I observed was a real benefit of playing text-based role-playing games or something that just happened within our group.

When I entered college as an English major, I did not know that studying games and simulations as educational tools would be in my future. Later, when I learned of instructional design, I immediately knew that my focus would be games and simulations.

I still have not exhausted the research base in this subject domain, but my opportunities, such as the one presented in this study, are growing.

Several studies influenced the design and methodology of the current research. Helms (2009) was an aquarium-based simulation I conducted at the same high school. This was my first real opportunity to conduct case study research and I learned a great deal.

Many of the same techniques I used in preparing, conducting, and analyzing Helms (2009) were used again in the present study. I conducted a literature review for the earlier study to give me an idea of how to start and frame the research. I used interview strategies, field notes, and collected artifacts in the study as well. All of these data sources were used in the data analysis to triangulate my results. The data analysis step itself consisted of plowing through the transcriptions looking for patterns and evidence of transfer.

Another, unpublished, study attempted to develop an instrument to objectively categorize games and simulations. With these categories in place, the games could be examined to see if their factors had an effect on learning. This study gave me the opportunity to play many games and simulations from the perspective of a researcher. I looked for ways these games and simulations could be used in education and what behavioral objectives might be met by playing them. This study hit a snag and was terminated before it came to fruition.

I am also a game programmer with a basic understanding of Game Maker 7. I created a simple game called *Privateers* where players attempt to secure trade ports along the Caribbean by destroying English and French ships. I created this game to be a mixture

of a simulation and a game. Although the play is game-like, (i.e. destroying enemy ships and collecting treasure), the historical aspects of the game are real. It was my hope that the game would be fun and educational at the same time.

Lastly, I play many games. I play the popular games such as *World of Warcraft*, *Halo 3*, *Grand Theft Auto IV,* and sometimes dabble in *Second Life*. Sometimes I look for the educational benefits of these games, but mostly I play just to have fun. I am always interested in the newest and hottest games on the market, but do not get the chance to play them often because of my work and school schedules.

Keeping marine and freshwater aquariums is also a personal hobby. At various times I have maintained a 35-gallon planted freshwater tank, a 100-gallon saltwater tank, and a 30-gallon saltwater reef tank. I have always found marine life fascinating and keeping an aquarium in my house lets me look at a small piece of marine life whenever I can.

I learned on my own how to keep a marine aquarium. I researched online before setting up my first saltwater tank. My research was mostly done on forums such as Marine Depot (http://www.marinedepot.com), Reef Central (http://www.reefcentral.com), and TalkingReef (http://www.talkingreef.com). Additionally, I listened to more than 100 podcasts on maintaining a reef aquarium many times to learn the skills I needed. I was also a contributor to the podcast later with a show on building a refugium and an advanced pluming show.

I am not as familiar with keeping stony corals as I am with keeping fish. I kept a mated pair of clownfish and a mated pair of cardinal fish. Although the clowns did not

lay viable eggs, I did raise two of the cardinal fish's fry to adulthood. I also kept several species of soft corals and have raised fragments of these corals into "adulthood" as well.

Case Study

According to Yin (2009), a case study is an "empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context…" (p. 18). Case study methodology is one of several methodologies that can be used in educational research. However, case studies are most applicable when the researcher is asking "How" or "Why" questions, control over subjects' behaviors is not needed or cannot be done, and the focus is on contemporary, present, events (Creswell, 2006; Stake, 1995). "How" and "why" questions address variables over time, rather than frequencies, thus they are more applicable to methodologies that can trace these changes over time.

Although case studies are employed when the researcher does not have direct control over behavioral events, some methods used in case studies, such as participant observation, can grant the researcher "informal manipulation" of events (Yin, 2009). Other methodologies, such as histories, are relevant when the event in question occurred in the past, and therefore cannot be manipulated at all. Case studies do allow some room for manipulation of behavior, but without the controls and constraints of a classical experiment (Stake, 1995).

Case studies offer an important contribution to the literature on a subject by addressing these sorts of issues. Experiments can establish the credibility of a treatment, but do not answer how the treatment works. Case studies can investigate such issues (Creswell, 2006). Therefore, case studies make an excellent complement to experimental

studies and can be used to "*enlighten* those situations in which the intervention being evaluated has no clear, single set of outcomes" (Yin, 2009, p. 20, emphasis in original).

Single-Case Designs

"A single-case study is analogous to a single experiment" and many of the same reasons used to justify a single experiment can be used for a single-case study (Yin, 2009, p. 47). Situations in which a single-case design is needed include: critical cases, representative cases, revelatory cases, longitudinal cases, and unique cases. The critical case investigates a case that is key to the building of theory (Yin, 2009). The representative case is thought to be a portrayal of the larger population. A revelatory case is when the researcher has access to a previously inaccessible situation (Yin, 2009). Finally, the longitudinal case follows the case over a long period. The unique case allows researchers to examine theories when the case is thought to be an outlier, and these cases can shed new light on theories (Creswell, 2006; Stake, 1995; Yin, 2009).

This study made use of the unique case rationale. The participant was considered unique for several reasons. First, he was identified as a unique student by his teacher, Mr. Percula, who said the participant was unlike many of his other students. Second, the participant was a unique student based on my experience with the school. Most of the students I encountered were highly motivated and independent learners. Third, the participant was unlike the participants for Helms (2009), which was conducted at the same school with the same teacher.

Generalizing From a Case Study

Results of a case study can be generalized, but not in the same way as results from a controlled experiment. Case studies "are generalizable to theoretical propositions and not to populations" (Yin, 2009, p. 15). This type of generalization is referred to as analytic generalization, as opposed to statistical generalization. The goal is to expand theories and not to apply the results to a population (Evers & Wu, 2006; Stake, 1995).

Yin (2009) argues that a single subject in a case study is not like a single subject in a randomized experiment. The goal of a case study, whether single-case or multiple-case, is to analytically generalize from the data. The researcher should design the case and gather data with this in mind.

Methods

The methods of research are the techniques and procedures used in the study (Crotty, 1998). This section describes the tools that were used in the present study to gather these data. The section will cover the research setting (i.e. where the study was conducted), the sample of participants, data collection techniques, and trustworthiness.

Research Setting

This study took place at a charter school in a suburb of Denver, Colorado. The classroom teacher, Mr. Percula, partially set up the aquarium before the study began. It was originally planned that the aquarium would be completely set up before the study commenced; however, Mr. Percula thought that having the participant set up the aquarium would help him learn prerequisite knowledge needed to maintain the simulation. The aquarium had some water, sand, and rocks in it before the study began in order to make the setup easier for the participant.

In addition to the aquarium, the student had access to lab quality water testing equipment for nitrate, nitrite, ammonia, calcium, magnesium, carbonate hardness, pH, and salinity levels. These tests were used before and during the simulation to measure the various water parameters. The lab room also had other science equipment such as scales, beakers, test tubes, and thermometers. This other equipment was used on an as-needed basis.

The student was required to be supervised by a school employee at all times. Because the researcher was not an employee, at least one teacher or staff member had to be present. This was Mr. Percula, the science instructor for the school. He was aware of the study and observed it to make sure that everything proceeded according to school rules and regulations.

Sample

The subject of this study was drawn from a list of volunteers provided by Mr. Percula. In accordance with the recommendations of Lawton and Wanska (1977), a paper-based pre-test was used to ascertain how much the student knew about marine aquariums and coral reef ecosystems.

Mr. Percula advertised the study to three of his high school science classes, totaling about 90 students. This was the same method used to gather participants for Helms (2009) and about five volunteers were expected; however, only one student volunteered. In accordance with the sample selection method, this volunteer was given the pre-test and results indicated he did not know much about marine aquariums. Because of this, he became the participant for the study. Although this was less than the number expected, the participant's behavior turned out to be unique and presented an opportunity

for testing theories in this new context. A discussion of how the participant was unique is included in the next chapter.

Data Collection

Data were collected using a combination of methods. A small digital voice recorder was operating during the entire class period. At the conclusion of the study, transcripts of the audio files were made and names changed in the transcriptions to protect the participant's identity. The audio files were then deleted. All data analysis was done using the transcriptions. To preserve as much non-verbal data as possible, I transcribed the audio immediately after the session and made extensive notes regarding non-verbal information (see Appendix).

Additionally, digital photographs were taken of the participant and of the work he performed. For example, the participant was allowed to manipulate the aquascaping in the aquarium and photographs were used to document this. The digital files of these photographs were manipulated to protect the identity of the participant.

There were also several artifacts collected during the study. The first was the written results from the participant's pre-test, which were kept and used for data analysis. The second planned artifact was notes the participant took on anything that could be preserved. It turned out that he did not write any information down (the pre- and post-tests were delivered orally). However, the participant did enter some data into a spreadsheet on the computer and this information was used in the analysis. The last artifact was the aquarium itself after the participant manipulated the rocks and added or removed animals during the study.

I conducted a series of semi-structured interviews throughout the study to gauge how the participant was using prerequisite knowledge and metaworld while working in the simulation environment. The interviews were audio recorded and transcribed as noted above. Although many of the questions were developed as needed during the study, some questions were:

Before the simulation:

1. How do you think you might apply what you are learning now to the aquarium?
2. There are many variables influencing water quality and the health of the fish, how will you manage these while maintaining the tank?
3. What interests you most about aquariums?

During the simulation:

1. Which of our earlier activities most influenced your use of the aquarium?
2. Did you have to go back and research more while setting the aquarium up?

Finally, I took copious field notes throughout the study. The notes covered observations, thoughts, and ideas not otherwise captured with the other data gathering methods. The notes themselves were handwritten during and immediately after meeting with students, and later typed into a computer data file for clarity and storage.

Trustworthiness

Trustworthiness is the researcher's credibility as a researcher and helps the reader evaluate the quality of the research conducted (Merriam, 1998). A variety of techniques was used in order to establish trustworthiness in the study. Data were triangulated between the interviews, photographs, field notes, and transcripts. I also interviewed the classroom teacher (Mr. Percula) to gather his observations and opinions on the artifacts gathered in the study. Each of the data sources was compared and contrasted to illuminate

similarities and differences in the findings. Triangulation between these sources was used to find convergence, inconsistencies, and contradictions in the data (Mathison, 1988).

Although originally planned, a member check (letting the participant look at the results) was not used in this study for two reasons. First, the participant graduated from the school at the end of the study and both the school and the IRB said I was not to talk to the participant after he graduated. Second, my conclusions and observations about the participant's unique behavior did not often portray the participant in a positive light. I believed that showing him the results would cause him to become defensive, which might have biased the results. I realize the participant might have been able to defend his actions with additional data.

Peer reviews were used throughout the study and during data analysis. Two general types of review were conducted. I discussed observations throughout the study and during data analysis with Mr. Percula and included his feedback in the field notes and the analysis. This proved to be very valuable since Mr. Percula's observations of the participant often differed from mine, and discussing these differences led to new conclusions. I shared my observations with Mr. Percula throughout the study, and shared my results (discussed in the next chapter) with him as well at the end of the study.

The second type of peer review was with my dissertation committee members at the University of Northern Colorado. These faculty members provided a formal review of the methods used in this study. The purpose of this second type of peer review was to "ask hard questions about methods, meanings, and interpretations" (Creswell, 2006, p. 202).

Thick, rich descriptions were used in the field notes, transcriptions, and the final report to allow readers to judge if this study transfers to other situations (Creswell, 2006). The descriptions covered the setting, participants, and procedures. To aid in the accuracy of these descriptions, detailed field notes were kept and photographs were taken for later reference.

Finally, an audit trail of the data is available for an external audit and will be kept for five years in accordance with American Psychological Association guidelines (2010). Names and other identifying information have been removed from the data to protect the privacy of the participant.

Procedure

The study was originally planned for six weeks, but to better fit within the time frame of the school, the study ran for 10 weeks. The first four weeks were dedicated to the briefing with the following six weeks dedicated to using the simulation. The debriefing took place on the last day. Sample selection proceeded as originally planned.

Sample Selection

The sample for the study was gathered in two stages. First, Mr. Percula asked for volunteers from his classes. Next, a pre-test was administered to the volunteer to ensure that he had only a minimal understanding of aquariums and coral reef ecosystems (Lawton & Wanska, 1977). The study was conducted with the remaining participant. Finally, the pre-test was used to establish the presence of subsumers (Lawton & Wanska, 1977). The results from the pre-test were used to create the advance organizer for the participant (Ausubel & Fitzgerald, 1961; Barnes & Clawson, 1975; Griffin et al., 1995).

To get an initial available sample, the instructor for the course asked for volunteers from his classes. At this point, the aquarium was already partially assembled in the classroom, without animals, to spark some curiosity with the students. The students were informed of the overall goals of the study and asked if they would be willing to participate in the research.

The next step was for Mr. Percula to examine the pre-test I had created. Mr. Percula provided feedback on the questions before the pre-test was administered to the volunteers. Mr. Percula liked the proposed questions but suggested adding a question regarding salinity. The pre-test was the following:

1. What are the steps of the nitrogen cycle?
2. What are the natural seawater levels for calcium, magnesium, and carbonate hardness?
3. What is the ideal calcium level for a reef aquarium?
4. How do stony corals use calcium?
5. What are the ideal temperature and pH ranges for a tropical reef?
6. What are some common detritivores you can use in your aquarium?
7. What are some common herbivores you can use in your aquarium?
8. What specifically happens to corals when the temperature begins to rise too high?
9. What is the ideal salinity for the aquarium?

Then, the pre-test was administered to the volunteer to assess his advance knowledge of marine aquariums and coral reef ecosystems. In accordance with the participant selection guidelines, if he had correctly answered more than half of the questions, he would have been excluded from the study. Additionally, the pre-test data were saved to evaluate learning at the end of the study. The volunteer correctly answered three of the nine questions (33%), which meant he was eligible to participate in the study.

Finally, the pre-test data were used to construct the advance organizer in accordance with the guidelines suggested by Lawton & Wanska (1977). Using these

guidelines, the pre-test was used to construct the advance organizer on the nitrogen cycle (Figure 1). It was apparent from the pre-test that the participant had no prior knowledge of the nitrogen cycle, which Mr. Percula and I thought was critical prerequisite knowledge for using the simulation. The advance organizer contained information about the nitrogen cycle at a higher level of abstraction than the participant would need to know for the simulation.

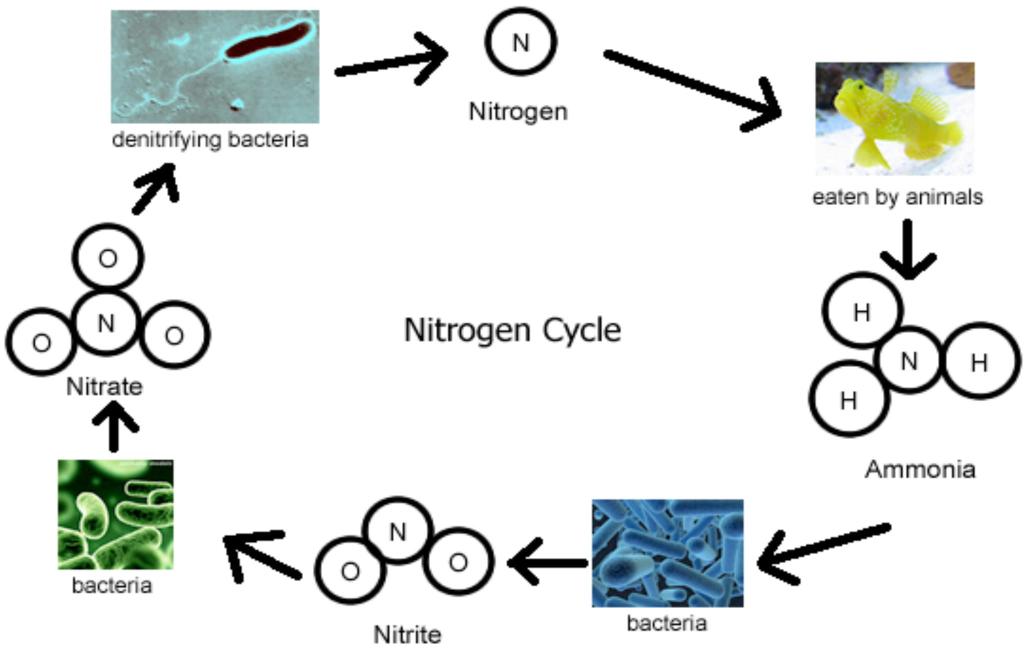

Figure 1. The advance organizer of the nitrogen cycle.

The Briefing

After the participant was selected and the advance organizer created, the briefing phase of the study began. During this phase, materials were given to the participant. I

presented four lectures on the basics of aquarium care and the participant toured the aquarium in the classroom. Following this, engagement officially began with the addition of live animals to the aquarium.

I gave the participant the advance organizer created using the data from the pre-test and a list of behavioral objectives. Mr. Percula and I went over these materials with the participant. The behavioral objectives were as follows:

1. Students will be able to describe the full nitrogen cycle.
2. Students will be able to describe how corals use calcium to build their skeletons.
3. Students will be able to mix tap water with artificial reef salt to the proper salinity and pH levels.
4. Students will be able to conduct a 25% water change in the aquarium.
5. Students will be able to write the ideal measurement ranges for calcium, magnesium, carbonate hardness, pH, and salinity.
6. Students will be able to describe the food web in the aquarium and on a coral reef.
7. Students will be able to predict the effects of rising sea temperatures on coral and other animals.

Informal lectures were given to the participant on the nitrogen cycle, coral uses for calcium and carbonate hardness, and the animals he was allowed to add to the aquarium. Additionally, a demonstration was given on how to mix artificial salt and water to the proper pH and salinity. These lectures and the demonstration were supposed to communicate the prerequisite knowledge needed for the participant to maintain the aquarium.

I had planned to have the participant listen to eight podcasts from TalkingReef (http://www.talkingreef.com), but listening to hour-long podcasts during the sessions proved impractical, as there were other tasks to do. Mr. Percula and I told the participant to listen to the podcasts on his own, and he reported later that he had listened to part of only one.

The tour of the classroom aquarium consisted of showing the participant the components of the simulation and how to use these components. For example, the participant was shown the heater with an explanation of its function and importance to the health of the aquarium. It was hoped that this step gave the participant the necessary prerequisite knowledge to use the simulation. Additionally, it was hoped that seeing the aquarium would help establish the participant's metaworld.

After this final step, the participant was allowed to start adding animals to the aquarium, marking the beginning of engagement.

The Simulation

Engagement with the simulation began when the participant started adding animals to the aquarium. At this point, he was expected to pay close attention to all of the variables in the simulation. The most important variables were the calcium level, magnesium level, nitrate level, pH, salinity, and temperature. This was the logical place to define engagement since the animals demanded the participant use all of his prerequisite skills from the briefing.

The reference system of the simulation was coral reef ecosystems. The simulation consisted of a 75-gallon aquarium, the fish and corals, the algae, the live rock, the water, and the instruments needed for testing water quality and coral growth. The animals used in this simulation were two ocellaris clownfish (*Amphiprion ocellaris*, see Figure 2), five blue-legged hermit crabs (*Clibanarius tricolor*), a sea squirt (tunicate, exact species unknown), and mushroom corals (family *Discosomatidae* or *Actinodiscidae*, exact species unknown). The fish, hermit crabs, and corals were added at the beginning of the

participant's engagement of the simulation. The sea squirt was attached to one of the rocks added during the briefing.

Both the researcher and Mr. Percula agreed on several limitations to the simulation before the study began. First, the simulation was limited to the domain of marine ecosystems and the chemical, physical, and biological factors contributing to the balance of the ecosystem. Second, the simulation did not include animals from the reference system (coral reef ecosystems) that were identified as dangerous by Michael (1999). Last, the simulation did not include animals with an Aquarium Suitability Index equal to or lower than three in Michael (1999).

Figure 2. These were the fish added at the end of the briefing.

Transfer, defined as the continued appropriate responses in the reference system as in the simulation (Jacobs & Dempsey, 1993), was measured by how well the participant applied knowledge from the simulation to coral reef ecosystems. The participant was also asked to evaluate the limitations of the simulation in understanding coral reef ecosystems (i.e. what aspects of the aquarium do not transfer to the reef?). The participant's lack of learning precluded any examination of transfer. This will be discussed in detail in the next chapter.

The Debriefing

The debriefing was planned according to the three stages outlined in Chapter 2. However, by this stage of the study it was apparent that the participant had not learned the material, and the attempt at a debriefing was thus hindered. I gave the participant the post-test (same questions as the pre-test) to measure what he had learned. The teacher, Mr. Percula, also tried to give the participant one final lesson on the nitrogen cycle (one of the processes of the simulation).

During the debriefing, I assumed the role of a facilitator and guided the participant through the post-test and lesson. As a facilitator, I did not enter the debriefing with an agenda, other than to administer the post-test, and I tried to let the participant decide on the direction this phase needed to take (Baker et al., 1997). I asked the participant several questions about his actions during his engagement with the simulation, and it was apparent he had not done any of the tasks Mr. Percula and I asked of him. Mr. Percula then decided the participant needed a last minute lesson on the nitrogen cycle, and this experience yielded valuable data.

CHAPTER 4

RESEARCH FINDINGS

Interviews, observation notes, and artifacts were collected over a 10-week period. The participant (who I will call Herman) often communicated non-verbally. To compensate, I relied heavily on other data sources including careful observations of Herman's behaviors. Data were triangulated between these sources and to Herman's comments when possible.

I met with Herman three times a week for an hour and a half each time, yielding about 27 hours of direct observation and five hours of interviews over 10 weeks. I had access to the site only in the morning, but Herman could come in as often as he wanted provided the teacher, Mr. Percula, was present. The teacher also observed Herman and reported to me.

Herman was a senior in his last semester before graduation and showed prior interest in the aquarium to the teacher. Herman is a white male and had served as Mr. Percula's student assistant in past semesters. Based on Mr. Percula's understanding, Herman was also successful in school. It appeared to me Herman had a great deal of free time during the school day as he would often come into the classroom to work with the tank when other students were in classes.

This study took place at a charter school in a suburb of Denver, Colorado. The school enrolls students from kindergarten to 12th grade although the elementary school

children are separated from the middle school and high school students. The school has approximately 400 high school students. The high school received a performance score of "high" on Colorado's School Accountability Report (Colorado Department of Education, 2009).

I worked with Herman in a designated area of the classroom, where there were two computers and a display of some plants (Figure 3). The equipment used in the simulation was donated to the classroom by Mr. Percula, parents, and by me. Other students would come over to use the computers, and Herman and I worked around them.

Figure 3. The majority of the study took place in this area. The aquarium is on the right.

Nature and Organization of the Analysis

The data were coded using qualitative analysis techniques, in which instances in the field notes, interviews, and transcripts were coded, using codes derived from the data and prior research. Five codes were used to classify the data according to self-efficacy, goal orientation, work effort, and the demonstration of learning (prerequisite knowledge).

Metaworld was used as a code originally but it did not adequately disaggregate the data and left large clusters of information. Using the research on motivation, the code was split to identify goal orientation and self-efficacy and this proved to be more interpretable.

Prerequisite knowledge was also used as a code but it was quickly apparent that Herman did not learn the material. Therefore, the code was reversed to identify instances where Herman was supposed to know the material but did not. This change again proved to be very interesting and increased the interpretability of the data.

Four relevant themes were titled: (a) Unanticipated/ Desired Goal-Setting Behavior; (b) Perceptions of Self-Efficacy; (c) Perceptions of Quality Work; and (d) Lack of Responsiveness. The pith of these themes was Herman's motivation and this literature was used to analyze the themes (see Table 1 for an advance organizer).

Themes were checked for accuracy by comparing them with the literature on motivation and the literature on simulations using the pattern matching technique (Yin, 2009). Similarities and differences between the patterns were included in the analysis of the themes. In addition, the themes were shared with the classroom teacher and his feedback was incorporated into the analysis.

Table 1

Organization of the Themes

Theme	Description	Evidence in the Data	Relationship with other themes
Unanticipated/desired Goal-Setting Behavior	Herman's goals were not aligned with my goals.	Ignored the advance organizer on the nitrogen cycle. Not interested in testing the water until I told him it delayed adding fish. Ignoring Mr. Percula's lecture about the nitrogen cycle. Interested in hatching brine shrimp. Not interested in the Ca or Mg mixtures. Post-study interview with Mr. Percula.	His goals were not aligned with Researcher's or Mr. Percula's, which may have influenced his level of effort on some tasks. If he was not interested in the task, he ignored it. May have influenced his self-efficacy.
Perceptions of self-efficacy	Herman had very high self-efficacy, but failed objective measures of his skills.	Failed the pre-test. Said he already knew everything. Had an aquarium at his house. Mr. Percula's impression of Herman's behavior. Participant's home aquarium crash. Failed the post-test.	Possibly influenced by his goal setting. If he did not think he was good at it, he did not perform the task well.
Perceptions of quality work	Herman said he did not like it when others "half assed" things but often did this himself.	Participant criticized Mr. Percula's work. Participant was meticulous while arranging the rocks. Participant's process for hooking up the protein skimmer. Participant skipped steps when mixing salt and water. Participant did not test the water. Participant did not add Ca and Mg additives.	Participant's perceptions of quality may have been influenced by his self-efficacy and goal setting behavior. His lack of effort caused problems that threatened his self-efficacy.
Participant's lack of responsiveness	Herman talked little, did not respond to questions, and did not listen to advice.	Participant rearranged power cords and nearly electrocuted himself. Arranging the rocks. Did not want to add the Ca and Mg additives to his aquarium. Hooking up the skimmer. Not listening to Mr. Percula's lecture.	Not listening to advice may relate to his failing the post-test.

The data that led to the creation of these four themes are detailed below. The headings used in the themes draw from Herman's behaviors, rather than the analysis of the data. This was done to avoid biasing the reader toward my interpretation of the data. Theories of motivation are then used to unite the themes.

Theme One: Unanticipated/desired Goal Setting Behavior

The first theme that emerged from the data was Herman's interest in fish and disinterest in the reference system of the simulation (coral reef ecosystems). The goal of the study was to teach him about coral reef ecosystems and the simulation was a tool to teach this subject matter. Herman showed more interest in the simulation than he did coral reef ecosystems, and ignored any learning materials that did not directly relate to adding fish to the simulation. Once the fish were added, he stopped experimenting with the simulation and only did the basic tasks necessary to keep the fish alive.

The Nitrogen Cycle

For example, I gave Herman an advance organizer on the nitrogen cycle (Figure B1) in the second week of the study. The nitrogen cycle is the process by which bacteria convert waste into nitrogen and remove harmful chemicals from the water. This cycle was critical to understanding life in aquatic ecosystems. Using the advance organizer, I gave Herman a lecture illustrating the steps of the nitrogen cycle while he was arranging the rocks in the aquarium. Three times during the lecture, I asked Herman if he understood and each time he said "Uh huh." I told Herman that he could have the advance organizer and that he should learn the cycle. I placed the paper in a three-ring binder for safekeeping.

To reinforce the nitrogen cycle, I created a spreadsheet to track the tested levels of ammonia, nitrite, and nitrate. I asked Herman to test the water every week and enter the data into the spreadsheet.

First, I had to train Herman on how to use the test kits for ammonia, nitrite, nitrate, calcium, magnesium (Figure 4), and to use the refractometer. I talked to Herman about the purpose of the test kits, and said that I wanted him to add the test results to a spreadsheet. We started testing the water:

> Researcher: "Okay so, why don't you do nitrate since that is the one we are worried about now. I will do ammonia."
> Herman: [no response. He reaches into the bag and takes out the test kit for nitrate.]
> Researcher: "Do you know what you are doing"?
> Herman: "Yeah."
> Researcher: "Have you used these before"?
> Herman: "No."
> Researcher: "Well the directions are right there on the sheet in the box."

Herman read over the directions and drew some water for testing. He did not seem interested in what we were doing, and he asked several times "when do we get fish." At first I just said "later," but finally I explained to him that we couldn't get fish as long as the nitrates were over 20 parts per million (ppm). Herman then became much more interested in the test. Based on the test results, we agreed the nitrates were 35 ppm. We then tested for nitrite, ammonia, calcium, and magnesium.

Figure 4. Starting from the left: Calcium, carbonate hardness (KH), magnesium (with the components removed). Not shown: nitrate.

He checked the nitrate levels twice a week but never entered the data into the spreadsheet. After a few weeks, the nitrates dropped to 10 ppm and I never saw Herman test the water after this. The teacher reported to me that he never saw Herman use the test kits after we added fish. I checked the spreadsheet after the study and no data had been entered.

I thought Herman's behavior was indicative of the Unanticipated/desired Goal Setting Behavior theme. Herman was not interested in the test kits until I explained to him that we could not add fish when the nitrates were over 20 ppm. The only way to know if the nitrates dropped was to test the water, which Herman did until the nitrates tested at 10 ppm, after which time Herman stopped testing. When the fish were added

(Figure B2), Herman did not test the water until told to by his teacher. My interpretation of this was that Herman wanted fish and was interested in the nitrate levels so long as they were too high to add fish. Once the fish were added, Herman thought that testing the water was no longer needed, which was incorrect.

On the last day of the study, I gave Herman the post-test. One of the questions on the post-test asked him to describe the nitrogen cycle. Herman responded "Ammonia first, then I don't know." This surprised both the teacher and me since we thought Herman had learned the cycle earlier. The teacher decided to give Herman a quick lesson on the nitrogen cycle. However, I could tell Herman was not paying attention by his body language. He was spraying water on some plants and adjusting the skimmer intermittently and only looked away from these activities when his teacher made him read something from the advance organizer. He never looked at what his teacher was writing on the whiteboard. The teacher seemed to be frustrated by Herman's behavior and confronted Herman:

> Mr. Percula: "What are you doing? Pay attention to this."
> Herman: "Oh. Why"?
> Mr. Percula: "This is something you were supposed to have learned."
> Herman: "Oh."
> Researcher: "Well, it might be too late now."
> Mr. Percula: "I think he needs to know this."
> Herman: "Oh."

Even after this exchange, Herman did not pay attention and showed no interest in learning the nitrogen cycle. The teacher tried to get Herman's attention focused on the lesson several other times, but to no avail.

Hatching Brine Shrimp

Herman showed a great deal of interest in hatching brine shrimp. The day I brought in the eggs and hatchery, Herman was already in the classroom rearranging the rocks in the aquarium. I told him what we were going to do:

> Herman: “What is this”? [Holding the brine shrimp hatchery]
> Researcher: “That is what we are going to hatch the shrimp in. So, look at this… [Holds up the eggs.] These are the eggs. We will add water and dump some eggs in it. Then we turn on the air and bubble the water until they hatch. See, look…”

We attached the airline tube to the hatchery and added water. Herman did not speak much during this time but he was paying attention and actively helping. He asked what the brine shrimp were for and I told him they would help get the aquarium ready to add fish.

The next session was after the weekend. The brine shrimp had hatched and we could see an orange cloud of them swimming in the hatchery. I gave Herman a net and told him to catch some shrimp. He did this and added the shrimp to the aquarium. Herman seemed excited by this. I then decided to add another activity to see how Herman would react:

> Researcher: “Here, give me some [brine shrimp] on this [a slide].”
> [Herman uses an eyedropper to suck up some brine shrimp and drip them on the slide. Helms then put the slide under the microscope.]
> Researcher: “Hmm. I do not see anything moving. [Pause] Wait; give me some water with that dropper.”
> [Herman adds a drop of water on the slide and Helms puts it back under the microscope.]
> Researcher: “Wow! Cool! Check this out man.”
> Herman: [Looking through the microscope.] “Ha! Hey Mr. Percula, come look at this. You can see them swimming.”

Herman seemed excited at seeing the brine shrimp swimming under the microscope, as illustrated in the above quotation. He looked into the microscope several

more times before going back over to the simulation. Over the next week, Herman continued to add eggs to the hatchery and add the hatched brine shrimp to the simulation.

Mixing the Additives

Later, we mixed the calcium and magnesium additives. The objective was to create the additives for the simulation while also using the time as an opportunity to review the importance of calcium and magnesium in the water. While Herman was mixing the calcium chloride with the distilled water, I explained to him its importance:

> Researcher: "Dude, see, that is what we will add to the tank. Remember all that stuff about the corals and the calcium"?
> Herman: [shakes his head]
> Researcher: "Okay well the corals absorb the stuff from the water and use it to get bigger. So that is why we are making this, to add to the water to help them grow. This doesn't really help fish, since they don't need it, but if it is too high it can kill them. Okay is that right? Be careful 'cause that gets hot."
> Herman: "Yeah it is warm."
> Researcher: "So what you can do is add this stuff to the tank later on to help the corals, when we get some."
> Herman: [no response]

During this activity Herman was distant and unmotivated. Even during the exchange above I could tell he was barely listening; this was evidenced by his lack of responses.

The additives were helpful to the corals but not the fish. My interpretation of this event was that Herman wasn't interested in the additives because he knew it did not bring us closer to adding fish. The additives were ancillary to the simulation and weren't really needed for it to run smoothly.

Herman's Interest

When the briefing ended, I called the teacher to talk about what happened over the previous few weeks. He told me:

> I don't think he cares about the oceans at all; the whatever it was you called it. He likes the tank but not what it means. Its weird man, I thought he was all into it and everything at first.

After the study ended, I asked him if Herman showed any interest in the simulation before the study began:

> I would assume so for the following… Sometime after seeing the tank I had at school, he opted to purchase one of his own where he began to borrow certain items such as salt, food, RODI water etc. A bit of questioning also ensued such as how to mix and measure the salt in the water and what animals he could maintain. I also directed him to a website that is popular for its collection of "nano-reef" aquariums. Over the span of several months, I noticed him on the site several times looking at other aquariums owned by the sites members.

I also asked the teacher if Herman showed any interest in coral reef ecosystems:

> Herman seemed more interested in just the maintenance of a small reef aquarium, and no evidence was ever witnessed by me leading to how these organisms actually live in the wild, let alone how an entire ecosystem behaved. This could be explained by his interest in obtaining relatively cheap anemones for his clown fish to host in. However, the anemones and the fish come from different regions of the world (Caribbean vs. South Pacific) and would have an incompatible relationship, or the clown fish would ignore the anemone as opposed to hosting in it.

The teacher's answers coincide with the evidence presented to construct the Unanticipated/desired Goal Setting Behavior theme. While Herman seemed interested in adding fish, he didn't seem interested in taking care of them to the extent to which I asked him. I observed similar behavior to what his teacher described in the quotations above. When the briefing ended and Herman had to take care of the fish, it did not seem to me that he put forth all the effort asked of him.

Many of these data were cited earlier under the Perceptions of Quality Work theme, but I will summarize them here. There were several tasks Herman was supposed to perform while working with the simulation on his own:

Daily:

- Feed the fish.
- Turn on the skimmer in the morning and turn it off when he left school.

Weekly:

- Mix some fresh saltwater and perform a 25% water change.
- Clean out the skimmer cup.
- Test the simulation water for calcium, magnesium, salinity, ammonia, nitrite, and nitrate and enter the data into the spreadsheet.

As noted earlier, Herman never performed some of these steps. He only tested the water for nitrate once and only as a result of the teacher telling him to do it. He also never cleaned out the skimmer cup. He did do the water changes, but he skipped steps in properly mixing the water.

Theme Two: Perceptions of Self-Efficacy

The second theme relates to Herman's self-efficacy. Several of Herman's behaviors led me to believe that he had high self-efficacy.

Pre-test Results

In the beginning of the second meeting, I gave Herman the pre-test orally while he worked on the simulation and wrote his answers on paper:

Researcher: What are the steps of the nitrogen cycle? [Question 1]
Herman: Don't know. [Wrong]
Researcher: What are the natural seawater values for calcium, magnesium, and carbonate hardness? [Question 2]
Herman: Don't know. [Wrong]
Researcher: What is the ideal calcium level for a reef aquarium? [Question 3]
Herman: Don't know. [Wrong]
Researcher: How do stony corals use calcium? [Question 4]
Herman: Absorb it from the rocks. [Wrong]
Researcher: What is the ideal temperature and pH ranges for a tropical reef. [Question 5]
Herman: 72-74 degrees. [Wrong]
Researcher: What are some common detritivores you can use in your aquarium? [Question 6]

Herman: Hermit crabs and snails. [Correct]
Researcher: What are some common herbivores you can use in your aquarium? [Question 7]
Herman: Emerald crabs. [Correct]
Researcher: What specifically happens to corals when the temperature begins to rise too high? [Question 8]
Herman: Pisses them off. [Wrong, not specific enough]
Researcher: What is the ideal salinity for your aquarium? [Question 9]
Herman: 35 parts per thousand. [Correct]

Herman got three out of nine questions correct. This indicated that Herman did not know much about marine aquariums or coral reef ecosystems. A few days later I asked Herman a question:

Researcher: “Are you seeing any applicability of what you are learning here to coral reef ecosystems in general”?
Herman: “Not really. Everything I am doing here I already know.”

I thought Herman’s statement was strange given his performance on the pre-test. This was the first evidence of a contradiction: Herman believed he knew a lot about marine aquariums and coral reef ecosystems, but this was not supported by objective measures.

Student Self-report

Early in the study, I asked Herman why he was interested in aquariums:

Researcher: “So dude, what got you interested in all this anyway”?
Herman: “Mr. Percula.”
Researcher: “What prompted you to get a tank at home”?
Herman: “Oh I just wanted (it). I just had two freshwater and had the cube so I decided to do the one with saltwater.”
Researcher: “How long have you had the saltwater thing at home”?
Herman: “Two years.”
Researcher: “Really, the salt water”?
Herman: “Yeah, he is trying to get me to get a bigger tank and I just don’t have the money for it.”
Researcher: “Yeah, they are expensive. So what got you interested in doing this thing with this tank here”?
Herman: “Oh we just set one up here and I was into it.”

This exchange with Herman revealed that he had experience with something similar to the simulation prior to the study. In order to maintain a salt water aquarium, Herman would have to be able to perform a water change and know how to feed the fish. I thought that knowing the nitrogen cycle, how to mix salt water, how to work an RO/DI filter, having an understanding of the food web, and knowing something about the fish and coral's wild habitat was also necessary to maintaining an aquarium. However, based on the results of the pre-test, Herman did not know these things yet still maintained that he had a salt water aquarium for two years. This may have revealed a bias on my part about the skills needed to maintain a salt water aquarium: I assumed skills were required that may not have been.

After the study ended, I asked the teacher if Herman had made any comments to him about the study. Mr. Percula responded, "Herman claimed he really didn't learn anything. As he had said frequently, he already knew everything that was explained in the study."

I thought this perception by the teacher was interesting given my observations of Herman. The implication of the teacher's answer is that Herman told him more than once that he already knew everything. I heard only one of these comments, and was unaware until his teacher answered this question that Herman had made other comments to this effect.

Using the Additives

Another example of Herman's self-efficacy was when we were mixing the calcium and magnesium additives. During this activity, Herman seemed disinterested so I decided to try to make what we were doing relevant to his aquarium at home.

Researcher: "Here, add this one and I will make another batch. Just barely enough. So now I will fill this up with water. All right, give that a couple of good shakes. We can add more water if it doesn't all dissolve. So you could take some of this and add it to your tank at home you know."
Herman: "No."
Researcher: "No"?
Herman: "I don't want to mess with it."

I had explained to Herman how the additives would help the corals. My impression when Herman made the comment quoted above was that his aquarium at home was in good condition. If that were true, I could understand why he would not want to disrupt what was working already.

Resistance to Learning Experiences

The second to the last day of the study, Herman said that his aquarium at home had experienced serious problems:

Mr. Percula: "What happened"?
Herman: "Like all the water turned white and the corals started to die. I lost two fish."
Researcher: "When did it happen"?
Herman: "Two days ago. I brought in all my stuff to save them. There they are."
Researcher: "So what did you do? Did you add something to the tank or change something"?
Herman: "I don't know what happened, it just turned white and everything died."
Mr. Percula: "That is your corals there right"?
Herman: "Yeah. They will probably do better in here because of those mixtures."

In the jargon of the salt water aquarium hobby, an experience such as the one Herman described is referred to as a crash. Herman's crash speaks to his skills as a caretaker of a marine aquarium. I have about three years' experience with salt water aquariums, and from my experience only the addition of too much calcium or magnesium would make the water turn white. In this situation, the chemical would precipitate out of the water as white flakes, which would choke fish and smother corals. Based on this

experience, I suspected that Herman was not totally honest when he said he didn't know what caused the crash.

Also, Herman knew that his corals would do better in the simulation because of the "mixtures," which I took to mean the calcium and magnesium additives. I thought this was a revealing statement given his refusal to use them in his aquarium at home.

In my experience with aquariums, crashes are always the result of human error. Because of this, I interpreted Herman's crash as evidence of his inexperience with saltwater aquariums. I asked the teacher what he made of Herman's crash:

> His failure or "crash" of his own personal tank is based on his lack of understanding water chemistry. When "symptoms" occur within a tank such as algae overgrowth, it is usually the sign of an elevated concentration of some chemical.

This reinforces my interpretation of Herman's aquarium crash. The teacher also added support to my hypothesis that the crash was a result of a spike in calcium or magnesium. However, the chemical must be deliberately added to an aquarium for a precipitation event to occur. Although he didn't admit it, Herman may have tried to use the mixtures and added too much. This implies Herman was resistant to admitting fault and learning from his experience.

Post-test Results

Additional evidence of the Perceptions of Self-Efficacy theme was found in Herman's performance on the post-test, given to Herman at the end of the study in a conversational tone. During this exchange, Herman was moving rocks around in the aquarium and watering plants:

> Researcher: "It shouldn't be as bad anymore. So dude, let me ask you some questions like I asked you the first time. So, do you remember the nitrogen cycle"?

Herman: "No. It was that little thing you gave me right? With the arrows"?
Mr. Percula: "What dude? You better remember."
Herman: "Ammonia gets sucked up or something. I don't know I looked at it [the advance organizer] that one day and that was it. I am not going to lie."
Researcher: "Oh I believe you. I don't suppose…"
Mr. Percula: "So [Herman] could you put, essentially if you just started a tank, nothing but new stuff in there. Is it wise to put stuff in there"?
Herman: "Like damsel fish"?
Mr. Percula: "You could do that, but is it wise to do that"?
Herman: "Maybe but that is how I started mine though, with a damsel fish."

The nitrogen cycle was one of the key items Herman was supposed to have learned from using the simulation. I gave Herman an advance organizer of the nitrogen cycle during the briefing. However, by his own admission he looked at it once and never again.

I continued to question Herman:

Researcher: "I think we might have to cut that tube and make it shorter. But that is a different tube though. So [Herman] this might be a dumb question, too. I saw you glance at this once but not sure if you did again. Do you remember the ideal values for calcium, magnesium, nitrate, and all that do you"?
Herman: "No."
Researcher: "Do you remember how corals use calcium"?
Herman: "It helps them grow doesn't it"? [He starts talking to Mr. Percula about something else but I can't hear it]
Researcher: "Okay. Do you remember the ideal temperature range"?
Herman: "79 to 80."

We had discussed the ideal values for calcium, magnesium, nitrite, nitrate, and ammonia several times in the study. We also spoke at length about how corals use calcium, but Herman could not answer these questions. He did give the correct temperature range. We continued:

Researcher: "What are some common detritivores you can use"?
Herman: "Hermit crabs, snails…"
Researcher: "What are some herbivores you can use"?
Herman: "What"?
Researcher: "Herbivores, do you know any"?

Herman: “No I don’t.”
Mr. Percula: “What”?

Herman was able to name an herbivore when given the pre-test (emerald crabs). The food web was discussed during the briefing, but herbivores were not specifically emphasized. His answer to the detritivores question was correct. We continued:

Researcher: “Let’s see what you know how to do… Can you describe to me the food web in an aquarium”?
Herman: “Does that have to do with that nitrogen cycle”?
Mr. Percula: “Oh God! That’s not a good start.”
Researcher: “No! Well do you know what a food web is”?
Herman: “That’s like the fish eat it and poop out ammonia and stuff right”?
Researcher: “No that’s the nitrogen cycle. Do you know what comes next”?
Herman: “Is it magnesium”?
Researcher: “Magnesium…”
Herman: “Well I don’t know I just glanced at it that one day. If I look at it again I could tell you.”
Researcher: “Okay no worries.”
Mr. Percula: “Do you, Mr. Researcher, do you want to take a little more time and go over this stuff”?
Researcher: “Now that is up to you.”
Mr. Percula: “If you leave me those questions I can hit him with them again.”
Researcher: “That’s up to you.”

At this point, I gave the teacher the post-test and he started reviewing the nitrogen cycle with Herman. In the above quotation, Herman revealed that he did not know the food web or the nitrogen cycle, both of which were covered in the briefing. Herman was able to answer two of the nine questions correctly, which is worse than he did on the pre-test. In a written interview with the teacher after the study, I asked him why he thought Herman failed the post-test, he responded:

> Student arrogance – as previously mentioned he said he knew everything that the study was trying to give him. (He had) difficulty in accepting other people (besides the teachers at the school) as an educational figure.

Mr. Percula’s response reveals that Herman may not have seen me as an “educational figure.” This explains why he didn’t respond to my comments or take my

advice. Mr. Percula writes that he thought Herman was arrogant, and that is why he failed the post-test. Mr. Percula may have come to this perception from Herman's adamant stance that he already knew what we were trying to teach him. Herman's self-efficacy was strong enough to be seen as arrogance by his teacher.

Theme Three: Perceptions of Quality Work

One theme that emerged from the data was a juxtaposition of Herman's attitudes and actions toward completing tasks. Herman's attitudes overall indicated he preferred to do a task well. Conversely, with some actions he would skip steps and insist that his method was "good enough." Examples in the data included: (a) a comment Herman made to his teacher; (b) Herman's insistence that the rocks in the simulation look well placed; (c) his interest in attaching the protein skimmer; and (d) his behavior after the briefing ended.

Discussing With the Teacher

Herman's attitude was exemplified in the following exchange between him and the teacher (Mr. Percula). At the time, the teacher was sectioning off parts of his board and Herman was watching.

> Herman: [To Researcher] "I didn't do one [a water change]. I just added water to the top. [To Mr. Percula] What are you doing to your board?"
> Researcher: "Oh, okay well let me start mixing up some stuff."
> Mr. Percula: "That might solve your nitrate problem man."
> Herman: "Mr. Percula, what are you doing?"
> Mr. Percula: "I am taping off sections for…well…I don't know. I am thinking that if I tape off these sections I can make a schedule out of it."
> Herman: "It's going to look bad unless you do it right."
> Mr. Percula: "Well what do you think I should do?"
> Herman: "Just leave it and I will come back in and do it."
> Researcher: [To Herman] "Tell you what let's do two of these buckets. Where's a power head?"

Mr. Percula: [to Herman] "Well if you are going to be an ass about it…" [Tries to wrap tape around his head]
Herman: "You know I hate it when people half-ass things."

I thought Herman's last statement was brazen for a student to make to a teacher, although the teacher didn't seem bothered by it. Later, I asked the teacher what he thought about Herman's comment. He said it was an understanding he and Herman had had; they would often joke around and Herman would make comments like the one above.

Herman finished the teacher's board later in the day. I saw the work the next week and asked the teacher, when Herman was not in the room, if he thought Herman did a better job than he would have done. Mr. Percula said he did.

Arranging the Rocks

There were other incidents that fit this theme. When working with the aquarium for the first time, Herman decided to arrange the rocks. The arrangement of the rocks did not affect the functionality of the simulation, but Herman insisted they look well-placed. After removing all the rocks, he started deliberately and carefully adding the rocks into the aquarium. At one point, I said "Dude, the rocks are going to fall over. It is really hard to balance them," referring to an unstable structure he was building. He responded, "You have to have mad skills, like me," and continued.

Later that day Herman came back into the class. His teacher observed him and reported he stayed for about an hour rearranging the rocks. Interestingly, by this time the structure I had warned Herman about had fallen; he built a different, more stable, structure out of the rocks (Figure 5).

Figure 5. Image of Herman moving the rocks around the simulation.

Attaching the Protein Skimmer

Later, Herman decided to attach the protein skimmer (skimmer) to the aquarium (Figure 6). The skimmer was not an important part of the simulation and I told Herman not to install it since it was a flood risk. Herman ignored my request and attached the skimmer. When Herman turned it on, the skimmer didn't work properly. While we were troubleshooting, the following conversation took place:

> Herman: "No, that's not going to work."
> Researcher: "We could try…I am not sure."
> Herman: "We need something like plastic."
> [Herman goes in the back and comes out with a length of plastic tubing. He gets the scissors and cuts a three inch piece of the tube off. He puts the piece of tube on the in-tank of the skimmer and it starts working.]
> Researcher: "Oh wait you might have gotten it."
> Herman: "Should we plug this into the same timer that the lights are on?"
> Researcher: "Well the lights are on longer and they will come on over the weekend too and we don't want that. So I would just plug it in when you come in. It is not so critical that you are going to lose anything if you

don't have it. You are not going to stock this tank so heavily that you will really need it."

Herman: "Oh, okay."

Herman was able to troubleshoot the skimmer successfully with my help and I noticed he was determined to install the skimmer properly. I thought his efforts coincided well with his statement that he liked to do things well.

Herman's Behavior
After the Briefing

I observed other actions by Herman in which it appeared that he did the minimum. After the briefing, I had the teacher observe Herman and report to me later in the week. I decided to let the teacher do the observation since he was already in the room with the simulation and could watch Herman without being obvious. If I had

Figure 6. The protein skimmer is hanging on the left side of the aquarium.

done the observations myself, I would have had to overtly watch Herman. I thought this would have biased the data since Herman would know he was being watched. Also, Herman often came into the room later in the day when I could not be at the site; the teacher could observe him at any time of day.

The teacher observed Herman working with the simulation (with fish and corals added) for six weeks. Although the school day began at 7:45 a.m., Herman would often come in around 8:30 a.m. He would plug in and adjust the skimmer and add some flake food for the fish. Then he would sometimes watch the fish. When the bell rang he left for class. Sometimes he would come in later in the day and feed the fish more and adjust the skimmer, other times he did not. His teacher noted that Herman's actions were rather careless and he seemed disinterested.

Every week Herman would perform a water change in the simulation. He would fill a plastic bucket with purified water and add the salt mixture and a water pump. He would leave the class for about an hour while the water and salt were mixing. Next, he would come back and siphon out the aquarium water into an empty bucket and add the freshly mixed water. Last, he would clean up any spilled water and leave.

During the briefing, the steps described to Herman for mixing the water and salt were:

1. Place the purified water outlet tube in a 5-gallon bucket in the sink.
2. Turn on the reverse-osmosis/deionization (RO/DI) filter and wait for the bucket to fill.
3. Measure out three cups of aquarium salt and add it to the bucket of purified water.
4. Add a water pump.
5. Add a heater.

6. Let the water mix and warm up for 24 hours.
7. Check the salinity of the water with the refractometer to make sure it is 35 parts per thousand (ppt).

Herman consistently skipped the last three steps. Before the briefing ended, I tried to explain to him the importance of these steps:

> Researcher: "Are you adding a heater? You should use a heater."
> Herman: [no response]
> Researcher: "Dude, you should use a heater and let the water warm up. A temperature shock could kill the fish. You should also let the water sit overnight to let the CO_2 levels equal out."
> Herman: "Nah."
> Researcher: "Dude? You could kill the fish when we get them."
> Herman: "Nah. This is good enough."

His refusal to perform the last three steps continued from the briefing into his use of the simulation. Herman never added a heater, let the water sit overnight, or checked the salinity using the refractometer (Figure B7). Also, his measurements of the salt were not precise. Herman was supposed to check the aquarium water's salinity before adding the freshly mixed water, but he never did this either.

Figure 7. On the left: the refractometer. On the right: the probe used to test temperature and pH.

I told Herman that he should test for ammonia, nitrite, nitrate, calcium, and magnesium every week and enter the data in a spreadsheet. In an interview with the teacher, I asked if he had seen Herman do these checks. He reported: “No. He’s not doing them. The test kits are still in the bag.” I checked the spreadsheet after the study was over and no data had been entered.

I was worried about the fish in the simulation dying from nitrate toxicity, and I asked the teacher if he would tell Herman to perform a nitrate test. The next day, the teacher told Herman this and he performed the test as directed. His teacher reported that Herman said the only reason he did the test was that he was told to.

Herman was also supposed to add the calcium and magnesium mixtures (Figure 8). During Herman’s use of the simulation, the teacher reminded him several times to add the mixtures, but Herman never used them. I checked the bottles after the study ended and they were still full.

Figure 8. The calcium mixture is on the left, the magnesium mixture is on the right.

Altogether, Herman’s attitudes and actions did not always coincide. On the one hand he stated “you know I hate it when people half-ass things.” On the other hand, in many of the actions he took he would cut corners or not perform them at all. This led me to believe that he was not motivated by all aspects of the simulation.

Theme Four: Lack of Responsiveness

Another theme that emerged from the data was Herman's tendency not to give any indication he was listening or responding to suggestions. This occurred throughout the study but there were some specific examples. The teacher charged Herman with rearranging the power cords under the simulation, but Herman did not ask for his teacher's advice. Herman did not want to add the calcium and magnesium mixtures to his aquarium at home, and he insisted he install the skimmer although his teacher and I advised against it. Lastly, Herman ignored his teacher's lecture at the end of the study.

Arranging the Power Cords

One example of this theme was when the teacher told Herman to rearrange the simulation's power cords. The teacher's main concern was the power strips were plugged into each other (daisy-chained) and underneath the skimmer, which was not a safe place. When Herman arrived, the teacher explained the situation to him and he got to work. Once Herman had everything unplugged, he started plugging devices back in to different surge protectors without asking the teacher how it should be done. I found this odd considering the teacher was the one who would have to approve the final result. So, after giving Herman a chance to ask, I asked the teacher how he would like the cords arranged:

> Researcher: "Dude, what do you want us to do with these cords?"
> Mr. Percula: "Make them look better for the fire marshal. They can't all be daisy chained like that."
> Researcher: "So what do you want us to do? Should we leave some stuff unplugged?"
> Mr. Percula: "Do what you have to, but they have to be better."
> Researcher: "Okay. [Herman] does that make sense to you?"
> Herman: "I already know what I am doing."

Herman was not interested in his teacher's directions and went ahead with his plans. After this exchange, Herman had to start over on some of the cords because he had them daisy chained; exactly what the teacher had said he did not want.

It took Herman about 40 minutes to rearrange the cords before he was able to turn the power on. When he did, the skimmer overflowed into one of the surge protectors, causing it to spark and start smoking. Herman immediately pulled the plug out of the wall. He then unplugged everything from the surge protector and discarded it. This caused him to have to start all over again:

> Mr. Percula: "Oh, what just happened?"
> Herman: "It overflowed when I turned it back on [the skimmer]."
> Mr. Percula: "Oh that's bad. That's going to stink."
> Researcher: "I wonder why it did that. Wait! You didn't just get zapped did you?"
> Herman: "No it is smoking [the power strip]."

I was worried Herman could hurt himself so I took a more active role. Before he could turn on the power, I interjected:

> Researcher: "Dude, you know what? Why don't you put the power strips on the table instead of the floor? That way they can't get wet."
> Herman: [no response]
> Researcher: "Dude, put them on the table."
> Herman: [no response]
> [Herman is about to turn on the power when Researcher reaches down and picks up the cords.]
> Researcher: [irritated] "Here man. Now they can't get wet."

When he turned on the power this time everything worked correctly. It was nearly the end of the period and Herman got up to pack. He did not ask the teacher for his final opinion of the work. This was interesting since the teacher had to approve the final result; it appeared that Herman was not interested in the teacher's approval.

Making the Additives

As well as not responding, Herman would not take advice, such as when we were mixing the calcium and magnesium additives. I first explained to Herman what we would be doing, how it connected with the reference system, and that the chemicals would help the corals grow faster. We then started to mix the chemicals in the water jugs (Figure B6).

I explained to Herman that the additives kept two chemicals in the water that were critical for coral growth: calcium and magnesium. By adding a little of each mixture every week, Herman could maintain the proper calcium and magnesium levels in the water. We had the following conversation:

> Researcher: “Here, add this one and I will make another batch. Just barely enough. So now I will fill this up with water. All right, give that a couple of good shakes. We can add more water if it doesn’t all dissolve. So, you could take some of this and add it to your tank at home you know.”
> Herman: “No.”
> Researcher: “No?”
> Herman: “I don’t want to mess with it.”

I had explained to Herman how the additives would help, but he was unwilling to add them to his home aquarium. I assumed at the time that I knew more about aquariums and coral growth than Herman, and I thought Herman perceived me in the same way. The exchange above indicated that this might not have been the case.

Installing the Skimmer

To use an incident presented earlier, at one point during the briefing Herman installed the protein skimmer. The teacher and I advised Herman not to install it and gave him no support. When I noticed he was starting to attach it to the aquarium, I mentioned to him “you might not want to do that; it could seriously flood the place.” Herman gave

no response and continued to work. Mr. Percula, said, "[Herman] do you know what you are doing? Because if you mess that up and flood my class…." Herman ignored him as well.

Herman admitted earlier he did not know how to install the skimmer. Occasionally, he would ask me how to do something and I would answer his questions although I still expressed my concerns. For example, at one point he needed a hose to fit in the outlet part of the skimmer. Without direction, Herman went into the teacher's back room and began rummaging through buckets. He came back with a section of PVC piping that fit the outlet connection and cut the pipe so it was the right length.

Before he plugged in the skimmer, I asked Herman to make sure the valve was open but he ignored me. When he plugged it in, water overflowed out of the top of the skimmer and onto the floor. He immediately unplugged it and asked me why it didn't work:

> Herman: "Why did that happen?"
> Researcher: "I'm not sure, maybe that thing is closed."
> Herman: "What"?
> Researcher: "That opening thing. It might be closed down all the way. Try turning it this way."

He opened the valve and the skimmer worked properly. I thought this incident was telling, given that Herman could have avoided flooding the floor if he had listened to my advice. Herman also did not listen to my insistence that he not install the skimmer at all.

The Teacher's Post-test Lecture

Another telling moment was at the end of the study when I gave Herman the post-test. He missed all but two of the nine questions, which alarmed the teacher, who decided

to give Herman a lecture on the nitrogen cycle. Herman was spraying water on some plants and adjusting the skimmer while the teacher talked:

> Mr. Percula: “So let’s do this, ‘what are the steps of the nitrogen cycle’ here so [Herman] when fish eat this they poop out what”?
> Herman: “Ammonia”?
> Mr. Percula: “Yes right ammonia. Now does it stay ammonia forever”?
> Herman: “No”?
> Mr. Percula: “Right. Now do you know what ammonia looks like”?
> Herman: “No.”
> Mr. Percula: “Well look it up it is right here.”
> [Mr. Percula points to the advance organizer of the nitrogen cycle, which has been lying open in front of Herman this entire time.]
> Herman: “Is it three hydrogen and one nitrogen”? [Reading the advance organizer]
> Mr. Percula: “Then it goes to what”?
> Herman: “Nitrite.” [Reading the advance organizer]
> Mr. Percula:” Which looks like what”?
> Herman: “Um, one nitrogen and two oxygen”? [Reading the advance organizer]

While the teacher was asking the questions, Herman was watering plants that were not part of the study. Herman’s body language and facial expressions indicated that he was not interested in listening. Herman had his back turned to the teacher and did not make eye contact. Although the teacher was writing on a whiteboard, Herman never looked at it and only looked at the advance organizer when asked a question. The tone of Herman’s voice implied boredom. I recorded in the field notes at the time that “Herman didn’t care at all about this. He was only answering the questions because his teacher was making him.” I recorded this observation as a result of Herman’s demeanor during the incident.

Even when taking the post-test, Herman had the answers to the nitrogen cycle on a sheet of paper at his disposal. If he had looked at it, he would have correctly answered the questions. However, it was not until Mr. Percula told him to look at the advance organizer that Herman actually did.

These examples best illustrate the Lack of Responsiveness theme but it was Herman's overall demeanor that gave rise to the theme itself. In virtually every instance, he never spoke unless asked a direct question, and even then, he would sometimes not answer.

Motivation Theory

The four themes can be united using theories of motivation. Authors often discuss two aspects of motivation, goal orientation and self-efficacy, and both of these aspects work together to influence an individual's motivation.

Goal Orientation

Learners can have two different types of goals: mastery and performance. "With a mastery goal, individuals are oriented toward developing new skills, trying to understand their work, improving their level of competence, or achieving a sense of mastery based on self-referenced standards" (Ames, 1992, p. 262). Performance goals, on the other hand, focus on self worth and the individual with these goals often measures success by out-performing others and avoiding failure (Ames, 1992). In this sense, mastery goals are seen as more adaptive and desirable than performance goals, which can sometimes lead to ego-defensive and task-avoidant behavior (Morgan & Fuchs, 2007).

Goal theory hypothesizes that motivation is a result of individuals' desire to achieve set goals; however the theory does not explain how individuals set these goals.

> One's achievement goals are thought to influence the quality, timing, and appropriateness of cognitive strategies that, in turn, control the quality of one's accomplishments…learning goals refer to increasing one's competency, understanding, and appreciation for what is being learned. (Covington, 2000, p. 174)

Performance goals involve the desire to outperform others. Students who possess a learning goal engage in more self-regulated learning than those with performance goals, including using organizational strategies, self-monitoring, and making positive adaptations to failure. The performance goal's relationship to learning is not as consistent, although it is generally agreed that it is associated with rote, superficial learning.

Further differentiation is hypothesized by dividing performance goals into approach and avoidance sub-categories. In this case, a performance-approach goal is similar to a mastery goal in that

> …individuals perceive the achievement setting as a challenge, and this construal is likely to generate excitement, encourage affective and cognitive investment, facilitate concentration and task absorption, and orient the individual toward the presence of success-relevant and mastery-relevant information. (Elliot & Harackiewicz, 1996, p. 462)

The literature of performance-approach goals effects on learning and performance are mixed (Brophy, 2005; Harackiewicz Barron, Pintrich, Elliot, & Thrash, 2002; Kaplan & Middleton, 2002; Midgley, Kaplan, & Middleton, 2001). Students with performance-approach goals are motivated to outcompete others (Pintrich, 2000), and sometimes this motivation can encourage students to perform better. Pintrich's (2000) research suggested that learners can have a mastery and performance-approach goal orientations at the same time, and that those with both outperformed those with only a mastery goal orientation.

A performance-avoidance goal is based on avoidance of failure and decreases intrinsic motivation (Elliot, 1999; Pintrich, 2000). The literature on performance-

avoidance goals suggests that they are generally maladaptive and lead to task-avoidance behavior (Elliot, 1999; Hidi & Harackiewicz, 2000).

A hypothesis about Herman's goal orientation can be formed based on the definitions above and the data. The evidence suggests that Herman did not have a mastery goal orientation. If he had a mastery goal, theory suggests he would have been more apt to learn as many tasks as he could on his own, since the goal would be "mastery" of the skill of aquarium maintenance. For example, learning about coral reef ecosystems would have helped with the maintenance of the simulation, but Herman ignored this information.

Further, it would appear that Herman did not have a performance-approach goal structure either. Elliot & Harackiewicz (1996) hypothesize that learners with a performance-approach goal perform similarly to the mastery goal orientation. With a performance-approach goal, Herman would be interested in learning to take care of the fish properly since the survival of the fish depended on a balance of the simulation parameters and proper understanding of these parameters. This was not the case in the data. To take care of the fish properly, I explained to Herman that he should know the nitrogen cycle, test the water, add the calcium and magnesium mixtures, and complete all the steps in mixing salt water. He did not learn or perform any of this.

To identify whether Herman had a performance-avoidance goal, the first step is to determine how Herman defined failure. Herman did not perceive failing the post-test as important. When I told Herman that he had failed the post-test, he seemed amused and laughed at the results. Another possible goal is keeping the fish alive, which is supported in the data. Herman should have then been interested in the tasks that directly related to

this goal. Learning about coral reef ecosystems is not vital to keeping the fish alive, and the data suggest that Herman was not interested in learning about this. Herman continued to feed the fish, adjust the skimmer and perform water changes throughout the study, which were required to keep the fish alive.

However, there were some contradicting data to this theory. If Herman was interested in avoiding killing the fish then why did he skip the last steps of the salt water mixing process? I had warned him that doing so could result in the death of the fish, but he insisted his abbreviated method was sufficient. It is difficult to judge whether or not Herman's method was a deliberate effort to take shortcuts, or if he honestly thought that his method was an acceptable alternative. The fish did not die, so his method may have been, as he said, "good enough."

If his goal was to avoid killing the fish, then the fish did not have to thrive; they just had to not die. This would explain why Herman did not take any extra steps with the simulation. The one exception to this is the fact that Herman would always turn on the skimmer in the morning and turn it off at the end of the school day. The skimmer was not important for keeping the fish alive. However, Herman's behavior while installing the skimmer indicated that he perceived the skimmer as important.

It appears that Herman most likely had a performance-avoidance goal orientation. Herman wanted to avoid killing the fish and was therefore only interested in tasks and knowledge that directly related to keeping the fish alive. There must first be fish in the simulation to care for; therefore, his first goal was to get the fish. This would explain his behavior during the briefing, when Herman seemed only interested in things that he perceived as directly relating to adding fish.

Self-Efficacy

The other aspect of motivation that must be considered in combination with goal orientation is self-efficacy. Self-efficacy or “efficacy expectation” is not the same as outcome expectation according to Bandura (1977): "An outcome expectancy is defined as a person's estimate that a given behavior will lead to certain outcomes. An efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcomes" (p. 193). Based on the data, it appears Herman’s self-efficacy was based on his perceived ability to successfully keep the fish alive, and not his ability to master the learning material. This is evidenced by statements he made to me during the study and his actions with the simulation.

Self-efficacy is based on the individual’s “perceptions of reality, not reality itself” (Bouffard-Bouchard, Parent, & Larivée, 1991, p. 160). This explains the dichotomy of the fourth theme. Herman had a very high estimation of his own skills, yet failed the objective tests of these skills. Bandura (1997) states, “People who doubt their capabilities in particular domains of activity shy away from difficult tasks in those domains" (p. 39). This coincides with Herman’s avoidance of the reference system topics. Herman may not have been confident in his abilities to learn this material, which is why he avoided it.

An individual’s self-efficacy is based on performance accomplishments, vicarious experience, verbal persuasion, and physiological states (Bandura, 1977). Data collected reveal potential influences of performance accomplishments (Herman’s aquarium crash) and verbal persuasion (attaching the skimmer).

Bandura (1982) states that self-efficacy based on performance accomplishments which “provide the most influential source of efficacy information because it can be

based on authentic mastery experiences. Successes heighten perceived self-efficacy; repeated failures lower it…" (p. 126). The aquarium Herman had at his house likely determined his self-efficacy in the study. Since he had maintained his aquarium successfully, it gave him the confidence that he could do the same with the simulation.

When Herman's aquarium crashed and killed his fish, it seems that Herman would have re-evaluated his perceptions of self-efficacy. Instead, Herman insisted the crash was not his fault. This behavior is consistent with the theories of performance-avoidance goal settings. Furthermore, Herman's crash did not seem to influence his behavior with the simulation. I asked the teacher what Herman did with the simulation after the study ended and he replied: "Continued with very rudimentary basics of maintaining a reef tank." This is consistent with the teacher's observations of Herman during the study.

Another source for the creation of self-efficacy is verbal persuasion, "although social persuasion alone may be limited in its power to create enduring increases in self-efficacy" (Bandura, 1982, p. 127). Bandura's (1982) suggestion is supported by evidence from this study. When Herman was attaching the skimmer, the teacher and I were both trying to dissuade his actions. Herman remained determined and ignored our concerns. This suggests that Herman's self-efficacy was stable enough based on other sources to ignore verbal persuasion designed to reduce self-efficacy.

Relating the Themes

Herman's performance-avoidance goal of not killing the fish was not the same goal orientation as his teacher and I had for him. His teacher and I had a mastery goal orientation and this difference led us to value different aspects of the simulation than

Herman did. Herman's self-efficacy was based on his goal orientation, and this led him to feel confident about only specific aspects of the simulation.

Herman took steps to accomplish his goal, not the goal that I had for him. One example of this is Herman's insistence that he install the skimmer. Doing so was part of his goal of not killing the fish, whereas my goal at that time was not to flood the room. Herman's dedication in arranging the rocks is another example of his goal orientation. He likely wanted to make sure the fish had enough hiding places in the aquarium so they would not die of stress. To not kill the fish, Herman did not need to learn about coral reef ecosystems. Thus, he ignored all the learning material related to the reference system.

Mr. Percula and I both thought that learning about coral reef ecosystems (measured by the items on the pre- and post-tests) was important for successful salt water aquarium keeping since we had a mastery goal structure. Mr. Percula and I were successful salt water aquarium keepers. I had a 100-gallon aquarium and Mr. Percula and I each had 30-gallon aquariums for about three years prior to the study. To take care of our aquariums, Mr. Percula and I would learn about coral reef ecosystems and apply this information to our aquariums. This formed a bias with which we approached and judged Herman.

This difference in goal orientations explains why we thought Herman's actions with the simulation were rudimentary and haphazard. We were judging Herman's actions based on our goal orientations. The fish in the simulation did not die, however, so it is unfair to judge Herman's actions as inadequate: He succeeded in achieving his goal.

Herman's performance-avoidance goal also defined his self-efficacy. His confidence in achieving his desired goal of not killing the fish was very high. This would

explain why he ignored most of my advice during the study. He believed he could keep the fish alive and therefore didn't need my help. The reference system was also not related to his goal or his self-efficacy, so Herman ignored information relating to it as well.

Chapter Summary

This chapter presented the findings from a case study examining the role of pre-instructional activities on learning with a simulation. Coding of the data revealed four key themes: (a) Unanticipated/desired Goal-Setting Behavior; (b) Perceptions of Self-Efficacy; (c) Perceptions of Quality Work; and (d) Lack of Responsiveness. Theories of goal orientation and self-efficacy were used to discuss and unite these themes. The discussion revealed that Herman likely had a performance-avoidance goal centered on avoiding killing the fish. Herman also had high self-efficacy (he perceived he had the skills to take care of the fish), which led to some of his behaviors observed during the study. The evidence suggests learning with a simulation may be heavily influenced by the learner's goal orientation and self-efficacy. This will be explored in the next chapter.

CHAPTER 5

DISCUSSION

The main research question of this study was "How does the briefing affect the participant's metaworld and his interactions with the simulation?" Data were collected using a marine aquarium as a simulation of coral reef ecosystems. The study took place with one participant in a high school science classroom at a Colorado charter school. The study ran 10 weeks and used the case study methodology described in Chapter 3.

This study organized data, gathered from a case study on learning with simulations, around four major themes. Theories of goal orientation and self-efficacy were used to unite and discuss the themes. This chapter discusses the implications of the data. Suggestions for future research are then posited.

Overall Discussion

The main research question asked: How does the briefing affect the participant's metaworld and his interactions with the simulation? Based on the data described in the previous chapter, it appears that the briefing (defined as a formal introduction to the simulation) does not influence the learner's interactions with a simulation in cases where the learner has a performance-avoidance goal orientation. Goal orientation and self-efficacy have not been examined thoroughly in the literature on metaworlds and the

briefing (based on the literature review in Chapter 2). There are also many subtleties to this conclusion that will be explored later in this chapter.

Metaworld is the learner's perceptions of the simulation before using it. In this study, Herman had a "weak" metaworld, meaning his metaworld did not inspire him to use the simulation to learn about the reference system. This weak metaworld was based on Herman's low motivation, which was explored in the previous chapter, the themes related to goal orientation and self-efficacy. The data suggest that Herman was motivated to avoid killing the fish in the simulation, and this goal orientation did not inspire him to experiment with or explore the simulation in more depth. The study assumed Herman would be motivated to learn about the reference system (the real world situation the simulation attempts to mimic; that is, coral reef ecosystems in this study) and would experiment with the simulation after the briefing. This assumes a mastery goal orientation, which Herman in the study did not have. He did have high self-efficacy leading him to continue to work with the simulation throughout the study.

Based on the prior literature, the briefing should have defined his metaworld and given him the prerequisite knowledge to use the simulation successfully (Butler, 2005; Elshout & Veenman, 1992; Jackson, 1997). However, Herman had an aquarium at his house prior to the study; this normally would suggest the potential for higher motivation. However, his high self-efficacy and low goal setting might have inhibited this performance. He also came into the study with some prior knowledge, but the pre-test indicated he lacked specific knowledge about coral reef ecosystems. During the briefing, Herman ignored information about coral reef ecosystems and behaved as if he was disinterested in the material.

The data presented in Chapter 4 suggest that a briefing does not always influence a learner's interactions with a simulation. How and why this occurs is explored in more detail in this chapter, first by comparing this finding with prior literature. The literature on simulations and motivation is also explored in the context of the findings of this study. The findings also suggest enhancements to the understanding of goal orientation and self-efficacy. It is also possible that the definition and understanding of the briefing itself needs to be explored. A counter theory is explored and future research ideas are then posited.

Comparison to Prior Literature

Role of Metaworld

Helms (2009) was conducted at the same school, with the same teacher, using a similar simulation. Results from this prior study were very different. The briefing was so influential that the line between it and the usage of the simulation was blurred. The learners would return to the briefing materials frequently and apply them to the simulation in new and creative ways. This led to increased transfer and increased learning by the participants. The conclusion was that the briefing and using the simulation, originally conceptualized as two steps, were in fact one cyclical process.

In the present study, Herman made no use of the learning materials given to him in the briefing and did not extend his understanding through the use of the simulation. For example, Herman admitted that he ignored the advance organizer describing the nitrogen cycle, a process critical to the understanding of coral reef ecosystems. Herman also ignored his teacher's lecture on the nitrogen cycle at the end of the study.

The different outcomes may be the result of several factors: goal orientation, a team versus an individual, prior experiences, and the structure of the experience. First, it is likely that the participants in these studies did not share a similar goal orientation. The participants in Helms (2009) likely had a mastery goal orientation, based on the evidence of their learning; whereas in the present study Herman had a performance-avoidance goal orientation. This alone does not explain the different results. According to Elliot and Harackiewicz (1996), learners with mastery and performance-avoidance goal orientations often perform in the same way.

Another factor was a difference in the number of participants in the two studies. There were five participants in Helms (2009) all working as a team; whereas there was only the single participant in the present study. The absence of a team to work with may have influenced both the goal orientation and overall motivation of Herman in the present study. The role of teams in learning with simulations could be an avenue of future research. Schunk and Meece (2006) write that peers have a major influence on adolescents' self-efficacy. It is possible that peers also have an influence on each other's goal orientations. The team in Helms (2009) may have pushed each other to achieve higher goals, whereas the single participant in the present study decided he could get by with a lesser goal.

In the present study, Herman had an aquarium set up at home for two years prior to the study. This prior experience could have been a third factor. Because of this experience, he came into the study already knowing how to perform some tasks and with preconceived notions about the simulation. In Helms (2009), the participants had no prior

experience with the simulation or with the reference system. It may be that Herman's prior experience with the simulation influenced his metaworld.

Lastly, the participants in both studies were volunteers and high school seniors in their last semester before graduation. However, in Helms (2009) the study was embedded in a traditional class for the participants. Herman in the present study was volunteering his time and not receiving course credit or a grade for his participation. This difference might have also played a role in the formations of metaworld.

A common theme in these factors is the role of metaworld. The participants in Helms (2009) had strong, motivating metaworlds that encouraged them to explore the simulation. The participants would research new topics without teacher guidance and experiment with the new information using the simulation. This likely enabled them to be able to transfer most of what they learned to the reference system. Conversely, Herman in the present study had a weak metaworld, which dissuaded him from learning about the reference system. Herman did not learn the elements that could be transferred to the reference system; thus measuring transfer was moot.

Simulations and Motivation

Simulations are often used to increase learner motivation (Clark & Ernst, 2009; Gehlbach, et al., 2008; Limniou, Roberts, & Papadopoulos, 2008; Tarng, Change, Ou, Chang, & Liou, 2009), but this was not supported in the present study. It is difficult to say what Herman's motivation would have been without the simulation. However, the evidence suggests that simulations may not increase motivation for all learners. Herman continued to take care of the simulation both during the study and after the study ended. If he were completely unmotivated, he would have ceased participating early on.

Therefore, it may be possible to say that the simulation had some effect on the learner's motivation, albeit not to the extent that was anticipated. Goal orientation and self-efficacy may play a role in determining how motivating a simulation can be for a learner. A performance-avoidance goal orientation may preclude the learner from being motivated by all aspects of a simulation. In this case, the learner may use the simulation as a form of entertainment, not as a learning experience.

Goal Orientation and Self-Efficacy

In the present study, Herman's goal orientation and self-efficacy helped establish his metaworld. Herman had high self-efficacy and continued to work with the simulation throughout the study. His performance-avoidance goal did not relate to the reference system, so he ignored this learning material.

Bandura (1997) describes the attributes of a learner with high self-efficacy. Among these attributes are: (a) the learner will "approach difficult tasks as challenges to be mastered rather than as threats to be avoided"; (b) that high self-efficacy "fosters interest and engrossing involvement in activities"; (c) learners "set themselves challenging goals and maintain strong commitment to them"; and finally (d) learners "attribute failure to insufficient effort" (p. 39). This does not describe Herman in this study.

The conclusion that Herman had high self-efficacy was based on several statements he made to his teacher and the researcher. Additionally, Herman interacted with the simulation with a great deal of confidence and determination. However, he did not have any of the attributes described by Bandura (1997). Herman did not show much interest in the simulation beyond adding fish, nor did he show an "engrossing

involvement” in any of the tasks and activities assigned. He also didn’t set challenging goals for himself, and would often stop short of completing a full task. When his aquarium crashed, he did not attribute the failure to “insufficient effort” but rather chance.

There is a line of research suggesting that the relationship between goal orientation, self-efficacy, and performance isn’t always positive. Seo and Ilies (2009) summarize the argument as follows: “Participants who perform well develop high self-efficacy and upwardly adjust their goals somewhat, while at the same time developing a sense of overconfidence and allocate less resources for the subsequent performance episode, leading to lower performance" (Seo and Ilies, 2009, p. 122).

In several studies, Vancouver and colleagues found that self-efficacy negatively correlated with performance at a within-persons analysis but not at a between-persons analysis (Vancouver, & Kendall, 2006; Vancouver, More, & Yoder, 2008; Vancouver, Thompson, Tischner, & Putka, 2002; Vancouver, Thompson, & Williams, 2001). In one study, adjusting self-efficacy upward decreased performance at a within-persons level (Vancouver et al., 2002). The authors argue that an increase in self-efficacy creates a sense of overconfidence in the learner, which leads them to allocate fewer resources and less effort to attaining the goal, decreasing performance.

There is a lot of evidence against a negative correlation between self-efficacy and performance. In particular, Stajkovic & Luthans (1998) did a meta-analysis of 109 studies and concluded that self-efficacy and performance are positively correlated. Vancouver et al. (2001) argue that this occurs at a between-persons measurement but not at a within-persons measurement. A counter-explanation of this research is that the negative

correlation only shows up because of the simplistic task used in the studies (the participants played the game *Mastermind*). To examine this idea, Seo and Ilies (2009) used a simulation of the stock market and found results that contradicted Vancouver et al. (2001). They suggest that this difference was the result of using a more complex situation.

The results of the present study are more in line with negative correlation hypothesis. Herman had high self-efficacy but performed poorly. This can be explained by Herman's performance-avoidance goal. Seo and Ilies (2009) contend that goal orientation mediates between self-efficacy and performance. If learners have high self-efficacy and a difficult goal, they will perform better. However, if learners have high self-efficacy but a lower or easier goal, such as Herman, they will perform worse. The results of the present study lend support to this hypothesis.

This is in line with Austin & Vancouver (1996), who argue that externally imposed goals are meaningless to learners until they are translated into personal goals. Herman's translation of our goals was very different than what we defined for him. In this way, he had high self-efficacy to achieve his goals, not ours. Herman's performance was measured based on our goals, and by this measure he performed poorly. However, if Herman's goal was indeed to not kill the fish, he succeeded in this goal and performed very well. Therefore, the measurement of performance used by researchers examining self-efficacy, goal orientation, and performance cannot account for participants who have personal goals that differ from the measure. This is where qualitative methodology can reveal additional information not seen in quantitative studies like those previously conducted.

The same can be argued for the studies conducted by Vancouver and colleagues (2002). For example, in Vancouver et al. (2002), the researchers measured performance by counting the logical errors made in playing *Mastermind*. This assumes that the goal of the subjects was to make as few logical errors as possible. If the participants' goal was something other than how the authors defined, then their desire to achieve the external goal would diminish, reducing scores on the performance measure. For example, in Vancouver et al. (2002), three participants were dropped from the first study and one from the second study because they never found solutions to the *Mastermind* game. In Vancouver et al., (2001), five participants were dropped for the same reason. The authors explain this as the participants "not taking the task seriously" (Vancouver et al., 2002, p. 510). These participants may be the most overt examples of those who had different goals than those assigned by the researchers. In future studies, it would be interesting to qualitatively examine the personal goals of the participants.

"Although each [goal orientation, self-efficacy, and self regulated learning] has been established independently, the relationship among these variables and how they might work in concert have not been fully explored" (Crippen & Biesinger, 2009). The present study helps illuminate the relationships between goal orientation, self-efficacy, and performance.

In the previous chapter, it was established that Herman had a performance-avoidance goal orientation centered on avoiding killing the fish. His self-efficacy was based on this goal in that his perception that he could successfully avoid killing the fish was very high. Because his goal was not to learn about coral reef ecosystems, Herman's self-efficacy did not relate to aspects of the simulation relating to this outcome. Thus, it

may be that Bandura's (1997) ascribed attributes to a learner with high self-efficacy may only be true if the learner also possesses a mastery goal orientation.

Alternative Explanations

It may be unfair to label Herman's metaworld as the sole reason he failed to learn the desired material. A counter-hypothesis is that the conduct of the educational experience may not have provided him with the perceptions, structure, and/or resources to learn.

Perceptions

I took the role of a participant-observer to conduct this study. The teacher (Mr. Percula) took a less active role in the lessons, as he was engaged with other students. In Helms (2009), Mr. Percula took a more active role in conducting the lessons and activities. The participants in both the present study and Helms (2009) recognized Mr. Percula as the primary and official teacher of the lessons. I was brought in as a volunteer, with my researcher role clearly defined, and presented as Mr. Percula's temporary assistant.

Mr. Percula's clout and experience with his students may have influenced the motivation of the participants in Helms (2009). As mentioned in the previous chapter, Mr. Percula thought that Herman had difficulty accepting me as an "educational figure." This may have been why my efforts to teach Herman were unsuccessful.

When conducting future research in this setting, my role as an educator may need to be solidly established and my credentials clearly stated before the study begins. If the participants see me as an inexperienced volunteer, they may be unlikely to accept my teaching practices. However, recall that Mr. Percula tried to give Herman a lesson on the

nitrogen cycle at the end of the study, and could not hold Herman's attention. This suggests that Herman in this study was not even influenced by someone he did see as an educational figure.

Structure

I am not a high school science teacher. I had two years' experience teaching at a college level before this study began, plus acting as the researcher in Helms (2009), in which I also took a participant-observer role. Mr. Percula had taught high school and middle school science for eight years. Since Mr. Percula was busy with other classes, I designed the activities and lessons for the present study although I did share them with Mr. Percula before the study began.

Herman's failure to learn the items on the post-test may reflect on my inexperience teaching high school science. I had the subject matter expertise to teach coral reef ecosystems at a high school level, but I did not have the experience as a teacher in this setting. Therefore, the lessons and activities I created may have been insufficiently structured to hold Herman's attention.

For example, I decided to let Herman use the simulation without my facilitation after the briefing ended. This was done from the point-of-view of a researcher and not a teacher. Mr. Percula was unable to facilitate Herman's learning during this time, since he was busy with other classroom demands. This may have been a bad decision from the standpoint of an educator. Perhaps the reason Herman took no extra steps with the simulation is that there was no one to guide him to do so. I left instructions for him to follow, but that may reflect a misunderstanding of high school students on my part.

During the briefing, I provided Herman with an overview of the entire study including what to expect and what I expected of him in terms of performance objectives. I stayed with him every morning session during the briefing and attempted to guide his attention and structure the learning experience. Despite these efforts, Herman's unwillingness to experiment with the simulation was apparent. Again, the decision to leave him on his own to use the simulation was based on the needs of the research; however, the teacher (Mr. Percula) was present to guide and monitor Herman. I also left Herman clear instructions about what he should do while I was gone. He followed some of the instructions (such as performing a water change), but ignored others (such as using the additives). Therefore, I concluded Herman's behavior would not have been substantially different had I stayed with him.

Resources

In the present study, Herman was given the advance organizer on the nitrogen cycle as well as many internet sites as resources to supplement the simulation. These resources may not have been sufficient for Herman to procure the information he needed to effectively use the simulation. Again, a comparison with Helms (2009) is warranted.

Helms (2009) made heavy use of the school's computer lab, the local public aquarium, and the local hobby fish store. The present study relied on the computer in the classroom and online materials. Example websites include Drs. Foster and Smith (http://www.drsfosterandsmith.com), Nano Reef (http://www.nano-reef.com), Marine Depot (http://www.marinedepot.com), and Talking Reef (http://www.talkingreef.com). We also used computerized spreadsheets to track the results of the tests. In Helms (2009), the students used the same online resources including podcasts from talkingreef.com.

One major difference was the visit to the Denver aquarium in Helms (2009), which could not be done in the present study due to travel restrictions. This difference in resources may have contributed to Herman's different metaworlds. It might be that the learner needs a more diverse pool of resources to establish a strong metaworld.

However, in the present study Herman did not make use of the resources at his disposal. Thus, it is difficult to conclude that more resources would have helped him. Additionally, Mr. Percula reported he gave Herman a resource outside of the study (nanoreef.com) but Herman chose not to use it. If Herman had made use of the resources given to him and still faltered, it may be justifiable to suggest he needed more resources.

Summary

It is possible that my conduct of the educational experience was inadequate and that my inexperience as a high school science teacher contributed to Herman's failure on the post-test. Indeed, that Herman did worse on the post-test than he did on the pre-test speaks to this conclusion. However, the evidence in the data is that Herman had a weak metaworld based on a performance-avoidance goal orientation. Although my inexperience may have played a role, it does not preclude the role of metaworld.

It is clear in the data that Herman's goal orientation and metaworld influenced his ability to learn with the simulation. There may have been additional steps I could have taken to enhance his metaworld, but I certainly did try to encourage and direct Herman in the study. As an educator, I wanted him to succeed and learn, and I did what I could think of to encourage this. Despite my repeated attempts to influence Herman's learning, he remained obstinate.

Implications for Design

The data collection process and the results of this study suggest design recommendations. In Chapter 1, the briefing was defined as "the context provided prior to the use of a simulation, including other instructional activities, explanations, interactions, and other activities used to introduce students to the simulation." It was not said the briefing must be provided by a teacher or that it has to be a formal lesson, although this was how the briefing was envisioned.

In the present study, the briefing likely began for Herman when he set up his home aquarium. It was at this moment that his context of the simulation began to be formed. When he entered the study, he had made up his mind about how to use the simulation and what he wanted to learn from it. He admitted in one interview that he thought he already knew the learning material, although his performance on the pre- and post-tests indicated otherwise.

The design of this study assumed the briefing would start at a set time, when Herman was "officially" introduced to the simulation. Chronologically, it began about midway through the first day. Therefore, a distinction may need to be made between a formal briefing and an informal briefing. A formal briefing consists of the planned, constructed, and organized lessons that occur before the learners interact with the simulation. The informal briefing is any dealings learners have with the simulation outside of the formal briefing. In the context of this study the formal briefing began when Herman was introduced to the classroom simulation. The informal briefing started when he purchased his own aquarium about two years prior, and likely took place again when he went home each day. Notice, then, that the informal briefing does not have to occur

before the formal briefing. It can coincide with the formal briefing as well. Additionally, the informal briefing does not have to occur at all. In some cases it may be that the formal briefing is the only experience the learners have with the simulation; this was the case in Helms (2009).

It is evident from this study that the informal briefing can have a major impact on learners' interactions with the simulation. In the present study, the informal briefing had more of an impact on Herman than the formal briefing. There is no evidence in the study to suggest that the formal briefing had any influence on Herman's interaction with the simulation. However, to conclude the formal briefing has no influence on the learners' interactions with a simulation is contradicted by Helms (2009). In Helms (2009), the participants' interactions with the simulation were greatly influenced by the formal briefing; so much so, that the briefing and using the simulation became blurred together. It may be that a formal briefing has limited power in changing the metaworld established by an informal briefing.

The results of the present study also indicate that once metaworld is established, it may be very difficult to change regardless of the design. Repeated attempts were made during this study to influence Herman's metaworld and all attempts failed. In this case, Herman's metaworld was established during an informal briefing and the formal briefing was powerless to change it. Indeed, even efforts made during Herman's use of the simulation were futile.

One issue discussed earlier was whether it was wise to let Herman use the simulation without my guidance. I left Herman on his own during this time so that it would not be obvious that I was watching him work. The teacher could watch him and

take notes covertly. From an educational stance, this may not have been the best idea. A compromise would be to plan activities during this time to give an educator the opportunity to engage the learner at teachable moments.

Educators might also want to do an assessment of metaworld before the formal briefing starts. This would be done for much the same reason as one gives a pre-test: Educators should know the preconception and knowledge the learner brings into the experience. With an initial assessment of metaworld, educators could tailor the formal briefing to the learner's needs. Also, the assessment would indicate if the learner was entering the experience with a preconceived metaworld. Part of this assessment could look at the learner's goal orientation and self-efficacy relating to the simulation.

On a more specific note, when the simulation is a marine aquarium, the aquarium should be set up and running smoothly before the formal briefing begins. It takes an aquarium several weeks to be able to support aquatic life, and this is generally wasted time. It is interesting to note here that Mr. Percula disagrees. He thought the weeks waiting for the simulation could be spent doing other activities to teach the learner about the simulation's systems and properties. I thought another advantage to having the aquarium running with fish in it is that it might attract more participants as well.

Implications for Future Research

There are several areas of future research inspired by the present study. Researchers could examine the nature of an informal briefing, how to change a pre-established metaworld, examining the differences between Helms (2009) and the present study in more detail, and goal orientation's affect on metaworld.

Future research could follow up on one of the main findings from this study: metaworld can be established outside of a formal briefing. Understanding how an informal briefing influences metaworld is important to using simulations as effective learning tools. The informal briefing itself may be difficult to study since it occurs outside of a formal setting.

Future research could also examine methods to enhance a weak metaworld. Several attempts were made in the present study to enhance Herman's metaworld, but all were unsuccessful. Identifying strategies to accomplish this could be vital for using simulations with disinterested learners.

Several of the differences between Helms (2009) and the present study deserve more attention. The role of teams and peers in learning with simulations and how this impacts metaworld could be examined. Most importantly, research should examine how metaworld is formed and exactly how it influences learning. The different outcomes between Helms (2009) and the present study point to the critical importance of metaworld.

More research needs to be done on the role of goal orientation in the formation of metaworld. In the present study, goal orientation was the pith of Herman's weak metaworld, which hindered his learning with the simulation. This line of research could help reveal how metaworld is formed and how educators can influence it.

There may be additional areas of research based on this study. Hopefully, future research will help educators understand the nature of the briefing and how it influences learner actions with a simulation. Research that helps shed light on this issue is always welcome.

Conclusions

The main findings from this study were: (a) in cases where the learner has a weak metaworld centered on a performance-avoidance goal, the formal briefing has little impact on the learner's use of the simulation; (b) learners must have a strong, motivating metaworld to learn with a simulation; (c) simulations do not always increase motivation; goal orientation may mediate between self-efficacy and performance; and (d) an informal briefing occurs outside of the formal briefing and can have a major influence on the formation of metaworld.

I conducted a case study using a simulation of coral reef ecosystems. The review of the literature suggested the briefing would have some influence on the learner's interaction with the simulation. This study was developed to examine the nature of that influence.

The results of this study add to the body of research on learning with simulations. This study contributes specifically to the literature on simulations regarding learners with weak metaworlds. It was assumed at the outset of this study the formal briefing would have some observable affect on the learner. The results suggest that this is not always the case. Little is known about the informal and formal briefings and this study makes some progress into exploring their nature.

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APPENDIX

SAMPLE TRANSCRIPTS

[Mixing the Mg and Ca additives. P did most of the work here and I directed what he was doing. I helped add some of the chemicals for the Mg mixture but he did most of it. He did not seem all that interested in the process actually and seemed reluctant to do anything.]

M = all right, so these are what we are going to put them in but it is too much water. So, I need something to put the water in.

P = what like a bucket? [Participant is rummaging through the back closet. I am not sure what he was looking for originally but he came out with a five-gallon bucket.]

M = yeah. Hey, Mr. Percula, what is in here? Just salt? [Mr. Percula nods.] All right dude here we go. Put some water in here; here dump out some of this water. This one is easy it is just 2 cups of this stuff. All right, here is your beaker. And it is going to get hot. So, 2 cups is 473 of those doohickeys. This is road salt; it is the stuff they use to de-ice roads.

[Herman is looking up measurements online. We have to convert the cups into milliliters.]

P = so 473 about. [He gets out a beaker.]

M = yeah that's right. Hey, man do you have a bigger funnel?

P = I don’t need it. [This was not said very politely, and I thought he needed a bigger funnel.]

M = So, now shake it up, and it is going to get hot so be careful.

[P starts shaking the jug of Ca mix.]