The relationships between student perception of constructivist learning environment, self-directed learning readiness, problem-solving skills, and teamwork skills

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The relationships between student perception of constructivist learning environment, self-directed learning readiness, problem-solving skills, and teamwork skills

by

Shu-Huei (Lisa) Lin

A dissertation submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of
DOCTOR OF PHILOSOPHY

Major: Industrial Education and Technology (Training and Development)

Program of Study Committee:
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Ames, Iowa

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This is to certify that the doctoral dissertation of

Shu-Huei Lin

has met the dissertation requirements of Iowa State University
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ABSTRACT

Constructivism is a recent educational philosophical development. This study was designed to ascertain the level of constructivism implemented in the Industrial technology program as observed by students. The study also sought to determine the level of constructivism students’ desire, and the relationship between what they observed and what they preferred. The faculty view of the implementation was also collected. A comparison was made between the faculty view of the level of constructivism and the student view of the amount of constructivism being used.

An instrument for the aspects of constructivism was used for data collection, three parts were an Australian validated and reliable instrument. The fourth part about problem solving was prepared, validated and tested for reliability at Iowa State University. The faculty instrument was a modification of the questions toward faculty perception rather than the student view. Interviews were made with several students, the results confirming what were determined by the instrument.

A high correlation existed between students who observed a higher level of constructivism practices being used with higher scores on problem-solving and teamwork skills than for their peers.

Satisfactory indices of a good fit between a hypothesized model and the observed data led to the development of a structural equation model. This model suggested that student learning in an constructivist environment could improve their self-directed learning readiness, problem-solving skills and teamwork skills.
CHAPTER 1. INTRODUCTION

Introduction

In today's fast-paced world, it is critical that knowledge be updated quickly to accommodate the changes in various aspects of our environment, both in living and working. This trend requires that learners in formal educational institutions be well trained in critical thinking skills, problem solving skills, and teamwork skills (Doolittle & Camp, 1999; Rice & Wilson, 1999), as well as continuously striving to remain lifelong learners. Research, conducted in a classroom study, has suggested the importance of these skills for preparing workers to be competitive and qualified in the workplace. For example, Rice and Wilson (1999) state that capacities to learn, reason, and solve problems, as well as collaborate and negotiate with others, are the expectations of our society. Educational institutions should set up a learner-centered learning environment by means of engaging students in activities, such as hands-on activities, small group projects, and self-directed inquiry. Doolittle and Camp (1999) claim that an educational program should provide job skills, higher-order skills, problem solving skills, and collaborative skills. They argue that traditional behavior theory fails to connect learning to these skills. Instead, the constructivist approach is a new direction toward technical education reform. The issue has come to educational reform proponents' attention with convincing evidence of learning outcomes (Lunenburg, 1998). Yet, only two relevant studies in the area of Industrial Technology have been found that the learning of these skills should be associated with a constructivist learning environment. Not only has the philosophical view of technology expanded to assert that technology may benefit from constructivist learning (Brey, 1997), but also the empirical study of technology has substantiated the effectiveness of constructivism (Yaiverbaum & Ocker, 1998).
Constructivism, a learning theory for the purpose of preparing students to be capable in socially expected skills, asserts that students construct knowledge by integrating their own and others' experience rather than receiving information from teachers. By virtue of the studies and practical application of constructivist learning environments, teaching and learning have shifted the focus from teacher-centered to learner-centered (Prawat, 1992). Specific instructional strategies based on learner-centered activities are gaining the interest of educators who incorporated them into the classroom. Prawat (1992) indicates that the challenge of implementing a constructivist approach to teaching can be overcome by teachers' willingness to help students understand and learning objectives fostered by constructivist techniques. However, the initial active encouragement of the application in constructivism learning was due to the practice of teaching that embeds an actual learner-center into student perceptions and results in conceptual change of what students learn rather than a focus on content delivery. The basic fundamentals of constructivist learning are that students gain meaning from what they learn and then the learning results in conceptual changes.

As a result of the new reform of education, the practice of constructivism is viewed as an effective paradigm, particularly when combined with collaborative teams in learning. Students involved in this new paradigm need to take more responsibility for their learning (Lunenburg, 1998). This manner of learning has been regarded as highly related to improving higher-order thinking, which is the core element of problem solving and the heart of self-directed learning.

With learner-centered implications, self-directed learning indicates an effective strategy for developing learners who become capable of external self-management during the
learning process, as well as internal self-monitoring for worthwhile knowledge (Garrison, 1997). These two capabilities require that learners take responsibility for their own construction of meaning. From the perspective of communication, the learning process integrates internal information processing associated with critical thinking and external self-control of the learning process. In fact, the two learning capabilities must include responsibility in idea reflection and sharing, while learning is emphasized in a social context. The reality is that these two capabilities have been expressed to be better for adult learners, in particular, learning as teams in a collaborative learning environment. Because critical thinking is highly related to problem solving, working in teams helps learners foster high-order thinking ability. Savery and Duffy (1995) propose that learning in a group enables individual students to develop a body of knowledge because the manner of learning “can test our own understanding and examine the understanding of others as a mechanism for enriching, interweaving, and expanding our understanding of particular issues or phenomena” (p. 32). The factors of problem-solving skills, high-order thinking ability, and working in teams construct a framework of learning in constructivism that can be an effective instructional strategy not only in science education but also in other disciplines, in particular technical education. Doolittle and Camp (1999) suggest “preparation of workers for entry into and advancement in the workplace of the next decade requires an educational program that provides not only job skills, as career and technical education did throughout the 1900s, but also higher-order thinking, problem solving, and collaborative work skills” (p. 1). Therefore, technical educators predict that the implementation of constructivism will be a future practice in technical education.
Problem of this study

The central research problem of this study was to ascertain differences in student perception scores on the scale of actual constructivist learning environment (CLE) and the preferred CLE scale and to compare the actual student CLE results with instructors’ CLE perception as indicated by the data collected from the student CLE survey and the instructor CLE perception scale.

Another problem of this study was to investigate the relationships between student perception about constructivist learning environment, self-directed learning readiness, problem solving skills, and teamwork skills among students in technology-related classes as indicated by the data collected from the student learning environment survey.

Purpose of the Study

The purpose of the study was threefold:

First, the study would help educators in the field of industrial technology to realize how students actually learn and how they prefer to learn in a constructivist learning environment.

Second, the study was designed to identify gaps between instructor perceptions of the constructivist learning environment and students’ perception of actual learning environment in technology classrooms.

The third focus of the study was to develop a model to interpret the relationship between student perceptions of a constructivist learning environment, self-directed learning, problem-solving attitude, and teamwork skills.

Through the survey, it was possible to explain how student perceptions of the actual constructivist learning environment was associated with self-directed learning, problem-
solving attitude, and teamwork skills, as well as how students preferred constructivist learning environment associated with these factors.

Importance of the Study

Constructivism provides a new thought for education reform. The new thought challenges the philosophy of technology, as well as the direction of empirical studies of technology. Brey, proposing a constructivist view of discussion about the philosophy of technology, states: “philosophy studies of technology that presuppose some conception of technological change would consequently be improved, I claim, by incorporating informed models of technological change” (1997, p. 2). He suggests that social constructivist approaches “suggest new directions for philosophy of technology” (p. 13). In an empirical study, Spigner-Littles and Anderson (1999) conducted constructivist learning workshops that were designed to train workers to be able to learn material requirement planning. He found “they were relatively effective” and that further study is suggested. Today’s workers are expected to have high motivation, to continue gaining knowledge by becoming lifelong learners. With the purpose of improving learning performance, they conclude that “the constructivist learning theory is effective for older learners” (p. 206).

Research Questions

Based on the focus of the research problem, the following research questions were investigated:

1. How were demographic characteristics related to student perceptions of both actual and preferred constructivist learning environment (CLE)?

2. Was there a significant overall difference between students’ perception of actual and preferred CLE?
If yes, how did learning about technology, learning to speak out, learning to learn, and learning to communicate correlate with each other?

3. Was there a significant difference between instructor perceptions of CLE and student perceptions on the actual CLE scale? If so, how did learning about technology, learning to speak out, learning to learn, and learning to communicate correlate with each other?

4. How did student perceptions on the actual CLE scale correlate with the self-directed learning readiness, problem-solving skills, and teamwork skills scales?

5. How did student perceptions of preferred CLE correlate with self-directed learning readiness, problem-solving skills, and teamwork skills?

6. Was a model that described the causal effects among “student classification,” “student perceptions of CLE,” “self-directed learning readiness,” “problem solving skills,” and “teamwork skills” consistent with observed correlations among these variables?

**Delimitations of the Study**

1. This study was delimited to investigate a general constructivist learning environment although there were various definitions of constructivism, such as information processing, social constructivism, radical constructivism, and interactive constructivism.

2. The study was limited to students registered for classes in the spring 2003 semester in the department of Industrial Education and Technology at Iowa State University.

**Definition of Terms**

1. Constructivism: A theory of learning in which learners construct knowledge by making meaning from integration of their previous experience and from testing the ideas of peers to make sense in concept construction (Jadallah, 2000; Luneburg, 1998).
2. Leaner-centered: An instructional approach in which students share more autonomy for their learning from instructors.

3. Self-directed learning: A learning process in which learners have control over the identification of learning goals, plan setting, and taking action to achieve the goals (Peter, 1989). It takes place in a social context, but learners possess the autonomy of their own learning (Brookfield, 1985).

4. Self-directed readiness: A varying degree of personal characteristics, attitude, trait, and ability that individuals possess for self-directed learning (Guglielmino & Guglielmino, 1994).

5. Problem solving: Problem solving is cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver (Mayer, 1995). Problem solvers, in the process, improve higher-order thinking skills by applying existing knowledge and skills to collect information for coming up with appropriate solutions.

6. Problem: a problem is an unexplained phenomenon that could comprise a set of questions puzzling enough for people to look for solutions by applying relevant knowledge (Barrows, 1986; Ross, 1995).

7. Teamwork skills: a set of behaviors that enable an individual to be a responsible team member. These skills are identified as adaptability, coordination, decision making, interpersonal, leadership, and communication (O’Neil, 1998).
CHAPTER 2. REVIEW OF THE LITERATURE

Constructivism

Constructivism is a learning theory which is associated with the research on how students learn (Henriques, 1997). The nature of constructivism is the belief that personal knowledge is constructed by learners rather than being feed by instructors or information itself (Doolittle & Camp, 1999; Hein, 1991; Kerka, 1997). Grounded on this learning theory, several assertions regarding the educational setting in constructivist manners have been expended. Also, an epistemology regarding knowledge (Lorsbach & Tobin, 1992) has been studied in how students interact with others and the how the interaction forms a learning community. Educators and researchers studying constructivism and how students learn in a constructivist setting may need to expand the learning theory toward other related dominions, such as the theory of teaching, the theory of education, and the theory of the origin of ideas (Matthews, 2002).

Based on the perspective of cognitive constructivism, the term constructivism emphasizes that knowledge is constructed from the process of interaction between the individual and the environment. This process takes place in the individual’s own mind, in that the major concerns are cognitive self-organization and analyses of the individual learner (Cobb, 1996; Jadallah, 2000). Accordingly, prior experience and knowledge are bases for individual cognitive development. Kerka (1997) defined the term as: “learners actively construct knowledge by integrating new information and experiences into what they have previously come to understand, revising and reinterpreting old knowledge in order to reconcile it with the new” (p. 1). Thus, constructivism is a way of making sense by active
interaction among learners for meaning negotiation and knowledge construction (Fraser, 1998). In this learning paradigm, students share control with instructors and the instructors act as facilitators to support student learning.

**Common beliefs**

A summary of identified common beliefs regarding constructivism can be found in research conducted by Garrison (1993), Hein (1991), and Teslow et al. (1994), as follows:

*Learning is an active process.* Encouraging learners to engage the mind as well as in hands-on activities is most important for actively constructing meaning. Constructivism, which proposes knowledge constructed by referring others’ knowledge and the individual’s previous experience, is a pervasive assumption of cognitive psychology (Garrison, 1993). Rooted in this assumption is that knowledge is not fed from limited materials, but emerges from active learning, which takes place in the process of interactive dialogue. Learners, at the center of learning, take responsibility in forming their knowledge construction. Self-directed learning occurs for students when they take more responsibility to construct their own knowledge through individual, active involvement, rather than the instructor simply utilizing a blackboard to post a teaching note (Garrison, 1993). Thus, a constructivist approach has shifted learners from mere note-takers toward becoming knowledgeable participants.

*Individual understanding comes from personal interpretation of the world.* Knowledge occurs when an individual makes sense cognitively from interacting with the environment. Garrison (1993) stated that the interaction proceeds through “dialogue with oneself as well as others” (p. 201). The dialogue is a way of processing information, in that learners examine, analyze, and interpret personal experience to gain knowledge. Contradictory arguments, and much dialogue among the learners themselves, are necessary
during learning. Language plays a critical role in learning. As Hein (1991) noted, “language and learning are inextricably intertwined” (p. 3).

*Learning takes place in a social context.* Since humans live socially, learning takes place within a community, which traditionally is referred to as the classroom, while it also can take place within non-traditional settings such as a discourse group in an online environment. Learners interact with each other through discourse, during which learning is accomplished (Tobin, 1998). With higher expectations by society for students to become more responsible and capable of self-learning, learning is not merely a transmission of limited ideas. Learning should entail a broad perspective with various social values. Garrison (1993) remarked that learning is: “a social phenomenon, learning in an educational context is a process of transmitting and consensually validating societal values and knowledge as well as critically examining differing perspectives and assumptions” (pp. 204-205).

*An authentic view of constructivism.* Hein (1991) and Petraglia (1998) purported that knowledge is not independent of the learners' experience; rather, learning takes place in an authentic context. For the learner, a personal cognitive conflict or puzzlement directs the action of searching for relevant information. The puzzlement is the stimulus for learning (Savery & Duffy, 1995) and the lack of stimulus can be the source of a learning problem. According to Savery and Duffy, the reasons are: (a) a real problem can comprise all dimensions of information that learners are open to within the context of learning; (b) learners are more familiar with the context from a real problem that encourages them to engage in more than a made-up problem; and (c) the outcome of the problem is more attractive to learners. Teslow et al. (1994) claimed that schools should equip students with authentic tools and realistic contexts to facilitate individual knowledge construction.
Kearsley and Shneiderman (1999) asserted that students with job experience have highly increased motivation and satisfaction when they solve problems with an authentic focus. Therefore, it seems logical that technical educators agree that authentic experience enhances knowledge construction (Doolittle & Camp, 1999).

Moreover, scholars of constructivism believe that learning in socially interactive groups and authentic settings enable students to become actively involved in effective knowledge construction. Constructivism is a pattern of learning in terms of active participation and process evolvement (Garrison, 1993). This approach to learning allows learners to participate in the process of idea structure by integrating new information with previous experience.

**Conceptual change**

Learning takes place when learners encounter new phenomena. Basically, learning is a rational activity encompassing a process of conceptual change. Whenever learning occurs, learners examine new phenomena based on their knowledge of previously existing concepts. The investigation results in intelligibly and rationally changing concepts when accommodation is obtained (Posner et al., 1982). Accommodation occurs when the new information is made to “fit” into the previous existing knowledge of the learners. From the perspective of conceptual change, learning is based on sequential development of an individual’s schemes that are used to construct knowledge (Driver & Oldham, 1986). The construction should integrate the learner’s previous experiences. Posner et al. (1982) purported that learning is a rational activity in which “the student must make judgments on the basis of available evidence” (p. 212). During this process, conceptual change involves...
two distinguishable phases: assimilation and accommodation. When learners perceive a new phenomenon, assimilation functions as a vehicle to guide the learners to understand the phenomenon by referring to their previously existing experience and/or concepts. Hence, constructivism is viewed as students making sense by interacting based on their prior knowledge (Henriques, 1997; Jadallah, 2000). Since the learners’ prior experience is inadequate, accommodation takes the position of helping the learners reorganize their own conceptual framework by which they regenerate knowledge (Posner et al., 1982).

Conceptual change emerges only when several conditions are satisfied. Posner et al. (1982) proposed that the conditions entail when dissatisfaction with currently existing concepts occurs and the new ideas are intelligible, plausible, and fruitful. Generally, new learning is brought forth into the learners’ conceptual framework based on their dissatisfaction with previous knowledge. The dissatisfaction serves as a stimulus to force students to understand the limitation of the current knowledge and the need to restructure their ideas. The dissatisfaction, according to Hodson and Hodson (1998), may result from the failure to deal successfully with the situation “beyond its previous restricted context” (p. 34), or it may be due to the learners’ recognizing the intelligibility and plausibility of the new ideas.

Lunenburg (1998) indicated that learners individually and collectively construct their own knowledge. Individually, learners reframe their concepts by solving problems in the environment in which previous concepts and experiences interact with the phenomenon they encounter. By the collective effort of sharing ideas, learners refine their knowledge. Generally, cooperative-learning groups provide the opportunity for collective idea reflection. Therefore, constructivism asserts that knowledge resides in individuals; that knowledge
cannot be transferred intact from the head of a teacher to the heads of students (Lorsbach, 1992, p. 5).

A constructivist teaching and learning sequence may be a more effective strategy to help understand the process of conceptual change within the context of teaching and learning. Figure 1 shows a modified model of teaching and learning using the constructivist approach originally proposed by Driver and Oldham (1986). The model starts from an orientation to provide motivation for learning, and ends with the application of ideas based on students exchanging their ideas. If one accepts the belief of constructivist theory about teaching and learning, employing a process such as this should incorporate a circle of conceptual change, including both assimilation and accommodation, into the model, even though the model’s original intent was to illustrate a framework from the teacher’s perspective.
Figure 1. A constructivist teaching and learning sequence.

As indicated in the left frame of Figure 1, comparison with previous ideas represents assimilation. Students construct their views from prior experiences (Driver & Oldham, 1986). In the right frame, when students bring their ideas into the process, the new ideas are clarified and exchanged through discussion. Inadequacy may be pointed out from the comparison. “It is reasonable to suppose that an individual must have collected a store of unsolved puzzles or anomalies and lost faith in the capacity of his current concepts” (Posner et al., 1982, p. 214) when they are explored to form new ideas. From the perspective of conceptual change, before the new ideas are accepted and can be applied, the ideas should be examined to determine if they are intelligible, plausible, and if they will become fruitful to students; hence, accommodation will occur.

Four approaches

Several views of constructivism have emerged during the past decades. These interpretations provide information to assist the understanding of this paradigm for intentionally arranging an effective learning and teaching environment. Prawat and Flodent (1994) identified three world views—contextualism, organicism, and mechanism—in discussing how and what knowledge evolves. Social constructivism, radical constructivism, and information processing are identified in their study. Borrowing from Pepper’s (1942) assertions, Prawat and Floden categorized information processing as a mechanistic approach, social constructivism as an approach of contextualism, and radical constructivism as an approach of organicism. Each approach differentially embraces a specific theory about truth.

Interactive constructivism, the fourth approach of constructivism, has been discussed in studies by Henriques (1997), and Christensen and Hooker (1999). This approach, as well
as the three previously mentioned ones, “fit along a continuum of constructivist interpretations on decreasing teacher structure and increasing learner control” (Henriques, 1997, p. 3). However, each has unique assumptions that are based historically and theoretically based on different views of how knowledge is constructed. Although each has been criticized based on different points of view, these approaches provide important outlines to provide perspectives on the philosophical entity of constructivism.

*Information-processing.* At one end of the continuum of a constructivist approach is information-processing, which proposes that students engage continually in personal construction of knowledge by learning facts via teachers and experiences (Fisher & Lipson, 1985; Henriques, 1997). This approach interprets learning as close to most concepts of classroom learning, in that instructors design lessons and class activities. Nevertheless, learning is still based on individual conceptual change through assimilation and accommodation.

From the perspective of information processing, objective reality exists when individuals’ understanding of information is compatible with previous experience. Fisher and Lipson (1985) explained that the existence of reality is based on the frequent awareness of the discrepancy between one’s expectation and observation. When the discrepancy occurs, “we must absorb the contradictions and reassess and revise our mental models. Deviations from expectations prime us from learning, but only if we notice, pay attention, and make the effort to adjust our models” (p. 51). Thus, it seems that learning should take place mentally and physically, for the student to become aware of the context of learning. The awareness includes both absorption and ignorance.
The view of knowledge in the information-processing approach is that knowledge is organized into mental organizational structures, called schemas, and a data structure, called frame. “A frame, then, is a data structure that represents a concept in memory” (Fisher & Lipson, 1985, p. 55). People store information that may be organized to form their conceptual framework, and it may be reorganized to become knowledge. Although human memory is unique and limited, it plays a functioning role in how people understand and interpret the phenomena they encounter. The discrimination among humans results as individual perspectives of reality emerge.

**Social constructivism.** Rooted in Vygotskian views, social constructivism is concerned with the social context that cognitive development occurs in the interaction between individuals, peers, and teachers (Hodson & Hodson, 1998; Jadallah, 2000). Hodson and Hodson (1998) argued, according to Vygotskian perspective, learning to understand science is not only a matter of personally making sense of the physical world, but it also involves making sense within social activities. Language is the primary cognitive and communicative tool. Several basic assumptions provide the framework to understand social constructivism:

**Reality.** Social constructivism denies reality is an individual’s discovery. Instead, reality is generated from social activities. It is a result of a process by which “we, together as members of a society, invent the properties of the world” (Kim, 2001, p. 1).

**Knowledge.** From the perspective of social constructivism, knowledge is a social product constructed through interactions among individuals, and between individuals and the environment (Kim, 2001). The approach insists upon a shared concept of the creation of objective knowledge. Researchers acknowledge humans should have individual subjective
knowledge and individual experience to shape the knowledge. From the theoretic perspective of social constructivism, there is a connection between objective knowledge and individual subjective knowledge. According to Ernest (1993), the connection is as follows:

The social is constituted by individuals together with their shared forms of life. And because of this shared feature, with all of its complexity and human-constituting properties, it cannot be reduced to individuals alone, thus the objective knowledge which rests in the social is based on share language use, rules and understanding, embedded in share forms of life. It is essentially supported by the subjective knowledge of individuals, but because of their interrelations, it is correlated in a complex and ever changing way. (p. 146)

Learning. Social constructivism asserts learning takes place in a social process in which individuals engage (Kim, 2001). Traditionally, the social community refers to the classroom, but it can be a discourse group in an online environment. Learners interact with each other through discourse in which learning is accomplished (Tobin, 1998). With higher expectations by society for students to be more responsible and capable, learning is not merely a transmission of limited ideas. Learning should be a broad perspective with various social values. Garrison (1993) stated that learning is a “social phenomenon, learning in an educational context is a process of transmitting and consensually validating societal values and knowledge as well as critically examining differing perspectives and assumptions” (pp. 204-205).

Enculturation. Tobin (1998) interprets teaching and learning in terms of enculturation. This is a process of social interaction in which learners examine others’ representation based on their knowledge. Others’ knowledge will be constructed into learners when it fits an acceptable level. There are several reasons for concern about learning in groups. For example, Savery and Duffy (1995) claim that learning in collaborative group
enables learners to test theirs and others’ understanding so that the testing enriches learners’
views to the issue that they are learning. Gokhale’s (1995) study found that collaborative
learning could foster critical thinking. With the high expectations of society, critical thinking,
problem-solving ability, communication skills, and the skill of working in teams have been
regarded as important qualities for employment (Rice & Wilson, 1999). Since contemporary
learning communities have shifted, to be more pluralistic within diverse cultures, group
learning brings about the opportunity for learners to enculturate themselves into the
community (Tobin, 1998). Learning itself is a process of enculturation. The diversity of
students facilitates group learning through the contribution of knowledge and experience.
Hodson and Hodson (1998) regarded this way of learning as “collective memory,” a cultural
resource of society (p. 37).

*Radical Constructivism.* As the primary exponent of radical constructivism,
Glasersfeld (2000) incorporated Piaget’s processes of assimilation and accommodation into a
cognitive model of learning (Glasersfeld, 2000; Hardy & Tylor, 1997). Students in this
learning environment share a unique experience that is generated in an individual way based
on their culture and social background (Henriques, 1997). The belief of radical
constructivism proposes that an individual’s experience is the center of learning. The
assumption of radical constructivism is as follows:

*Knowledge.* Radical constructivism holds the belief that knowledge is a product of
individual creation (Prawat & Floden, 1994). The creation is unique. As Glasersfeld (2000)
stated: “knowledge is under all circumstances constructed by individual thinkers as an
adaptation to their subjective experience” (p. 4). “We may wonder how it takes place. It is
not discovered from social context that people interact to come up with a common agreement.
Instead, knowledge is created by individual experience” (Henriques, 1997). Hardy and Taylor (1995) stated, “the learner constructs knowledge from his experiences in an effort to impose order on and, hence, make sense of those experiences” (p. 2).

*Truth.* Grounded in coherence theory of truth, radical constructivism posits that truth is an ideal coherence of our rationale and belief of acceptance of one another (Prawat & Floden, 1994). Nevertheless, the coherence is established individually based on different perspectives and lived experiences. Students have their own beliefs of what is right. Coherence allows for different interpretations of common evidence among students (Henriques, 1997). Consequently, truth includes a system of beliefs that enables students to move toward a complete understanding by an integration process with various fragments. Students themselves initiate the integration of the fragments into complete conceptual harmony (Prawat & Floden, 1994).

*Language.* Language is a fundamental component of knowledge construction in radical constructivism. It is a tool having an instrumental function to conduct both cognitive construction and thinking. Actually, radical constructivism acknowledges the critical function of social interaction in learning. It posits the necessity of collaboration and communication among people to overcome the limitations of an individual’s experience. Social interaction enables people to test the viability of constructions (Hardy & Taylor, 1997). However, language is comprised only of symbols and it cannot be meaningful without association with concepts. From the perspective of the necessity of communication as a social interaction in radical constructivism, language serves only as a bridge to assist one’s individual subjective experiences to be meaningful. Therefore, there are no shared meanings
identified though radical constructivism; rather, there are various culturally viable interpretations of phenomena (Henriques, 1997).

*Interactive Constructivism.* Utilizing different perspective of constructivism, Yore et al. (1999) described an ecological approach of constructivism, or an interactive-constructivist model of learning. This description of learning is different from the ones proposed by social and radical constructivism. According to Yore et al., “learning in which dynamic interaction of prior knowledge, concurrent sensory experiences, belief systems, and other people in a sociocultural context lead to multiple interpretations that are verified against evidence and privately integrated (assimilated or accommodated) into the person’s knowledge network” (p. 4). This is a middle-of-road view of constructivism. Prawat and Floden (1994) denied a hybrid approach of mechanistic, organicist, and contextualist views of learning, since interactive-constructivism views learning taking place by learners interacting with others and the environment in which they live.

Some assumptions of the constructivist approach are described as follows:

*Learning.* Both public and private phases of learning are accepted. Students make sense from interacting with each other and from their own private reflection to construct knowledge (Yore et al., 1999). Interactive constructivism posits that instructors act as facilitators, which is similar to the commonly expected role of teachers in the general concept of constructivism. Through the encouragement of facilitators, students make sense in short-term memory and store knowledge in long-term memory (Heniques, 1997).

Christensen and Hooker (1999) utilized a concept of autonomy to introduce learning in interactive-constructivism, in that complex interaction, when processed, leads to construction of higher-order properties related to an individual’s life and cognition that
includes norms, functions, and meaning. This theory views knowledge as a capacity of context-sensitive action. Knowledge is generated through a distinctive adaptive strategy, a form of adaptability, from complex action in variable environments. Therefore, within the context of an autonomous system, characterized as an interactively self-generating system, students learn by interacting “with their environment and within themselves that they are able to acquire the needed resources and direct those resources into the reconstitution of themselves” (p. 139). Interestingly, the higher-order process is associated with self-directedness. Christensen and Hooker proposed that students use cognitive development in terms of self-directed anticipative learning, which includes anticipations and a search process for the refinement of knowledge.

**Expectations of instructors**

Most studies of constructivism regard instructors as facilitators (Garrison, 1993; Lunenburg, 1998; Rice & Wilson, 1999; Yore et al., 1999). Based on the concept of active learning, instructors (i.e., the facilitators) in constructivism tend to assist rather than lead students directly, particularly in problem solving. The purpose of facilitation is to: (1) provide guidance to help students to develop their own hypotheses and conclusions in learning activities (Lunenburg, 1998; Rice & Wilson, 1999); (2) help students become independent in their studies (Savery & Duff, 1995); (3) set tasks, provide resources for information, and arbitrate students’ performance (Petraglia, 1998); and (4) empower and encourage students to formulate their own perceptions (Lunenburg, 1998).

Yore et al. (1999) described various aspects of the role of facilitators from the perspective of interactive-constructivism. First, the characteristics of the instructor are
spontaneousness, flexibility, and anticipating students’ interest, questions, and problems.

Second, the manner of the instructors is holistic and contextual, to commit to well-defined goals and cross-curricular connections. Third, the teaching plan for interactive-constructivist instructors is interaction with literature, initiating activities such as cooperative group projects, and incorporating students’ prior experiences to encourage learning. This approach to teaching tends to deploy more self-directed, personally-responsive, and socially-mediated learning (Ravitz et al., 2000).

Ravitz et al. (2000) divided instruction into traditional transmission instruction and constructivist-compatible instruction. The division is grounded on three aspects: (1) the theory of student learning; (2) the role of teacher and student; and (3) the social structures for learning. In traditional transmission instruction, most likely comprised of traditional lecture-based classes, the instructors are responsible for giving prepared information as much as possible. Learning is primarily absorbing the content of an instructor’s explanation or of class materials. In contrast, constructivist-compatible instruction requires students to engage in their learning. To facilitate students, instructors are more likely to arrange their teaching practice into five types of activities: (1) projects, (2) group work, (3) problem-solving tasks, (4) reflective thought through writing, and (5) meaningful thinking. Instructors who are constructivists are expected to provide challenges and support while serving as resources of cognitive construction that drive students toward a higher-order thinking approach in learning (Lunenbure, 1998).
Empirical constructivist studies

A comparison between constructivism and traditional instruction was conducted by Ravitz et al. (2000) who reviewed constructivist literature for the purpose of identifying the differences among teachers embracing specific teaching practices and beliefs. A national survey was conducted to assess traditional transmission instruction and constructivist-compatible instruction by eliciting the responses of 4,083 teachers. Among the findings was that constructivist teachers believe that giving students opportunities to express their understanding and ability in problem solving instead of obtaining answers from tests is the focus of learning assessment. Another finding was that teacher beliefs are an important vehicle in predicting a pattern of practice. Ravitz et al. (2002) stated, “beliefs do help determine practice, and therefore to increase the frequency of constructivist practice” (p. 2).

Fraser et al. (2000) conducted a cross-national study for constructivist learning environments assessment by combining qualitative and quantitative methods. The study investigated differences between students’ perceptions of constructivist approaches in Australia and in Taiwan. Statistical results from constructivist learning environment survey (CLES) scores revealed that each country had significant differences in aspects of constructivism. This cross-national study provided for validation of the CLES. Interestingly, the qualitative interviews enabled the investigators to ascertain and meaningfully interpret students’ responses. According to Fraser (1998), a cross-national study provides broader insight based on culture differences.

DiBello and Spender (1996) provided a feasible application of constructivism in a training environment via a two-day constructive learning workshop of material requirements planning (MRP). Instead of the risky, expensive, and inefficient learning using traditional
classroom training, the research utilized problem-solving activities in a constructivist learning context. Participants in the training were asked to perform simulation tasks in teams. The MRP scores for each participant were collected twice, from a pre-test and post-test. There were significant differences in the participants' pre-test and post-test MRP scores. The researchers concluded that when learners construct their own solutions, their performance reveals that effective, in-depth learning has occurred.

Self-Directed Learning

Since technology has shifted contemporary learning toward a more information-orientated process, self-directed learning has become one of the most valuable ways to acquire knowledge (Siaw, 2000). The term self-directed learning, as defined by Garrison (1997), refers to “an approach where learners are motivated to assume personal responsibility and collaborative control of the cognitive (self-monitoring) and contextual (self-management) processes in constructing and confirming meaningful and worthwhile learning outcomes” (p. 18). Educators in higher education believe that self-directed learning enables students to learn how to learn actively and collaboratively at their own pace in a non-traditional structured environment (Ramsey & Couch, 1994). Knowles (1975) defined self-directed learning as an andragogy, or an approach to help adults learn. People who are proactive learners do better in learning than do reactive learners.

Assumptions and elements (Knowles, 1975)

Knowles (1975) compared two types of learning by listing assumptions and elements as shown in Table 1. Knowles labeled teacher-directed learning as “pedagogy” and self-
directed learning as “andragogy,” both originally from Greek words. First, a self-directed learning approach assumes that learners have independent personalities. Learners do not need instructors to decide what and how to learn for them, and they are able to set learning goals by mutual negotiation. Second, since self-directed learners are mature in their learning, their experience provides rich resources to learning, whereas teacher-directed learners depend more on textbooks and materials that are teacher-prepared. Third, self-directed learners’ readiness for learning is generated from individual life tasks they perform and the problems they encounter. Thus, each individual pattern of readiness is different. In contrast, teacher-directed learners tend to rely on different levels of maturation for readiness of learning. Fourth, self-directed learners view learning from a task-or problem-centered orientation. They prefer to learn through problem-solving projects rather than merely by subject content. On the other hand, teacher-directed learners have more subject-centered preferences, such as course syllabus and content units in sequence. Fifth, self-directed learners are motivated by internal incentives such as “the need for esteem (especially self-esteem), the desire to achieve, the urge to grow, the satisfaction of accomplishment, the need to know something specific and curiosity” (p. 21). To the contrary, teacher-directed learners are motivated by external rewards, such as grades, degrees, awards, etc.

Knowles (1975) insisted that one needs to read these characteristics as on a continuum. It is not necessarily bad or good for self-directed learning or teacher-directed learning. Some learners may tend to be more teacher-directed in some aspects and self-directed in others. Guglielmino and Klatt (1994) indicated that learners’ learning preference and attitudes vary in determining needs, planning, and implementing of learning.
Guglielmino and Klatt found that self-directed learners are capable in terms of creativity and problem solving, and they are better than teacher-directed students in dealing with change.

Table 1  A comparison of assumptions and process of teacher-directed (pedagogical) learning and self-directed (andragogical) learning

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Process Elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>About</td>
<td>Teacher-directed learning</td>
</tr>
<tr>
<td>Concept of the learner</td>
<td>Dependent personality</td>
</tr>
<tr>
<td>Role of learner's experience</td>
<td>To be built on more than used learning</td>
</tr>
<tr>
<td>Readiness to learn</td>
<td>Varies with levels of maturation</td>
</tr>
<tr>
<td>Orientation to learning</td>
<td>Subject-centered</td>
</tr>
<tr>
<td>Motivation</td>
<td>External rewards and punishments</td>
</tr>
<tr>
<td>Planning</td>
<td>Primarily by teacher</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Primarily by teacher</td>
</tr>
<tr>
<td>Setting goals</td>
<td>Primarily by teacher</td>
</tr>
<tr>
<td>Designing a learning plan</td>
<td>Content units</td>
</tr>
<tr>
<td></td>
<td>Course syllabus</td>
</tr>
<tr>
<td></td>
<td>Logical sequence</td>
</tr>
<tr>
<td>Learning activities</td>
<td>Transmittal techniques</td>
</tr>
<tr>
<td></td>
<td>Assigned readings</td>
</tr>
<tr>
<td></td>
<td>Experiential techniques</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Primarily by teacher</td>
</tr>
</tbody>
</table>

Source: Knowles (1975, p. 60).

**Partnership model (Ramsey & Couch, 1994)**

To understand self-directed learning better, Ramsey and Couch (1994) proposed a partnership model, which is based on and expands the concepts of Knowles’s self-directed
learning. The model serves as a mechanism in the development of a partnership between teachers and learners. The objective of partnership development is to encourage self-directed and cooperative learning. In partnership mode, different situations of teaching and learning can be displayed in three dimensions: (1) control of learning choices, (2) type of learning situation, and (3) selection of learning approaches.

**Control of learning choices.** The first dimension indicates the subject of learning choices in “what to learn, how to learn, where to learn, and from whom to learn” (Ramsey & Couch, 1994, p. 142). As depicted in Figure 2, other control and self-control for choices are at the two ends of a continuum. Teacher-centered and student-centered represent the two extreme forms of instruction. Shared control is the third type between the two extremes. If students have been used to learning in the context of traditional instruction, they tend to ignore personal responsibility in making choices to achieve learning goals, while these students have more autonomy for choices under self-control.

**Types of learning situations.** Types of learning situations indicate sources of data or learning content. The types are comprised of acquisitional, vicarious, and experiential learning situations. Learning in an acquisitional situation relies on course materials, such as books, media, and lectures. On the other hand, experiential learning is based on sources from personal actions, experiences, and interactions with others. In a vicarious situation, learning information comes from the learner’s observations of others’ actions.

**Selection of learning approaches.** The dimension consists of planned and unplanned learning. Planned learners are goal-orientated; they set up goals in advance and deliberately implement learning strategies as well. In contrast, unplanned learners comprehend from their...
reflection on learning after conclusions and generalizations are made; learning occurs retrospectively.

The three dimensions form a $3 \times 3 \times 2$ matrix that includes 18 cells. Six of the cells express the character in teacher-centered learning, another six in student-centered learning, and the remaining six in partnership learning. Ramsey and Couch (1994) argued that it is impossible and inappropriate to be completely self-directed. However, it is reasonable to gain a certain degree of control over learning through exercise. “The more realistic goal of those
who promote self-directed approaches, then, becomes one of helping people become more, rather than totally, self-directed” (p. 147).

**Comprehensive model (Garrison, 1997)**

In disagreement with previous studies of self-directed learning that paid attention to external management of the learning process, Garrison (1997) claimed the appropriateness of a collaborative constructivist perspective in discussing this concept. Garrison proposed a comprehensive model that integrates three dimensions: self-management (contextual control) internal monitoring (cognitive responsibility) and motivation (entering and task). The three dimensions are not separate from one another but, rather, are connected mutually (Figure 3).

*Self-management.* The first dimension focuses on an external task control associated with learning goal setting and the management of resources. When learners are satisfied with the need of having autonomy in learning processes and are being provided with availability and flexibility in sources, self-management will enhance meaningful learning continuously.

![Figure 3. Dimensions of self-directed learning (Garrison, 1997)](image-url)
From the perspective of collaborative constructivism, learners construct meaning in a shared world in which learning task control is regarded as “a collaborative relationship between teacher and learner” (p. 23), and the responsibility of goal setting is shared among learners. The degree of self-management varies in a balance between the skills and abilities of teachers and learners, the availability of support and assistance, and the interdependence between institution and learners in norms, and their integrity and choice.

Self-monitoring. The second dimension is concerned with the cognitive and metacognitive processes related to taking responsibility for construction of personal meaning through the integration of new and previously existing knowledge. The integration is based on reflecting and confirming one’s own previous knowledge and the experience of others. This process is a critical component for examining whether learning outcomes meet the goals, as well as for shaping future learning strategies.

Both internal and external feedback are necessary for self-monitoring. There should be a balance between self-monitoring regarding the learner’s responsibilities and self-management related to control. In internal feedback, students observe, judge, and react to learning tasks and activities to cognitively self-monitor their progress from learning. To improve the accuracy and explicitness of learning, external feedback from teachers is necessary to provide a function of monitoring the quality of learning outcomes. Garrison (1997) argued that collaborative control between the teacher and learner produces a more effective learning performance since control over the learning process shifts the balance to being learner-oriented. Self-directed learning (SDL) is a collaborative process. Garrison (1992) stated:
We live interdependently and knowledge is socially determined. The real purpose of increased control is to achieve a deeper understanding of content and the opportunity to confirm knowledge objectively. This suggests a symbiotic relationship between external control concerns and internal responsibility. (p. 141)

Motivation. The importance of motivation is its reflection in “perceived value and anticipated success of learning goals at the time learning is initiated and mediated between context (control) and cognition (responsibility) during the learning process” (Garrison, 1997, p. 26). Garrison proposed that a learner’s entering motivation is based on valence and expectancy. Valence indicates the attraction to specific learning goals. Personal need for particular goals and affective states regarding attitudes in self, task, and goal preferences determine valence. On the other hand, expectancy indicates a learner’s beliefs in the achievement of learning outcomes. Personal characteristics are associated with personal perceived skills, ability, and knowledge, and contextual characteristics are associated with perceived institutional resources, barriers, and constraints in ideological and socioeconomic aspects. The framework of the factor relationship regarding motivation is shown in Figure 4.
Self-directed learning model (Hmelo & Lin, 2000)

Hmelo and Lin (2000) proposed a model that develops SDL by using problem-based learning as a learning strategy (Figure 5). Hmelo and Lin’s theoretical study indicated that several features of problem-based learning (PBL) have the function to support the development of SDL. These features organize SDL activities that take place in the process of problem solving. The features and associated activities of SDL include the following:

1. Learner-centered nature: A learner-centered nature directs students toward taking more responsibility for their own learning. The critical goal of PBL is to design a learner-domain environment that serves as a stimulus to develop capability to take ownership of the learning process (Savery & Duffy, 1995). In SDL, students are expected to have autonomy in learning at their own pace.
2. Apply existing knowledge to identify and solve problems.

3. Identify their knowledge deficiencies and generate issues: They solve problems by examining their own knowledge and applying previous knowledge, as well as referring to others’ knowledge. A gap occurs when learners find there is deficiency in their existing knowledge.

4. Make efforts on research independently: Students should be acquainted with the research approach when learning through PBL. By practicing independent research, learners become good at locating information.

5. Evaluate the appropriateness of research resources.

6. New knowledge to solve problems: Learning in a specific methodology facilitates students in the development of problem solving skills.

7. Reflect on self-directed learning: In PBL, students apply the ability of reflective self-assessment to obtain knowledge.
Guglielmino's Self-Directed Learning Readiness Scale (SDLRS).

Developed by Guglielmino in 1977, the Self-Directed Learning Readiness Scale (SDLRS) has been applied widely during the past two decades for the purpose of investigating self-directed learning. Guglielmino (1977) applied the Delphi technique by asking 14 experts to develop the scale. The scale consists of 58 Likert-type items that are classified into positive and negative phrases in two categories (Field, 1989). The scale is a continuum, from less to more self-directed learning (Guglielmino, 1977). Bonham (1991) examined the scale and argues that there are two opposites of readiness for self-directed learning. The opposites include other-directedness and "dislike for, and avoidance of, all learning, whether self-directed or other-directed" (p. 92). Eight factors were identified by
Guglielmino eventually from the original 13 factors via a factor analysis. The factors are as follows:

**Factor 1: Openness to learning opportunities.** This factor is related to an individual’s interest, satisfaction, love, and expectation, responsibility, and ability to accept criticism in learning (Guglielmino, 1977/1978). Since terms in this factor may include other-directed, avoiding any learning opportunities is in the opposite (Bonham, 1991).

**Factor 2: Self-concept as an effective learner.** This factor is associated with an individual’s confidence, self-discipline, self-view, and ability to use time management in learning (Guglielmino, 1977/1978). Learners with these characteristics tend to have a tolerance of risk, ambiguity, and complexity in learning (Siaw, 2000).

**Factor 3: Initiative and independence in learning.** This factor indicates that learners take their responsibility to initiate, plan, and implement learning. Other-directedness or dislike of learning may be the opposite (Bonham, 1991).

**Factor 4: Informed acceptance of responsibility for one’s own learning.** This factor is related to an individual’s willingness, intelligence, belief, and preference for learning.

**Factor 5: Love of learning.** This factor indicates a strong desire to enjoy learning. Naturally, dislike of learning is the opposite, but not dislike of self-directedness (Bonham, 1991).

**Factor 6: Creativity.** This factor indicates the learner’s creativity, such as abilities in taking risks, thinking of alternatives for learning topics, and learning curiosity, etc.

**Factor 7: Positive orientation to the future.** Siaw (2000) noted this factor as the view of learning as a lifelong, beneficial process.
Factor 8: Ability to use study skills and problem solving skills. Learners in this situation are more likely to take the challenge of problems and have a view of themselves as life long learners (Field, 1989; Guglielmino, 1977/1978). Dislike learning is the opposite.

Empirical self-directed learning studies

Several studies are related to administrating the Self-Directed Learning Readiness Scale in the field of higher education. A validation study of the self-directed learning readiness scale conducted by Long and Agyekum (1983) concluded there is a significant difference associated with a student’s age and educational level. The researchers noted that older students tend to have learned more self-directness. From a similar viewpoint, more self-directed students are more likely to continue taking college courses.

Caffarella and Caffarella (1986) administrated learning contracts to encourage students to become more responsible in the learning process. The process of using learning contracts enables students to negotiate learning resources, objectives, evaluations of learning, and time lines for completing learning. The Self-Directed Learning Readiness Scale was used to investigate student’s readiness for self-directed learning. The difference between the pre-tests and post-tests for self-directed learning showed that incorporating learning contracts into the class impacts several competencies of self-directed learning. The competencies that were affected are: (1) translating learning needs into learning objectives; (2) identifying resources, both in human and material aspects, for different learning objectives; and (3) effectively choosing strategies when using learning resources.

Guglielmino and Guglielmino (1994) conducted an investigation at Motorola Corporation to test the relationship between self-directed learning readiness and job performance. They found that self-directed learning readiness is highly associated with an
outstanding job performance that requires high degrees of creativity and problem solving. They suggested that SDLRS is an appropriate instrument to be used when selecting employees who need to be responsible for special jobs.

Grounded in constructivism, problem-based learning (PBL) has been found to be associated with self-directed learning. As an important component for lifelong learners and problem solvers (Hmelo & Lin, 2000), SDL is defined as a source to emerge abilities associated with knowing learning purpose, formulating questions, as well as applying knowledge to come up with solutions. These abilities are critical components of PBL. Hmelo and Lin’s empirical study of PBL in a medical school are consistent with the theoretical discussion. The study compared PBL curriculum with non-PBL curriculum, and concluded that PBL affects the development of SDL strategies effectively. The findings indicated PBL students tend to be more skillful in identifying hypothesis-related learning problems and generating SDL plans with well-specified starting points, as well as integrating new information into problem solving (Hmelo & Lin, 2000). Siaw’s (2000) study related to business education supported Hmelo and Lin’s conclusions. Following an eight-month PBL course, a student’s SDL readiness was improved significantly.

**Problem Solving**

**Problem solving and problem solvers**

While various disciplines have interest in this issue, problem solving is an important focus in psychology. From the perspective of a cognitive process, Mayer (1991) claimed that problem solving involves four major ideas: cognitive, personal, directed, and indicating a
process. Greeno (1978) discussed problem solving from the concept of information processing. According to Greeno:

The major advantage of information-processing theory, in contrast to behaviorist and associationist approaches, is that performance in problem solving is analyzed in detail, and theoretical interpretational includes specific assumptions about the component cognitive processes involved in the performance. (p. 240)

Savery and Duffy (1995) claimed a hypothetical-deductive problem-solving process that works as a cognition-processing loop. When dealing with a problem, learners should be able to identify the issues, set the learning goals, proactively locate and select resources, self-evaluate their learning strategies and knowledge, and make decisions on their own.

Problem solving skills are teachable. The purpose for training problem-solving skills varies in different circumstances. For example, it is just as important to teach problem-solving skills to satisfy the need of creativity in industry as well as improving problem-solving skills in college students. Generally, problem solving aims to improve performance (Mayer, 1983). From a narrower point of view, teaching problem solving enhances a student’s ability when solving routine problems, while enhancing ability in solving non-routine problems is the purpose based on a broader view (Mayer, 1994). Relevant skills that can be taught to solve problems successfully are problem definition skills, brainstorming, and decision making (Heppner et al., 1983).

Types of problems

Problems occur when people perceive a gap between their existing knowledge and additional knowledge when trying to come up with the solutions. For specific educational purposes, problems are displayed in different formats and statements to achieve specific goals, as well as to enable specific target audiences to operate (Gilhooly, 1982; Mayer, 1991).
From each definition of problem type, one may find that individuals may have different perceptions about the types of problems.

Mayer (1991) described different types of problems according to the specification of statements in problems and the degree of required creativity:

1. **Well-defined problems vs. ill-defined problems.** Well-defined problems indicate the problems with clearly-presented components in operation. In contrast, ill-defined problems have one or more components that are not presented clearly. Generally, a problem consists of three major components: a starting state, a goal state, and a set of processes (Gilhooly, 1982).

2. **Routine problems vs. non-routine problems.** When people have a pre-existing strategy to solve a problem, the problem is routine; the problem is non-routine when people do not. For example, "7891 / 13 = ____ (p. 285)" is a routine problem for a normal adult. Non-routine problems require more creativity to generate and evaluate alternative solutions.

Greeno (1978) specified three types of problems:

1. **Problems of inducing structure.** In these types of problems, problem solvers are given some instances and asked to find a pattern or rule among instances (Mayer, 1991). Greeno (1978) indicated that a form of understanding is the major cognitive ability for the patterns.

2. **Problems of transformation.** When problem solvers are given an initial situation, a goal, and a set of operations that make changes for different situations, problems of transformation occur. In these problems, problem solvers must "Find a sequence of operations that transform the initial situation into the goal" (Greeno, 1978, p. 241).
3. *Problems of arrangement.* Problems occur when some elements are provided and the problem solvers are required to arrange the elements in such a way to produce a solution. Anagram problems and cryptarithmetic problems are examples (Mayer, 1991).

In addition to well-defined problems and ill-defined problems, Gilhooly (1982) proposed other types of problems:

1. *Adversary problems* vs. *non-adversary problems.* Two types of problems are related to how people tackle problems. Competition among thinking opponents is the main task of adversary problems (e.g., playing chess and poker) (Gilhooly, 1982; Mayer, 1991). For the non-adversary problems, a single person or people work in a group to discover solutions (Mayer, 1991). The challenge is that real or symbolic problem materials do not respond actively to solvers, which may frustrate them.

2. *Deductive problems* vs. *inductive problems.* These problems are related to reasoning. In deductive reasoning, problem solvers must decide the conclusion by logically following specific statements. For inductive problems, problem solvers must determine the implication from limited information to test the hypothesis. Mayer (1991) classified inductive problems as problems of inducing structure, and deductive problems as problems of transformation.

**Process**

The need for a structure or a model to guide a problem-solving process is based on a variety of reasons, such as keeping one’s work on track, avoiding wasted effort, reducing ambiguity, etc. (Wilson, 1993). The framework of problem solving consists of the stages of
problem solving and methods of problem solving. The methods working within stages are the major steps of the process (Wu, 1994). Several studies have been proposed to explain the process.

**Mayer's four stages (1991)**

Mayer (1991) proposed four interrelated stages in the process of problem solving by integrating Wallas's and Polya's ideas.

*Representing.* The task of representing is to gather information and expectation for solutions. In this stage, problem solvers “translated the given problem into an internal mental representation of the givens, goals, and available operators in the problem (Mayer, 1991, p. 285).

*Planning.* In this stage, problem solvers deal with sub-goal setting for solving problems. This stage Polya calls devising a plan.

*Executing.* This is the stage of the process in which problem solvers take a series of actions to implement the plan.

*Monitoring.* This stage occurs when problem solvers assess their progress of problem-solving and how each action adopted for the problem fits the plan for solutions.

**Heppner's model (1997)**

Borrowing from D'Zurilla and Goldfried's (1975) model, Heppner (1997) proposed a problem-solving model that includes five stages. The stages provide an applicable framework allowing problem solvers to follow the steps sequentially though the discussion within counseling context.
General orientation. The first stage refers to identifying a problem solvers' predisposition that impacts a certain behavior. Three classes of effective behaviors in problem solving can be identified. The first class of behaviors is associated with a higher probability that problem solvers are more likely to tackle problems by discussing them with others. Heppner (1997) indicated that people tend to be more effective problem solvers in a highly confident, controlling environment. The second class of behaviors is a set of dispositions that enables problem solvers to identify troublesome situations and label them. The third class comprises the behavior of acting cautiously, but that do not avoid the problematic situation.

Problem definition and formulation. Gathering all the information and facts is a crucial step for successful problem solving. Heppner (1978) suggested successful skills and abilities to: (1) identify problem boundary; (2) organize the facts in order; (3) identify and exclude irrelevant facts; (4) recognize the gap in necessary information; and (5) identify the information to fill the gaps.

Generating alternatives. This stage allows for discovery of possible solutions for the problems. It is a goal-directed process in that the ability of using previous experience is the major focus for the selection of alternatives. To generate alternatives, brainstorming is a more effective method. It is necessary to avoid judging the alternative in advance, and more alternatives are better.

Decision making. This stage indicates choosing actions from available alternatives. To make a successful decision, problem solvers need to collect information and need to assess probability and utilities or preferences, as well as evaluate the outcomes of different alternatives.
Verification and evaluation. This stage indicates assessing outcomes from choosing actions according to a given criteria. The problem solving will be performed until choosing actions that are consistent with given criteria. Heppner (1978) claimed that self-monitoring, self-evaluation, and self-management are important skills in verification.

According to the model and process discussed previously, one may find that the process of problem solving can be summarized as four fundamental steps: (1) problem identification/definition, (2) development and identification of solutions, (3) implementation, and (4) testing. Wilson (1993) indicates that any problem solving starts with defining the problem. One may use divergent thinking techniques to develop solutions and convergent techniques to identify the best solution. This suggestion particularly fits when solving problem in teams.

Empirical problem-solving studies

Empirical studies related to problem solving can be found in a variety of fields, such as counseling psychology and computer education. Researchers on distance education, particularly when the focus has been on computer-related technology as instructional tools, have discussed the issue. For example, Yaverbaum and Ocker (1998) investigated students' perceptions of collaborative learning techniques in a problem solving environment via a 2 × 2 factor experiment. Participants in the study were undergraduate and graduate students who worked in asynchronous or synchronous communication teams. Team projects encompassed primarily in problem solving and decision-making circumstances. The results of two surveys showed that there was a significant difference between feelings of task accomplishment and general satisfaction with the problem solving process. Yaverbaum and Ocker (1998)
proposed that computer conferencing was a valuable way of communicating in problem solving.

Heppner et al. (1982) administrated a Problem Solving Inventory to examine differences in several characteristics of students who have been perceived as successful and students who have been perceived as unsuccessful problem solvers. The characters included cognitive, behavioral, and affective self-report in interpersonal and intrapersonal problems. The study found differences across these problem-solving styles. In addition, the finding of this study supported previous research indicating that problem solvers should engage in brainstorming activities and perceptions of problems in life as well.

Furthermore, Heppner et al. (1983) examined the association between problem-solving appraisal and several trait variables. The appraisal was divided into effective and ineffective problem solvers. Trait variables included encoding related to the self and use of self-regulatory systems. The results indicated that “Students who differ in their self-appraised problem-solving effectiveness also differ in their encoding about the self and use of self-regulatory systems” (p. 542). For example, effective problem solvers tended to rate higher in having positive self-concepts and in the consistency and certainty of self-perceptions. Wu (1994) compared technological problem-solving and personal problem-solving among students in technology, engineering, and the humanities, and found that differences in personal problem-solving did not exist among the three majors.

Fostering Teamwork Skills by Learning in Collaborative Group

Learning with others is important, as such learning enables one to test his or her own understanding. Savery and Duffy (1995) noted, regarding learning in a collaborative group,
"We can test our own understanding and examine the understanding of others as a mechanism for enriching, interweaving, and expanding our understanding of particular issues or phenomena" (p. 32). Since learning is related to the balance of control learning tasks, communication capabilities are critical for successful learning (Garrison, 1997).

Peers are resources rather than competitors in a cooperative learning setting that encourages students to share ideas with others. The collaborative setting has become much improved better with the support of Internet technology as a mean to pass information and ideas to each other not limited by distance. Through working together in collaborative problem solving by sharing knowledge and skills among learners, learning is a source of motivation of learning, and learning provides the opportunity for learners to identify their strengths and weaknesses (Petraglia, 1998).

Features of a team

Teams are goal-orientated groups in which people interact dynamically, adaptively, and interdependently with other members to accomplish a set of goals (Salas et al., 1992). According to McIntyre and Salas (1995) and Salas et al. (1992), a team must have four necessary components: (1) interaction among team members; (2) a purpose for valued and specific goals; (3) adaptation to circumstances; and (4) a limited duration of membership.

Regarding team types, teams complete tasks in different fashions according to the way that specific tasks are assigned to members. For example, members may perform tasks differently from each other in a team; in contrast, all team members may have the same task in a team. Teams vary in structure, such as pyramid, flat, and dependent types. The difference is due to the heterogeneity of team members, team autonomy, staff hierarchies, and required
tasks (O’Neil et al., 1992). Salas et al. (1992) proposed the concept of a continuum for team types. Teams that are highly structured and interdependent fall at one extreme of the continuum. On the contrary, teams with little interaction and collaboration fall at the other.

**Teamwork model (Dickson & McIntyre, 1997)**

Considering the lack of devotion to the investigation of teamwork performance in previous studies, Dickson and McIntyre (1997) proposed a teamwork model to explain how input variables determinate team performance. The conceptual model consists of seven core components (as shown in Figure 6). Communication plays a key role in linking to other components of the model.

*Communication.* The major activities for communication include sharing information from an individual member or a subset of members to other members.

*Team orientation.* This component consists of: (1) team members’ attitudes toward others, team tasks, and team leadership; (2) team members’ self-awareness; and (3) group cohesiveness.

*Team leadership.* This component indicates the direction and structure for teamwork. Team leaders or other members provide the leadership that members respond to for specific behaviors or purposes.

*Monitoring team performance.* This component implies team members understand their own and others’ tasks by observing and being aware of the activities and performances of others.

*Feedback.* In this component, team members share feedback with others. The sharing of feedback enables each member to learn from the success of the team performance.
Backup behavior. This behavior means team members are willing to provide assistance to others to perform tasks.

Coordination. This component means that in team activities, “members respond as a function of the behavior of others” (Dickson & McIntyre, 1997, p. 22).

From the perspective of collective behavior, successful team performance should be based on the cohesion of team members rather than individually outstanding performance of tasks. In particular, when team tasks are highly complex and need a high level of organization, effective communication and coordination are very important (Salas et al., 1992).

![Teamwork model](image)

Figure 6. Teamwork model (Dickson & McIntyre, 1997)
**Teamwork behaviors (McIntyre & Salas, 1995)**

Through the study of a military team, McIntyre and Salas (1995) summarized nine principles for teamwork behaviors and characteristics. Those principles are related to specific behaviors. Principle 1 indicates that team members monitor others' performances by keeping track of others' work to ensure tasks are running as expected. Principle 2 indicates team members provide feedback to each other. In principle 3, teamwork needs effective communication among members. Principle 4 indicates teamwork needs willingness, preparedness, and proclivity among members when operating tasks. Principle 5 means team members view the team as a whole group, in which members collaboratively interact with each other. In principle 6, teamwork consists of interdependence among members. The interdependence includes team tasks that are mutually interdependent and team members possess the attitude of interdependence. In principle 7, teamwork includes a set of behavioral skills that alter flexibly according to circumstances. Principle 8 indicates teams change and develop over time for the necessity of maturity. Principle 9 suggests there is a difference between teamwork and taskwork. In contrast to teamwork, taskwork focuses on individual work performed autonomously rather than interdependently.

**Teamwork skill dimensions and behaviors**

Baker and Salas (1992) introduced relevant teamwork skills and their behaviors by summarizing studies of teamwork. Seven dimensions of teamwork skills are included, and behavioral examples for each dimension are expressed. In the dimension of giving suggestions or criticisms, members need to ask for the information for the purpose of clarification. The behavior of the dimension for cooperation reminds other members of what needs to be done next. The dimension of communication is the behavior to clarify unclear
communication by asking. The dimension of team spirit and morale is the behavior for discussing methods to improve team performance. The dimension of adaptability is the behavior that changes the way a task is implemented. The behavior of the dimension for coordination is giving members directions for the next step. The behavior of the dimension for acceptance of suggestions or criticism shows appreciation to another member who reminds the team of the mistake.

**Empirical teamwork skill studies**

Chung et al. (1999) conducted measurements of team processes and team outcomes using computer-based collaborative knowledge mapping. Team processes included adaptability, communication, coordination, decision making, interpersonal, and leadership. Although the results showed no significant relationship between most team processes and team outcomes, several valuable questions were raised in the study. For example, the knowledge mapping task of the study was more suitable for small groups rather than with a team. Although groups and teams share several behaviors, a distinction between the two terms exists. Groups may allow individuals to perform tasks, but a team focuses more on interdependent performance (O’Neil et al., 1992).

Brannick et al. (1993) applied the method of multitrait-multimethod analysis differently to measure team performance by evaluating 52, 2-person teams flying an aircraft simulation. Results of the study showed that communication among team members was highly associated with team performance. Moreover, in a higher-performance team, team members were more likely to be cooperative, including monitoring each other and providing assistance. These results are consistent with previous theoretical studies.
CHAPTER 3 METHODOLOGY

Introduction

The purpose of this descriptive study was to investigate the difference between students’ perception of actual and preferred learning in a constructivist learning environment and how both of the perceptions were associated with students’ self-directed learning readiness, problem-solving skills, and teamwork skills. Empirical studies of every single issue have been discussed in public, but the association among these factors remains of interest to researchers. A learner-centered teaching approach, which is the important element of constructivism, has been proposed in technical education, but how the actual practice differs from students’ learning perception in a technology-related context is unknown.

Another purpose of this study was to explore the relationship between student perception of constructivist learning environment, self-directed learning readiness, problem-solving skills, and teamwork skills.

This study included two parts of investigation. Quantitative analysis provided statistical information regarding the difference among the assumptions. Qualitative data collection gathered by student interview and instructor interview after the survey provided information to interpret the phenomenon, with the purpose of richer insight into the results of the study. As Fraser states “students are at a good vantage point to make judgments about the classroom because they have encountered many different learning environments and have enough time in a class to form accurate impressions” (1998, p. 8). The research methods used in this study aimed to provide contribution for learning environment investigation.

The methodology included the following sections: Procedures of the Study, Research Design, Methods of data collection, and Data Analysis.
Procedures of the Study

The procedures for this survey research included:

1. Review literature and formulate the problem of the study.

2. Design the survey instrument based on a process of: (1) developing constructs from relevant studies; (2) designing statements for each constructs from relevant literature and from existed studies; (3) asking permission to use questions from existing instruments.

3. Establish the content and face validity for the problem-solving portion of the instrument.

4. Obtain human subjects approval for both pilot tests and formal tests.

5. Administer a pilot test to students in the College of Engineering. Another pilot test for an instructor version of the instrument was administered to instructors in the College of Education and College of Engineering.

6. Compute the reliability from the results of the pilot tests.

7. Arrange the times for distributing the questionnaire.

8. Code the data.

9. Analyze the data by using Statistical Package for the Social Sciences (SPSS).

10. Interview students to obtain richer insight regarding different perceptions between students and instructors of a constructivist learning environment.

Research Design

Survey research with students and instructors was adopted in this study as the primary method for data collection. Subjects were asked to fill out a questionnaire. Student interview procedures were followed to gather qualitative data as a meaningful supplement for interpretation of the survey results.
Population and Sample for this Study

The participants for this study were all the registered undergraduate students and instructors teaching classes in the department of Industrial Education and Technology (ITEC) at Iowa State University in spring 2003. The number of students for each classification was 16 freshmen, 53 sophomores, 57 juniors, and 89 seniors. The total was 215. Twenty one instructors participated in this study.

Variables

Dependent Variables.

Self-directed learning readiness, problem-solving skills, and teamwork skills were three of the dependent variables in this study. These variables were measured by a questionnaire adopting statements from previous studies. Cumulative GPA was collected as another dependent variable.

Independent Variables

1. Student perceptions of actual and preferred constructivism learning environment (CLE) were the primary independent variables in this study.

2. Instructor perception of CLE was measured to compare with student perceptions of actual CLE.

3. ACT scores were collected as a covariate.

4. Demographic characteristics of the students, such as student classification, working experience, and age were analyzed in relation to the primary independent variable.

Qualitative Data Collection

The qualitative data collection was based primarily on a single one-on-one structured interview with selected students from each classification. Purposive sampling was
administrated to extend the information in depth. The objective of purposive sampling was to ensure that the data could provide richer information, as well as to find specific samples that match participants’ characteristics in the research (Mertler & Vannatta, 2000). Interview questions were developed primarily from students’ responses to survey items. The interview questions were taken from the CLE instrument, 2 to 3 items from each of the four scales.

**Instruments**

The study used two questionnaires, a student questionnaire (see Appendix B) and an instructor questionnaire (see Appendix A), to collect data. The student questionnaire included four sections: (1) perception of actual and preferred CLE; (2) self-directed learning readiness; (3) problem-solving skills; and (4) teamwork skills.

The instructor questionnaire only measured perception of CLE. The survey was modified from Taylor’s Constructivism Learning Environment Survey (CLES) (Taylor et al., 1997). Taylor referred to classes, whereas the new instrument referred to a program.

**Constructivist Learning Environment Survey**

Student perception of CLE was measured by the CLES designed by Taylor et al. (1997). The new version of CLES is comprised of five scales designed to measure to what extent students perceive learning in a constructivist approach in classrooms. The scales are personal relevance, uncertainty, critical voice, share control, and student negotiation. The reported Cronbach Alpha reliability coefficient for the CLES ranged from .79 to .98.

In this study, modified statements from the CLES survey were tested for reliability. Both students and instructors took the new test forms. The student version included actual perception and preferred perception. The instructor version included perceived environment only. Four scales were included in both student and instructor versions. The scales were
learning about technology, learning to speak out, learning to learn, and learning to communicate. Students and instructors were asked to select one response from a 5-point Likert-type range: 1 = Almost never, 2 = Seldom, 3 = Sometimes, 4 = Often, and 5 = Almost always.

**Self-Directed Learning Readiness**

Twenty statements that were developed from Fisher et al.'s study (2001) measured self-directed learning readiness. Fisher et al.'s study applied the Delphi technique by asking a panel of experts to reach consensus on pre-designed items developed from relevant literature on self-directed learning. Three factors were identified as self-management, desire for learning, and characteristics of self-control. Cronbach’s Alpha coefficient was reported to be .92 for the total item reliability.

**Problem Solving Skills**

Twenty statements representing problem solving skills were developed by the researcher from relevant studies of problem solving. The questions used to develop the scale included the aspects of: (1) identifying problems, (2) generating and choosing solutions, (3) planning and implementing the solutions, and (4) monitoring the solutions to see if students accomplish their goals.

**Teamwork Skills**

Thirteen statements representing teamwork questionnaires used in O’Neil’s study (1998) on measurement of teamwork skills. The teamwork skills include six dimensions: (1) adaptability, (2) co-ordination, (3) decision making, (4) interpersonal, (5) leadership, and (6) communication. The reported reliability coefficient for the teamwork skill questionnaire was .82.
In self-directed learning readiness, problem solving skills, and teamwork skills, students were asked to respond to a 5-point Likert-type range including following response options: 1 = Almost never, 2 = Seldom, 3 = Sometimes, 4 = Often, and 5 = Almost always.

Pilot Test

Since the instrument applied to test instructors’ perception on constructivism was modified, as well as a questionnaire designed to test students’ self-directed learning readiness and problem solving, it was necessary to conduct a pilot test for reliability of both questionnaires. A panel of five faculty members from the College of Engineering and the College of Education participated in establishing content and face validity for the questionnaires. The items for the instructor survey were pilot-tested with a group of instructors teaching in Engineering and Education. Cronbach alpha was calculated to assess the reliability of the four scales. The Cronbach alpha reliability coefficients for the pilot test were .65 for the learning about technology scale, .83 for the learning to speak out scale, .90 for the learning to learn scale, and .81 for the learning to communicate scale (as shown in Table 2).

For the student survey, the questionnaire was pilot-tested with a group of students in the Department of Industrial and Manufacturing Systems Engineering and a group of students in the Department of Computer Science. Reliabilities of the scales for the student version instrument is displayed in Table 3. The Cronbach alpha reliability coefficients for the pilot test were (1) .70 for the learning about technology scale, .85 for the learning to speak out scale, .91 for the learning to learn, and .92 for the learning to communicate scale in the section of student perception of actual CLE, (2) .67 for the learning about technology scale, .83 for the learning to speak out scale, .92 for the learning to learn, and .92 for the
learning to communicate scale in the section of student perception of preferred CLE, (3) .84 for the self-directed learning readiness scale, (4) .86 for the problem-solving skill scale, and (5) .89 for the teamwork skill scale.

Table 2. Reliability coefficients for instructor version instrument

<table>
<thead>
<tr>
<th>Scales</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning about technology</td>
<td>.65</td>
</tr>
<tr>
<td>Learning to speak out</td>
<td>.83</td>
</tr>
<tr>
<td>Learning to learn</td>
<td>.90</td>
</tr>
<tr>
<td>Learning to communicate</td>
<td>.81</td>
</tr>
</tbody>
</table>

n = 20

Table 3. Reliability Coefficients for student version instrument

<table>
<thead>
<tr>
<th>Scales</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perception of actual CLE</td>
<td></td>
</tr>
<tr>
<td>Learning about technology</td>
<td>.70</td>
</tr>
<tr>
<td>Learning to speak out</td>
<td>.85</td>
</tr>
<tr>
<td>Learning to learn</td>
<td>.91</td>
</tr>
<tr>
<td>Learning to communicate</td>
<td>.92</td>
</tr>
</tbody>
</table>

| Perception of preferred CLE    |             |
| Learning about technology      | .67         |
| Learning to speak out          | .83         |
| Learning to learn              | .92         |
| Learning to communicate        | .92         |
| Self-directed learning readiness| .84         |
| Problem solving skill          | .86         |
| Teamwork skill                 | .89         |

n = 36
Statistical Hypotheses

Comparisons of student perceptions of CLE

There is no significant mean difference between student perception of actual and preferred CLE.

\[ H_0: \mu_{\text{actual}} = \mu_{\text{preferred}} \]
\[ H_1: \mu_{\text{actual}} \neq \mu_{\text{preferred}} \]

Comparisons of student perceptions of CLE and instructor perceptions of CLE

There is no significant mean difference between student perceptions of actual CLE and instructor perceptions of CLE.

\[ H_0: \mu_{\text{student}} = \mu_{\text{instructor}} \]
\[ H_1: \mu_{\text{student}} \neq \mu_{\text{instructor}} \]

Testing the interaction on CLE between perception level and student classification

The relationship between perception of constructivism learning environment and student classification will not differ for actual and preferred perception.

\[ H_0: \mu_{\text{actual C}} = \mu_{\text{preferred C}} \quad C = \text{levels of student classification} \]
\[ H_1: \mu_{\text{actual C}} \neq \mu_{\text{preferred C}} \]

On the combination of variables

1. There are no significant mean differences in the variable (as measured by the combination of accumulative GPA, self-directed learning readiness, problem-solving
skill, and teamwork skills) for different levels of student perceptions of actual CLE among students, after controlling the effect of ACT.

2. There are no significant mean differences in the variable (as measured by the combination of accumulative GPA, self-directed learning readiness, problem-solving skill, and teamwork skills) for different levels of student classification among students, after controlling the effect of ACT scores.

\[ H_0: \mu_{\text{Freshman}} = \mu_{\text{Sophomore}} = \mu_{\text{Junior}} = \mu_{\text{Senior}} \]

\[ H_1: \text{At least one mean comparison was not equal} \]

3. There was no significant interaction between student perceptions of CLE and student classification on the variable (as measured by the combination of accumulative GPA, self-directed learning readiness, problem solving skill, and teamwork skills).

The significance level for testing hypotheses was set at 0.05

**Data Analysis Method**

**Data Screening**

Data screening for missing data was done prior to conducting the data analysis. Missing data were treated by mean substitution within the case. If missing data occurred in more than three items, List wise deletion was used in which the entire case was dropped (Schwab, 1999).

**Data Analysis**

Data analysis consisted of six parts:

1. The description of demographic characteristics.
2. Comparisons of perception of CLE between instructors and students and among students.
3. Estimation of relationships between demographic characteristics, student perceptions of constructivist learning environment, self-directed learning readiness, problem-solving skills, teamwork skills, and cumulative GPA.

4. One-way ANOVA for testing hypotheses on:
   (1) The difference between students' actual perception of CLE and preferred CLE.
   (2) The difference between students' actual perception of CLE and instructors’ perception of CLE.

5. A two-way MANCOVA was conducted to test hypotheses to determine if all levels of students' perception of CLE are equal on the combination of self-directed learning readiness, problem-solving skills, and teamwork skills.

6. An over-identified (too many parameters) structural equation model (as shown in Figure 7) was estimated to investigate if there were causal relationships between four scales of student perceptions of CLE, self-directed learning readiness, problem-solving skill, teamwork skill, and cumulative GPA. The paths of the model were used to express the strengths of the relationship between research variables. In this proposed model, student classification was treated as a main effect. Intervening variables included learning about technology, learning to speak out, learning to learn, and learning to communicate. Problem-solving skills, teamwork skills, self-directed learning readiness, and cumulative GPA were treated as endogenous variables. The Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), and Normed Fit Index (NFI), all with cutoff values close to .95 were employed as fit indices to evaluate model fit (Hu & Bentler, 1999).
Figure 7. Over-identified Student Learning Environment Model
CHAPTER 4 DATA ANALYSIS AND FINDINGS

The problem of this study was (1). to describe and compare the difference between student perceptions of constructivist learning environment (CLE) and instructor perception of CLE; and (2). to investigate the relationship between (a) student perception of actual CLE, (b) self-directed learning readiness, (c) problem-solving skills, and (d) teamwork skills.

Two hundred fifteen undergraduate students registered in the Department of Industrial Education and Technology at Iowa State University in spring 2003. A survey was used to collect quantitative data and 11 student interviews were conducted to collect qualitative data.

Twenty one instructors in the Department of Industrial Education and Technology at Iowa State University in spring 2003 participated.

The results were presented under the following sections: (1) description of demographic characteristics, (2) comparison of the constructivist learning environment between instructors and students and also among students, (3) qualitative data results of student interview regarding their perceptions of CLE, (4) the relationships between demographics, student perceptions of actual CLE, and dependent variables, (5) comparison between actual perception of CLE and combination of dependent variables, and (6) the results of structural equation modeling.

Description of Demographic Characteristics

A sample total of 152 (70.7%) of ITEC undergraduate students and 21 instructors including 14 Teaching Assistants (TA) and 7 faculty responded the survey. Table 4 summarizes frequencies and percentages of students’ demographic data. Student responses
included 63 seniors (41.4%), 43 juniors (28.3%), 34 (22.4%) sophomores, and 12 freshmen (7.9%). More than half (62.5%) of respondents' age ranged from 21-25 years old. The average age of respondents was 22 years. On average, the respondents had 4.13 years of work experience. Students having work experience from three to six years had the highest percentage of 29.6%. More than two-thirds (69.7%) of students had cumulative GPA ranging from 2.00-3.00. The average cumulative GPA was 2.57.

Table 4. Demographic Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>Freshman</td>
<td>12</td>
<td>7.9</td>
</tr>
<tr>
<td></td>
<td>Sophomore</td>
<td>34</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>Junior</td>
<td>43</td>
<td>28.3</td>
</tr>
<tr>
<td></td>
<td>Senior</td>
<td>63</td>
<td>41.4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>152</td>
<td>100</td>
</tr>
<tr>
<td>Age</td>
<td>18-20</td>
<td>46</td>
<td>30.3</td>
</tr>
<tr>
<td></td>
<td>21-25</td>
<td>95</td>
<td>62.5</td>
</tr>
<tr>
<td></td>
<td>26-30</td>
<td>6</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>31-35</td>
<td>3</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>36 and above</td>
<td>2</td>
<td>1.3</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Work Experience</td>
<td>None</td>
<td>25</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>Some but less than 3 years</td>
<td>37</td>
<td>24.3</td>
</tr>
<tr>
<td></td>
<td>3 - less than 6 years</td>
<td>45</td>
<td>29.6</td>
</tr>
<tr>
<td></td>
<td>6 - less than 9 years</td>
<td>34</td>
<td>22.4</td>
</tr>
<tr>
<td></td>
<td>More than 9 years</td>
<td>11</td>
<td>7.2</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>4.13 years</td>
<td></td>
</tr>
<tr>
<td>Accumulative GPA</td>
<td>Less than 2</td>
<td>15</td>
<td>9.9</td>
</tr>
<tr>
<td></td>
<td>2.00 – 2.50</td>
<td>61</td>
<td>40.1</td>
</tr>
<tr>
<td></td>
<td>2.51 – 3.00</td>
<td>45</td>
<td>29.6</td>
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<td></td>
<td>3.01 – 3.50</td>
<td>22</td>
<td>14.5</td>
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<td></td>
<td>3.51 – 4.00</td>
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<td>5.9</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>2.57</td>
<td></td>
</tr>
</tbody>
</table>
Comparison between instructor and student perceptions of actual CLE

The perception of Constructivist Learning Environment (CLE) instrument included four scales: (1) learning about technology, (2) learning to speak out, (3) learning to learn, and (4) learning to communicate.

The learning about technology scale was concerned with the degree that subjects perceived about social factors, human values, and cultures were involved in technology. The learning to speak out scale was concerned with the degree to which subjects perceived how students voiced their learning needs and expectation of learning activities. The learning to learn scale regarded the degree that subjects perceived how students shared with instructors in the determination of their learning path, their educational plan, content, and student learning evaluation. The learning to communicate scale regarded the degree to which subjects perceived the level at which students were provided an environment to share, clarify, and justify ideas with others.

Overall, the mean score for instructors’ (3.89) perception that the ITEC program made use of constructivist learning environments was higher than students’ mean score for perception of actual CLE. For the individual scale, as shown in Table 5, the mean scores revealed that instructors’ average perception of CLE fell between “sometimes (3)” and “often (4)” on the scale of learning about technology and on the scale of learning to learn. On the scale of learning to speak out and the scale of learning to communicate, most instructors answered between “often” and “almost always.” The instructors’ mean score was lower than students’ mean score on the scale of learning about technology.
Results of Independent-sample t-test revealed that disparities existed between instructor perceptions and student perceptions. There were statistically significant differences in overall comparison of actual perception of CLE (p-value .034), the individual scale of learning about technology (p-value .019), learning to speak out (p-value <.001), and learning to learn (p-value .001) but no significant difference for the scale of learning to communicate. Figure 8 showed a visual display of the mean difference between students and instructors on each scale. Students responded with a higher mean perception of learning about technology than did instructors. However, students perceived less constructivist impact on the learning to speak out and the learning to learn scales than instructors perceived.

![Bar graph showing comparison of mean perception of CLE between students and instructors.](image)

**Figure 8.** Comparison of actual perception of CLE between students and instructors.
Table 5 Comparison between student actual perception of CLE and instructor perception of CLE

<table>
<thead>
<tr>
<th>Scale</th>
<th>No of questions</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Student n = 152</td>
<td>Instructor n = 21</td>
<td>Student n = 152</td>
</tr>
<tr>
<td>Learning about Technology</td>
<td>6</td>
<td>3.77</td>
<td>3.43</td>
<td>0.59</td>
</tr>
<tr>
<td>Learning to Speak Out</td>
<td>6</td>
<td>4.04</td>
<td>4.66</td>
<td>0.73</td>
</tr>
<tr>
<td>Learning to Learn</td>
<td>6</td>
<td>2.62</td>
<td>3.15</td>
<td>0.87</td>
</tr>
<tr>
<td>Learning to Communicate</td>
<td>6</td>
<td>4.17</td>
<td>4.31</td>
<td>0.74</td>
</tr>
<tr>
<td>Total Mean</td>
<td>24</td>
<td>3.65</td>
<td>3.89</td>
<td>0.53</td>
</tr>
</tbody>
</table>

*p<0.05

Comparison between student perception of actual CLE and preferred CLE

Obviously, students responded with higher preference for emphasizing a constructivist learning environment in the ITEC program. Overall, the mean score of student perception of preferred CLE was higher than the mean score for student perception of actual CLE. The overall mean difference was 0.41. Moreover, each scale in student perception of preferred CLE had higher mean scores than each scale in student perception of actual CLE. The greatest difference between all the actual and preferred perception scales was the perception of “learning to learn” (mean difference = 0.97). The next mean difference was for the perception of “learning to speak out” (mean difference = 0.27). The two lowest mean differences were for the “learning about technology” scale (mean difference = 0.21) and “learning to communicate” (mean difference = 0.14) (See Figure 9).
A paired-samples $t$-test was conducted to investigate whether students had higher preference of CLE than their actual perception on CLE. The result indicated that the mean score of student perception of preferred CLE was significantly higher than the mean score of student perception of actual CLE ($t = -10.45$, $p < .001$). The results of paired-sample $t$-test for four scale mean differences revealed statistically significant differences as well. In the scale of learning about technology, students showed highly significant preference on constructivism than their perception on actual constructivism ($t = -5.08$, $p < .001$). Similarly, students responded that their preferred learning environment was more constructivism than the actual perception when learning to speak out ($t = -5.27$, $p < .001$), to learn ($t = -12.39$, $p < .001$), and to communicate ($t = -4.61$, $p < .001$) (See Table 6).

![Figure 9](image)

scale 1 = learning about technology, scale 2 = learning to speak out, scale 3 = learning to learn, scale 4 = learning to communicate

Figure 9. Paired-sample $t$-test on student perception of actual CLE and preferred CLE
Table 6  Paired-Sample t-test on student perception of actual CLE and preferred CLE 
\( (n = 152) \)

<table>
<thead>
<tr>
<th>Scale</th>
<th>No of questions</th>
<th>Mean Actual</th>
<th>Mean Preferred</th>
<th>Standard Deviation Actual</th>
<th>Standard Deviation Preferred</th>
<th>P value</th>
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<tr>
<td>Learning about Technology</td>
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<td>0.60</td>
<td>&lt;.001*</td>
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<td>4.31</td>
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<td>0.67</td>
<td>&lt;.001*</td>
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<td>Learning to learn</td>
<td>6</td>
<td>2.62</td>
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<td>0.88</td>
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<td>Learning to communicate</td>
<td>6</td>
<td>4.17</td>
<td>4.31</td>
<td>0.74</td>
<td>0.62</td>
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<tr>
<td>Total Mean</td>
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<td>3.65</td>
<td>4.06</td>
<td>0.53</td>
<td>0.49</td>
<td>&lt;.001*</td>
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</tbody>
</table>

*\( p<0.05 \)

**Comparison of CLE among groups**

Several one-way analyses of variance were conducted to evaluate the relationship between students’ actual perception of CLE and their demographic characteristics, as well as between students’ preferred perception of CLE and their demographic characteristics.

*Classification.* Classification, one of the independent variables, included four levels: freshman, sophomore, junior, and senior. There were statistically significant differences among these four levels on the scale of learning to communicate for both actual and preferred perceptions. The ANOVA was significant, \( F(3, 148) = 3.76, p=.012 \) for perception of actual CLE on the scale of learning to communicate and was significant \( F(3, 148) = 3.91, p=.010 \) for perception of preferred CLE on the scale of learning to communicate. Least significant difference tests (LSD) were conducted as post hoc comparisons to evaluate pairwise differences among the levels. The result of the multiple comparisons, as shown in Table 7, indicated that juniors actually perceived a greater amount of constructivism in their ITEC
program on the scale of learning to communicate than did freshman and sophomores. On the perception of preferred CLE scale, as shown in Table 7, the result of the multiple comparisons indicated that seniors preferred a greater emphasis of constructivism in the ITEC program on learning to communicate than freshmen and sophomores.

**Age group.** This variable included 5 levels: 18-20 years, 21-25 years, 26-30 years, 31-35 years, and 36 and above. There was statistically significant difference among these five age levels on the scale of learning to communicate for perception of actual CLE, as well as on both scales of learning about technology and learning to communicate for perception of preferred CLE. The ANOVA was significant, $F(4, 147) = 4.29, p = .003$ for perception of actual CLE on the scale of learning to communicate, significant $F(4, 147) = 2.66, p = .035$ for perception of preferred CLE on the scale of learning about technology, and significant $F(4, 147) = 4.45, p = .002$ for perception of preferred CLE on the scale of learning to communicate.

### Table 7  LSD test for CLE on learning to communicate by classification

<table>
<thead>
<tr>
<th>Levels</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
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<tr>
<td>Actual Means</td>
<td>3.93</td>
<td>3.91</td>
<td>4.43</td>
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<tr>
<td>Preferred Means</td>
<td>4.04</td>
<td>4.17</td>
<td>4.40</td>
<td>4.53</td>
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</table>

A follow up test by using LSD evaluated pairwise differences among the levels. For perception of actual CLE on the scale of learning to communicate, there were significant differences in the means between the group of 18-20 year-olds and both of the groups of 21-25 year-olds and 31-35 year-olds; between the group of 21-25 year-olds and the group of 31-35 year-olds. The result of the multiple comparisons is in Table 8. This table indicates that
students in the age group of 31-35 years perceived that the ITEC program application of constructivism was higher on the learning to communicate scale than student perceptions in the age of 18-20 years and in the age of 21-25 years. The group in the age of 21-25 years perceived a greater application of constructivism in the ITEC program as shown by the mean score on learning to communicate than students in the age of 18-20 years. On the perception of preferred CLE scale, there were significant differences in the means between the group of 21-25 year-olds and both groups of 18-20 year-olds and 31-35 year-olds on the scale of learning about technology. As shown in Table 8, the result of the multiple comparisons indicates that students in the age of 21-25 years had a higher preference that the ITEC program should emphasize constructivist practices when learning about technology than the group in the age of 18-20 years and the group in the age of 31-35 years. There were also significant differences in the means between the group of 18-20 year-olds and the group of 21-25 year-olds on the scale of learning to communicate. The results for the multiple comparison indicated that students in the age group of 21-25 years preferred a greater emphasis on constructivism in the ITEC program when learning to communicate than the age group of 18-20 years.

Table 8  LSD test for CLE on by age group

<table>
<thead>
<tr>
<th>Levels</th>
<th>18-20</th>
<th>21-25</th>
<th>26-30</th>
<th>31-35</th>
<th>36 and above</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual (Learning to Communicate) Means</td>
<td>3.96</td>
<td>4.32</td>
<td>3.92</td>
<td>3.06</td>
<td>4.58</td>
</tr>
<tr>
<td>Preferred (Learning about Technology) Means</td>
<td>3.83</td>
<td>4.05</td>
<td>4.14</td>
<td>3.33</td>
<td>4.58</td>
</tr>
<tr>
<td>Preferred (Learning to Communicate) Means</td>
<td>4.12</td>
<td>4.53</td>
<td>4.06</td>
<td>4.06</td>
<td>4.58</td>
</tr>
</tbody>
</table>
Qualitative Data Results of Student Interview Regarding Their Perceptions of CLE

Eleven students were selected for interview to obtain insight that was not revealed through the survey regarding how students perceived the actual teaching and learning phenomena in ITEC department and their preference for a learning environment. Several interview questions were developed by the researcher based on the questions that were asked in the survey. This section included Learning about Technology, Learning to Speak Out, Learning to Learn, and Learning to Communicate.

Learning about Technology

Basically, the ITEC program provided students with many opportunities for hands-on activities so that students learned technology regarding what it was and how it could be applied. By doing, students were “trying to figure out what you’re doing instead of just talking and saying what you think is going to happen” (Student c1-JN). That was the way students viewed the value of learning technology. Students were aware there existed a culture of learning in ITEC and it was not necessary to make a change from that because they were satisfied with this culture of learning in this department. They preferred to keep the current methods because they were actually learning the skills, the technology, and the knowledge that were taught in Industrial Education and Technology.

On the other hand, for technology itself, definitely, students were aware of tremendous amounts of change between previous and recent technology. Students expected change and were able to follow the track of the technology development in industry. Besides, they liked to learn about other cultures and all the other technology that enabled them to be diverse for advance study or for preparing well when working in industry.
Learning to Speak Out

In general, ITEC students felt comfortable asking why they need to learn the information that instructors arranged for the class. Students asked quite often, why do we need to learn theory? Moreover, students did not have a problem in receiving responses from instructors. A student, when describing instructors’ reaction to student questions said “they always have the time for me to sit down and talk to them” (Student c3-AS). Interestingly, students comparing ITEC classes with the classes in Engineering stated that learning in ITEC classes were less rigid in structure because they were free to ask questions and usually can get answers from instructors.

However, students received instructors’ response regarding why they should learn did not mean the learning situation would be changed to constructivist practices. Some possible reasons that instructors tended not to change when students questioned the ways or activities they were assigned included individual personality and/or individual teaching style. Personality and teaching style may be related. One reason for not changing when students ask questions regarding the way they are taught is because some instructors keep an existing teaching pattern with which they were familiar. For example a student stated “if their curriculum is set up it seems like … this is what they’re doing and this is the way we’ve done it in the past, this is the way the class was before, so this is the way we’re going to do it” (Student c2-JH). Other students responded similarly. For example, “they’re just going to do what they’re going to do and that’s going to be the end of it and if you ask them about it, they’re just like well that’s just the way it is” (Student c3-AW). Students preferred that more constructivist instructional practice be implemented than what they perceive to be actually
occurring in class. When students have learning needs, while studying in Industrial Education and Technology, they feel free to express these concerns.

**Learning to Learn**

*Question content and lesson plan.* Student perceptions obtained from the data show that actual constructivist practices being used were less than constructivist practice on the scale for learning to speak out, learning to communicate, and learning about technology. The summary of the interviews were positively correlated with these results. Students perceived that instructors had more knowledge to decide what, how much, and the way that students should learn. Students’ reaction about questioning the curriculum content and about what and how students should learn were similar, such as “question contents? Not as much as I should ... I’m only twenty years old and I’ve done a few internships so, depending on the professor’s knowledge” (Students c2-JH). “I don’t think it’s my place to judge what they’re teaching” (Student c1-JN). “But question, like content, I’ve never” (Student c3-AW). Students perceived they were able to question a lesson plan, but they observed that questioning did not lead to change. They perceived that there was a standard or some sort of routine set by the department and instructors should follow the standard. Changing the standard was beyond students’ perception. Furthermore, they agreed that individual opinions were different on this subject. The fact that some students felt a certain way about teaching did not mean the whole class had a consensus about the idea.

It was obvious to the researcher that students preferred their instructors to prepare well their instruction including a concrete plan to guide students to build up their knowledge. A student described a basic template; what was to be covered, what students should learn and how students would be evaluated. Students preferred to learn on their own path for
constructing knowledge although they expected that instructors had a plan in advance and that there was a standard for instructors to follow for the design of lesson plans. “Probably ... so that if the student is having problems or if their curriculum is too fast, too slow, too complicated ... so that they kind of tailor it to the students in that class” (Student c2-JH). Students expected instructors or other students to bring more industrial experience into the classes so that they can learn from authentic cases.

Students perceived that lesson content was adjustable. In general, instructors had concern if the class was not progressing along on the same timeline that the instructor had planned. Most students were willing to wait if specific content needed to be clarified for an individual, but it was not necessary to hold the entire class back for a certain few students. The responsibility for the few students should be theirs, for those who did not understand the content to find other solutions, such as asking the instructor outside of class or asking peers for help.

Question TA or faculty. Students thought instructors were supposed to know more than students about the topics that were to be taught. The reason was just “they know what’s right because they are the professor, ... that’s the reason they’re a professor” (Student c2-MH). When expecting the need for change, students perceived that professors who taught the course for a long time were more flexible to change their lesson plans based on student reactions.

However, comparing faculty with the TA, students tended to question the TA more than they question faculty members. One reason might be position-oriented. Students thought TAs were students who had their own classes to study for and usually had studied for only two or three years in the program. In contrast, the faculty went through a lot before being
hired for the position. The faculty were responsible, knowledgeable, and more flexible, and therefore able to change lesson plans. The other reason was usually TAs had not independently developed their own lesson plan. Instead, they had to follow the existing lesson plan of a previous instructor or the professor responsible for the class to which they were assigned. Within this learning context, students, and even TAs had to go step by step through the lesson rather than being independent and creative.

Lecture and Lab. The interviews reflected an overwhelming response about what students learned in lecture and in lab. Everyone said they did well and learned more in lab and they liked lab more than lecture. "The lab ... it's all fairly intuitive, it makes sense, so you don't really have to memorize anything going into it. Once you get there, you figure out how things work and what it is you're doing" (Student c1-JN). This indication reflected that students were more interested in authentic learning activities in which their learning was by doing, by interacting with others, and by testing their thinking.

In contrast, most of students indicated that many lectures in the ITEC program were monotonous and boring. In the monotonous lecture, students did not perceive strong interaction between instructors and students. In general, many instructors lectured. In that method, the instructors are the focus of the class and just stood up in front of the class and went through everything that students already read from textbooks or handouts. In this type of lecture, students did not perceive any involvement in learning. Students expected the instructors to structure their classes by incorporating more discussion into the lecture and thereby enabling students to learn more. Instructors should initiate discussion by asking questions.
There were some lectures conducted in a different way in which students perceived active learning and were more interested. “I think the best way to teach students is by having a lab and a lecture. Because then you get your visual and audio learning in the lecture and then you get your hands-on learning in the lab ….. I like the way that they have lecture and lab together” (Student c3-AS).

Student evaluation. The ITEC program is basically examination-oriented. “There is always an exam” (Student c4-JM) as the basic way to evaluate students. Students cared a lot about grades as well. Although students perceived that skills, including technical and interaction skills, were the important things to learn, they cared more about the grade that was received from tests and assignments. They agreed that tests were only related to memory and not much about real learning. They could only remember a small percentage or even forgot everything several months or years later.

Students expected instructors to find a way to evaluate what students really know and a fair way to judge how well students learned. It could be essay, or reports for lab. Students felt they really learned from that process when they had to organize some thoughts from a study. For example, one student stated “I did an extra credit lab where I had to write six pages. I had to do all that research and then I actually had to form sentences and paragraphs in the paper. Well, I still, to this day, remember what was on that paper because I spent that much more time, but I studied for that thing instead of for a test where I just kind of overviewed everything” (Student, c2-JH). Although grades were the focus that students brought to the class, ideally, students cared about other results that were important for students to learn, particularly applying knowledge and constructing concepts. “How you can apply on your knowledge that you’ve learned into the setting of the test …. not on how much
that he can read and how much he could remember. But, on the fact that if he can know a concept and be able to use that concept” (Student c3-ES). Students expected themselves actually to learn something and be evaluated fairly because, “A person can be book smart, but not have any common sense. . .. They know how to memorize and calculate, but they can’t put it together” (Student c1-JN).

Learning to Communicate

In the ITEC program, students received a lot of opportunities to express their ideas to others, ask questions to obtain solution for problems, and receive more information or feedback from others, or even obtain friendship by participating in group activities. The result from the quantitative data analysis revealed there was no significant difference on communication between instructor perceptions and student actual perceptions, or between student perceptions of actual and preferred CLE. Generally, statements that students made during the interviews were consistent with the quantitative results. The ITEC program provided many group-work experiences in classes and out of class.

The comparison of student communication that happened in different types of class activities found that lectures provided fewer opportunities for students to share ideas than labs or team projects. “Not so much that the teacher will allow us to talk about it during class, but they’ll mention it” (Student c2-JH). Instead, ITEC had a lot of group projects so students “can get other feedback from students, on their knowledge and also your knowledge. So you share knowledge and you just learn a lot more. . ..And the group projects are really good because in your career you’ll be working with a lot of people, you just won’t be by yourself working on one project” (Student c1-AR).
Students did not always learn about others' ideas from group work, although students generally cared about each others' learning in the class. A negative aspect regarding student participation of group work was the phenomena of uneven workload among team members. Students who had more workload felt it unfair to be graded for the result of group learning because some member provided less contribution to the group work. For example, some students worked with other "lazy" (Student c3-ES) members and they did not feel comfortable receiving the grade based on the work of others. The students who had more workload strongly claimed that everyone needed to take the responsibility for both individual and group learning.

The Relationships between Demographics, Student Perception of Actual CLE, and Dependent Variables

Pearson correlations were calculated to evaluate the associations between demographics, student perception of actual CLE, self-directed learning readiness, problem-solving skills, teamwork skills, and cumulative GPA.

The Relationships between Demographics and Student Perception of Actual CLE

Among demographics, only classification was significantly associated with the overall perception of actual CLE but not with the individual scales. None of the other demographics had significant association with the perception of actual CLE on overall and individual scale (see Table 9).
The Relationships between Demographics, Self-Directed Learning Readiness, Problem Solving Skills, Teamwork Skills, and GPA

As showed in Table 9, there were some significant relationships between demographics and the dependent variables. Results showed that students in higher levels were more likely to have higher GPA \((r = .34)\) and older students tended to have higher GPA \((r = .28)\) as well. Except for a moderately negative association \((r = -.19)\) between ACT scores and teamwork skills, there was no significant association between any of demographics and self-directed learning readiness, problem-solving skills, or teamwork skills.

Relationships between Student Perception of Actual CLE, Self-Directed Learning Readiness, Problem Solving Skills, Teamwork Skills, and GPA

As shown in Table 9, student perception of actual CLE was significantly correlated with self-directed learning readiness, problem-solving skills, and teamwork skills. Most of the Pearson correlations coefficients between these variable were above .30. The correlations of GPA with other variables were lower and were not significant. The results revealed that students who perceived more actual constructivist techniques in their learning environment also tended to express themselves better, be more self-directed in learning and have better problem solving skills, and have better teamwork skills than their peers who didn’t recognize constructivism in their environment.
Table 9 Intercorrelation between demographics, student perception of CLE, self-directed learning readiness, problem-solving skills, teamwork skills, and GPA

<table>
<thead>
<tr>
<th>Classification</th>
<th>ACT</th>
<th>Age</th>
<th>Work experience</th>
<th>AC1</th>
<th>AC2</th>
<th>AC3</th>
<th>AC4</th>
<th>Actual Perception</th>
<th>SD</th>
<th>PS</th>
<th>Teamwork</th>
<th>GPA</th>
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<td>.00</td>
<td>.07</td>
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<td>.09</td>
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</tbody>
</table>

*p < .05  (n = 152)

Classification: 1 = freshman 2 = sophomore 3 = junior 4 = senior
AC1 = Learning about Technology
AC2 = Learning to Speak Out
AC3 = Learning to Learn
AC4 = Learning to Communicate
SD = Self-Directed Learning Readiness
PS = Problem Solving Skill
Comparisons between the Perceptions of Actual CLE and the Combinations of Dependent Variables

One of the purposes of this study was to investigate the relationship between student perceptions of actual CLE and dependent variables, including self-directed learning readiness, problem-solving skills, teamwork skills, and cumulative GPA. The study treated these dependent variables in combination with hope that a more holistic perspective of the description could be obtained.

According to the results of Pearson correlations, as shown in Table 9, classification and ACT scores were associated with some dependent variables. MANCOVA was conducted to investigate the effect of classification and students’ perception of actual CLE on students’ performance measured by the four dependent variables combined when controlling for ACT scores. Classification was treated as a categorical variable. The mean score of student perception of actual CLE was divided into three categories: the group of low mean score was below 3.5, the group of medium mean score was from 3.5 to 4.14, and the group of high mean score was 4.15 and above.

The result of Box’s test for homogeneity of the variance-covariance matrix, \( F(90,3048) = 1.21, p = .092 \), indicated that Wilks’ Lambda will be used for the multivariate tests. The main effect of perception of actual CLE (Wilks’ \( A = .736, F(8, 274) = 5.683, p < .001 \), multivariate \( \eta^2 = .142 \)) but classification did not indicate a significant effect on the combined dependent variables. The covariate significantly effected the combined dependent variable (Wilks’ \( A = .922, F(4, 137) = 2.892, p = .025 \), multivariate \( \eta^2 = .078 \)). Univariate ANOVA results revealed the following results:
Effects on classification. Classification had a significant effect on only the dependent variable of GPA ($F(3, 140) = 4.568, p = .004$), partial $\eta^2 = .089$).

Effects on actual perception of CLE. The actual perception of CLE affected the dependent variables of self-directed learning readiness ($F(2, 140) = 10.475, p < .001$), partial $\eta^2 = .130$), problem solving skills ($F(2, 140) = 14.370, p < .001$), partial $\eta^2 = .170$), and teamwork skills ($F(2, 140) = 15.359, p < .001$), partial $\eta^2 = .180$). GPA was not significantly related to the perception of actual CLE.

Effects of the covariate of ACT scores. Only the dependent variable of teamwork skills was related to the covariate of ACT scores ($F(1, 140) = 8.373, p = .004$), partial $\eta^2 = .056$).

Table 10 shows the group means for the dependent variables by classification and the perception of actual CLE. Comparison of group means for perception of actual CLE revealed that students who perceived higher CLE had higher GPA and tended to evaluate themselves as more self-directed in learning, as well as having higher problem-solving skills and teamwork skills. Comparison of group means for classification revealed that students with a higher level of classification had higher GPA as well. However, students with a higher level of classification did not evaluate themselves as having higher self-directed learning readiness, problem-solving skills, and teamwork skills than freshman or sophomore. For example, sophomores had the highest group mean in self-directed learning readiness, but had the lowest group mean in problem-solving skills.
Table 10  Means for Actual Perception Group

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>SD</th>
<th>PS</th>
<th>TW</th>
<th>GPA</th>
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<tbody>
<tr>
<td>Actual Perception of CLE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.83</td>
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<tr>
<td>Medium</td>
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<tr>
<td>High</td>
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<td>Classification</td>
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<tr>
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<td>3.94</td>
<td>4.01</td>
<td>4.20</td>
<td>2.15</td>
</tr>
<tr>
<td>Sophomore</td>
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<td>4.00</td>
<td>4.21</td>
<td>2.39</td>
</tr>
<tr>
<td>Junior</td>
<td>4.05</td>
<td>4.06</td>
<td>4.22</td>
<td>2.51</td>
</tr>
<tr>
<td>Senior</td>
<td>4.04</td>
<td>4.03</td>
<td>4.20</td>
<td>2.79</td>
</tr>
</tbody>
</table>

Note: SD = self-directed learning readiness
PS = problem-solving skill
TW = teamwork skill
GPA = grade point average

The Result of Structural Equation Modeling

A structural equation model (SEM) was prepared without the latent variables for this study. The SEM analysis was conducted by using the Analysis of Moment Structures (AMOS) software. The maximum likelihood method of parameter estimation was employed to determine model-to-data fit. The result of SEM for the initial model (as shown in Figure 7, page 62) failed to provide a good fit for the data set. According to the results of the Pearson correlation and the MANCOVA test, classification was removed from the hypothetical model because of the lack of association with endogenous variables. Student perception of actual CLE was treated as an exogenous variable instead of using four separate scales for this
variable since they were highly correlated with each other. The modified model was conducted controlling for ACT scores as a covariate.

Although the chi-square value \( \chi^2 = 138.17, p < .001 \) testing the fit of the model was significant, the other fit indexes were satisfactory, with values of NFI = .96, TLI = .92, CFI = .97. Most paths were significant as shown by a critical ratio of more than 2.0. Student perception of actual CLE had a significant impact on self-directed learning readiness (path coefficient = .29), moderately influence on problem-solving skills (path coefficient = .31) and teamwork skills (path coefficient = .36), but no significant influence on cumulative GPA (see Figure 10).
Actual Perception of CLE

ACT score

ACT score

Problem solving skill

Teamwork skill

GPA

Self-directed learning

Figure 10. Student Perception of CLE Path

$\chi^2 = 138.17, p < .001$

NFI = .96

TLI = .92

CFI = .97
CHAPTER 5 DISCUSSION

The study was conducted to obtain evidence to further explain the reason for any discrepancy and how student perception of CLE was associated with self-directed learning readiness, problem-solving skill, teamwork skills, and cumulative GPA. Another purpose of this study was to identify the discrepancy between instructor and student perceptions of constructivist learning environments. Two categories of student perception of CLE were included in this study: perception of actual CLE and perception of preferred CLE.

The students who participated in this study averaged an age of 22 years. They had some work experience, but not much in technology areas. Students perceived that the ITEC program was very technical. Classes in the ITEC program were small. Instructors presented course materials primarily during lecture. There were a lot of hands-on activities in classes and in labs providing students opportunities to examine what they learned from the lecture content. Students participated in group activities either in class and/or for class assignments.

Comparisons of Perceptions of CLE

The Difference between Instructor and Student Perceptions of Actual CLE

The statistical comparison between instructor and student perceptions of actual CLE revealed that there was a significant difference between the two groups on the overall mean score and also on the scale of learning about technology, learning to speak out, and learning to learn. Instructors had a higher mean score for overall perception of CLE than did the students. Particularly, instructors perceived that students had autonomy in the determination of their learning path, plan, content, and evaluation and they provided opportunities for students to voice their learning needs and expectation of learning activities. However, no
significant difference between the two groups was found on the scale of learning to communicate. As one of the characteristics of the ITEC program, group projects got students more involved in idea sharing, as well as purposive and non-purposive communication with others. The lack of significant difference might suggest the ITEC program emphasizes collaborative learning.

That instructors perceived a constructivist pattern in their teaching did not mean their teaching practice would actually be constructivist, especially when students did not perceive constructivist teaching practice being used. The difference between both perceptions particularly was found on the issue of whether students questioned instruction or not. Traditionally, instructors designed lesson plans based on what they desire students to learn, the constructivist approach is to constantly adjust the class proceedings based on evaluation of what was being presented and what had been learned from previous classroom activities. The interview reflected that students perceived many instructors assume that everything was covered and then all of that knowledge would come to students if they concentrate on the class. Prawat (1992) indicated that this type of instructor usually focused on packaging and delivery of course content and usually believed the curriculum should follow a fixed agenda. Student input was separated from the curriculum, as most class-relevant activities were predetermined.

**Comparisons between Student Perceptions of Actual and Preferred CLE**

The results of a paired-sample t-test on comparison between students’ perceptions of actual and preferred CLE indicated that there was a significant difference on each scale between student perceptions of actual and preferred. Student preference was that the ITEC
program would have more emphasis on constructivism. Various reflections from personal
interviews supported the quantitative result. The greatest difference was students wanted to
have more input with instructors in the determination of their learning path, plan, content,
and evaluation. More student involvement in class learning was also emphasized.

In this study, classification, age, and work experience were three demographic items
used to identify whether student perceptions of the degree to which a constructivist learning
environment would correlate with different characteristics. The results of an ANOVA test for
each scale of CLE comparisons by three categories (high, medium, and low) revealed that
only the comparisons of groups for classification and age were significant for some of the
scales of CLE, but none of comparisons were significant for each scale of CLE when
considering work experience.

In the comparison of perception of actual CLE, junior students reflected a higher
mean level of perception on learning to communicate than did freshmen and sophomores. In
the comparison of perceptions for preferred CLE, senior student mean had greater preference
on learning to communicate with emphasis on constructivism than did freshmen and
sophomores. It was reasonable for students at higher levels to have higher expectation and
more experience sharing ideas with others. Since the ITEC program emphasized more group
activities in classes, students at higher levels had more experience and had more ideas
regarding this issue.

The majority of ITEC students were under 26 years of age, including the group of 18-
20 years and the group of 21-25 years. They were 30.3% and 62.5% of the total respondents
respectively. The ANOVA test on the scale of learning to communicate for actual perception
showed the comparison between two groups was significant. The result reflected that older
students tended to perceive they were provided opportunities to share ideas and interact with others in the class and they preferred that type of learning as well. Moreover, the comparison on the scale of learning about technology showed that the group of 21-25 year old students had higher mean scores than the group 18-20 years of age. The older students had a higher mean perception score on the data collection instrument than mean score for younger students that technology was changing frequently, diverse, and limited.

Student interviews provided more evidence for the research in mapping a picture regarding constructivist learning in students' perceptions. Several emphases were highly correlated with research on constructivism as found during the interviews:

*Authentic instruction.* The interviews reflected that students preferred to learn more technology that was happening in the real world. This means that authentic learning was emphasized. Students indicated that they would like instructors to bring industry experience into the class. The ITEC program required students to have internship experience from industry that was helpful to enrich students' technical knowledge to be more close to their future career lives. Students were interested in learning from real experiences when other students brought their intern experience into the class. Numerous studies asserted that authentic learning was one focus of constructivism (Kearsley & Shneiderman, 1999; Petraglia, 1998; Savery & Duffy, 1995). The majority of students strongly expressed that they liked hands-on activities in which they learned concepts by doing. The activities enabled them to make intuitive sense of their educational experience. The expression was consistent with the suggestion of engagement theory that students learned in authentic focuses and would be highly motivated and satisfied (Kearsley & Shneiderman, 1999).
Instructors were facilitators. Surprisingly, students had concepts regarding the instructor role and student role that were emphasized in most studies of constructivist learning. Students in the interview stated that students had to take responsibility for their own learning. Although most students tended to expect instructors to decide about lesson content, simultaneously, they agreed that there was limited time for instructors to cover more content. It was not necessary to ask instructors to go over class material in detail. Students have to learn on their own. For instructors, facilitating learning was expected; that increased more opportunities for student participation and involve students into the class discussion. Facilitating student learning included giving students guidance to help them develop their own learning process and giving supportive information to spark students' ideas. Instructors modified their ideas of instruction based on students' understanding of what was to be taught.

In contrast, students complained about lectures. Students did not experience frequent interaction with instructors. Prawat (1992) explained this situation while instructors viewed students as a separate factor from the instruction. Clearly, students did not view note-taking as an appropriate role for them. With the technical focus, classes in ITEC program took advantage of conducting lectures along with technical activities in which students applied and examined the knowledge that was discussed in lecture by hands-on practice.

Active learning. Students perceived they preferred learning actively rather than passively by memorizing the textbooks, or being read to by instructors from PowerPoint slides. Discussing about how instructors incorporate interesting topics to get students involved, students suggested using appropriate tools to activate class learning, such as using more of the chalkboard but not reading PowerPoint slides. To make the lecture interesting, there were several aspects regarding the manner in which the instructor conducts classes:
(1) Instructors know course material well and know how to lay it out for students to learn.

(2) Instructors ask for feedback at the end of or during the lecture. The asking enable instructors and students to examine students’ understanding.

(3) Instructors have students involved in the class by conducting class activities.

(4) Instructors interact with students vocally by initiating questions for discussion and inviting students to share ideas, as well as to justify to others their understanding.

Relevant constructivist literature supports the above reflections. For example, Simon (1995) suggested that instructors who employ constructivist instruction had a hypothetical learning trajectory before classroom instruction. In this trajectory, instructors’ learning goal, learning activities, and hypothesis of the learning process were conducted in sequence. The sequence of the process was based on instructor observation of interaction between students and instructors from which knowledge was collectively constructed by both instructors and students. Instructors were expected to be knowledgeable, to understand what happened in the classroom, and to be able to modify classroom activities through continuous interaction.

Students expected instructors who had a plan for the class and also cared about what students preferred. This was consistent with Simon’s suggestion that the class activities be decided collectively. Students were not separated from the curriculum. Rather, students were associated with the curriculum interactively (Prawt, 1992).

**Collaborative learning:** There was no significant difference between instructor and student actual perceptions for the scale of learning to communicate, but there was a significant difference between students’ actual and preferred perceptions on this scale. In this scale, the questions asked students to answer the situation regarding their vocal interaction
with others “in the class.” According to students’ statements in the interview, they rarely got chances to talk to other students during lecture when compared with lab. They indicated that lecture was usually boring and monotonous since most of them just sit and take notes. Instructors focused more on how much of the content should be and could be covered by following a planned schedule. However, students wanted to have more involvement in the class. Unlike in lecture, students not only received more chances in concept construction but also frequently interacted with others in lab. This finding indicated that collaborative learning more likely took place during lab.

CLE, particularly the assumption grounded on social constructivism, emphasizes learning taking place in a collaborative context (Cognition and Technology Group at Vanderbilt, 1993; Lunenburg, 1998; Petraglia, 1998). Group learning might motivate students to learn from multiple perspectives, leadership, and schedule management. On the other hand, some students might be frustrated from other team members’ non-cooperation or limited knowledge of the topic. How students were provided opportunities to share the control over group member selection was another issue for students working in teams. Students complained about other team members who did not contribute fairly when students were randomly assigned for group projects. More work load came to the students who cared about a high grade or wanted to take responsibility for the team project. Mahenthiran and Rouse (2000), investigating the impact of group member selection on learning performance, found that students had more positive attitudes and higher performance on learning when they were allowed to select a single friend in the group than those who were randomly assigned in the group. Mahenthiran and Rouse’s research supports the finding of this study. Students indicated that they tended to have their own cliques when instructors gave students
autonomy to select group members instead of assigning by instructors. In that way, they were
more likely to be excited about the class.

The Relationships between Demographics, Student Perceptions of CLE, and Dependent
Variables

Results of Pearson correlation showed that classification was slightly associated with
overall actual perception of CLE when classification was treated as a continuous variable.
Neither age nor work experience was associated with overall actual perception of CLE in this
study. This finding provided evidence that students at a higher level tended, but not strongly,
to perceive that more constructivist learning was emphasized in the ITEC program, compared
with lower level students.

Self-directed learning readiness, problem-solving skills, teamwork skills, and
cumulative GPA were dependent variables in this study. The statistical results showed that
several demographics were associated significantly with the dependent variables.
Classification was strongly associated with cumulative GPA, but not with self-directed
learning readiness, problem-solving skills, and teamwork skills when classification was
treated as a continuous variable. Age was only moderately associated with GPA, but not with
other dependent variables in this study. This finding differed from that of Agyekum's (1983)
study, which suggested that older learners tended to be more self-directed in learning. There
was no relationship between work experience and any of the dependent variables. Older
students and students in higher level tended to have higher GPA. Older students usually were
non-traditional students who had more previous experience in industry and perceived that a
good GPA enabled them to be more competitive against engineers for jobs. This could motivate those students to make stronger efforts to enhance their grades.

Statistical results showed that there were high associations between student perception of actual CLE and each dependent variable. The results based on a breakdown of student perception of actual CLE into four scales found that each scale was associated with self-directed learning readiness, problem-solving skills, and teamwork skills, but not with cumulative GPA. Relevant research suggested that constructivist learning took place in negotiational, self-regulated, and problem-oriented contexts (Kearsley & Shneiderman, 1999; Simons, 1993; Teslow, Carison, & Miller, 1994). The statistical results were consistent with these suggestions. Moreover, relevant empirical studies support the results. For example, Dibello and Spender (1996) found that an application of constructivism in a training environment significantly increased learner problem-solving performance. Brannick et al. (1993) found that team performance was highly associated with team member communication.

Among dependent variables, GPA was associated only with self-directed learning readiness, but there were significant relationships between self-directed learning readiness, problem-solving skills, and teamwork skills. Previous research yielded similar results. For example, a study incorporating collaborative environment into a problem solving task, in which students were asked to develop a computer program, found that students learning through collaborative efforts perceived they were more satisfied with the learning outcomes and the learning process (Yaverbaum & Ocker, 1998). Hmelo and Lin’s (2000) study found that deploying problem-solving into the curriculum affected the development of self-directed learning.
No significant relationship between student perception of actual CLE and GPA was possible because students’ grade had been based on traditional methods of evaluation, such as quizzes and examinations. Students got good grades partly from the degree of which they memorized, regardless of how strong or weak their perception of CLE. Higher grades did not necessarily reflect the actual degree of teamwork skills and problem solving skills.

Satisfactory indices of the SEM results, the values lead to the conclusion that a good fit existed between the hypothesized model and the observed data. The SEM findings suggest that students learning in a constructivist environment could improve their self-directed learning readiness, problem solving skills, and teamwork skills. Further, since student grades were decided by results on tests that were not based on a constructivist evaluation method, the cumulative GPA was not related to the degree of student perception of CLE.
CHAPTER 6 SUMMARY, CONCLUSIONS, AND IMPLICATIONS

Summary of the Findings

The purpose of this study was to compare instructor and student perceptions of CLE and investigate the relationships between student perception of actual CLE, self-directed learning readiness, problem-solving skills, and teamwork skills. Quantitative data and qualitative data were collected respectively by survey from 152 students and 21 instructors and by interviews with 11 students in the department of Industrial Education and Technology at Iowa State University.

The comparison of instructor and student perceptions of CLE showed that instructors thought they were using constructivist techniques in instruction at a greater level than the students perceived. The two scales of CLE that had the greatest difference were learning to speak out (mean difference = 0.62) and learning to learn (mean difference = 0.53). This indicates that ITEC students are not comfortable letting instructors know about their learning needs and desires. When assessing the learning environment, the instructors’ view of their use of constructivism in the teaching environment was not consistent with students’ perceptions.

The overall mean score of student perception of preferred CLE was significantly higher than mean student perception of actual CLE. This indicated that students desired more constructivist practice than what was currently taking place. What students would like to see improved the most was to have more input with instructors in the determination of their learning path, content, and student learning evaluation.
According to statements from student interviews, several focuses regarding constructivist learning that they preferred to happen in the ITEC program could be summarized as follows:

1. The focus of learning in authentic context referred to instructors providing students real work knowledge and experience in the course content and providing students more opportunities to learn by hands-on activities that results in student concept construction.

2. The focus of learning in collaborative groups referred to providing students an environment to learn in groups in which they share, clarify, and reflect their ideas to others.

3. The focus of instructors as facilitators emphasized that students take the responsibility to learn on their own based on guidance, support, and help from instructors.

4. The focus of active learning emphasized that students should be involved in their learning by active participation in class discussion, and during lab, and construct their knowledge by doing meaningful hands-on activities rather than memorizing information from textbooks.

The results of Pearson correlation revealed that student perception of actual CLE had a positive correlation with self-directed learning readiness \((r = .36)\), problem solving skills \((r = .41)\), and teamwork skills \((r = .40)\), but had a low positive correlation with cumulative GPA \((r = .12)\). The relationships among self-directed learning readiness, problem-solving skills, and teamwork skills had high positive correlations with each other (see page 82).

The MANCOVA test, which combined self-directed learning readiness, problem-solving skills, teamwork skills, and GPA as dependent variables, showed that student perception of
actual CLE had a significant impact on the combined variable. The covariate, ACT score, had a significant effect on the combined variable as well.

Based on the results of the Pearson correlation and the results of a MANCOVA test, a SEM model was generated.

**Conclusions**

Students did not perceive that constructivism practice was as widespread in the ITEC curriculum as instructors thought it was in their individual classes.

Students did not feel that it was appropriate for them to voice their learning needs and expectation to instructors to determine the learning path, plan, content, and student learning evaluation.

Students preferred a greater infusion of constructivism in ITEC instruction.

Students who were able to see constructivism within the curriculum were also seeing themselves as more self directed, and had a higher level of problem solving and teamwork skill than their peers.

Cumulative GPA was not associated with student perception of actual CLE. Students who had higher self-directed readiness scores tended to have higher problem solving skills and higher teamwork skills as well and vise versa. Students who evaluated themselves as good problem solvers were more likely to have good teamwork skills and vise versa.

**Implications of the Study**

**Implication for Practice**

Although there was no definitive indication of the appropriate cutting point for distinguishing between high and low student perception of CLE, a discrepancy clearly exists
between instructors’ perception and students’ expectation of the Iowa State University ITEC program. Similar studies explained the reasons for the perceived difference between teachers and students (Flick & Ault, 1997) or between students in two countries with different learning cultures (Aldridge et al., 2000). These studies did not further describe an expected learning environment of providing better motivation for student learning than the one that students actually perceived.

Statistical evidence of the difference between student perceptions of actual and preferred CLE in this study could help to identify whether ITEC students’ preference of learning environment was constructivist-orientated or whether there was a significant disparity between their perception of actual and preferred CLE.

A summary of student statements from interviews conducted for this study could provide information to describe the guidelines for employing constructivist instruction in a technical based learning environment, such as the ITEC program. The description of preferences regarding constructivist instruction could enhance curriculum design toward a student-centered approach.

Teslow et al. (1994) and Doolitte and Camp (1999) emphasized the importance regarding educational reform of communication skill and problem solving skill, which are related to higher-order thinking skills helping students to be creative and more competitive. The ability to be self-directed in learning has been an indication that identified people as being more likely to become lifelong learners. Theoretical research (Lunenburg, 1998; Prawat & Floden, 1994) suggested that these capabilities could be improved when learners explored in a constructivist instructional environment. Empirical evidence of this current
study substantiates the previous scientific finding that the relationship among these capabilities with student perception of CLE exists.

**Implication for Instructors**

As constructivism becomes a focus of educational reform, it is inevitable that instructors in the Iowa State University ITEC program need to be aware of the shift of instructional approach from traditional toward constructivist. At present the ITEC program does not specify a constructivist approach, and the results of this study revealed that students in this program prefer an increase in constructivist learning. This would result in teaching and learning administered as a student-centered approach.

Whether constructivist learning is only an idea or a practical instructional methodology depends on how individual instructors define their instruction conceptually and conduct their teaching effectively. A student-centered instruction does not mean instructors do nothing for the class and does not suggest that students administer instruction. Instead, students need guidance, support, and help from instructors to facilitate their knowledge construction. As suggested by constructivist philosophy, knowledge construction generates from conceptual change by the learners. The process of helping students in conceptual change requires that instructors understand student conceptual growth by interacting with students so that instructors realize what is happening in the student concept development process. Definitely, this requires more workload for instructors.

Although relevant literature has discussed many applications of constructivist instruction, constructivism by itself does not suggest specific guidelines to be employed (Cognition and Technology Group at Vanderbilt, 1993). However, by combining learning goals with student preferences that might help students to become better learners, guidelines
can be formed for developing the teaching approach. As suggested in educational reports, technical education should teach students to be able to communicate with others, work in teams, and solve problems with higher order thinking skills. To reach these goals consistently, a learning environment with authentic-oriented, cooperative, and active strategies is suggested. In cooperative learning, students are free to communicate with others in that they test their ideas on others or generate their ideas from different perspectives. An authentic focus provides students opportunities to construct knowledge from real work experience, particularly in meaningful learning problem solving. However, when designing authentic hands-on projects, instructors need to consider the degree of individual students’ work experience. Novice students may need more help from instructors to facilitate learning. In active learning, students are encouraged to be involved in class discussion instead of passive learning activities, such as memorizing information from textbooks. Active interaction between instructors and students motivates students to be interested in learning. A technical-based learning program, like the ITEC program, has the advantage of giving students lectures combined with hands-on activities. This combined instruction enables instructors to employ instruction easily in a student-centered approach because the abstract information provided from lecture can be conceptualized via student hands-on activities.

**Recommendations for Further Research**

Based on the results of this research and relevant literature, further recommendations are made to explore constructivist learning. Although the study focused on students in the ITEC department, a variety of characteristics potentially could influence the survey results. Some additional demographics could have been introduced into the study. For example, this study
assumed that work experience may correlate positively with constructivist learning.

According to Spigner-Littles and Anderson (1999), students who had previous experience were more effective in the learning process when constructivism was implemented in the instructional design. When designing the data collection instrument for a technically based study specific areas of work experience also need to be addressed. Therefore, it would be wise to specify a technical related area and non-technical related area when investigating participant work experience. The specification may help to identify further if discipline-related work experience might be a decisive factor in allowing students to learn effectively and if their work experience was also positively correlated with student perception of constructivist learning.

In addition, other factors that were not included in this study should be considered as potential variables that are correlated with student perception of CLE or with communication skills and thinking skills. For example, student learning style could be a variable that is associated with perception of constructivist learning and also could have an impact on self-directed learning readiness, as well as a different preference of communication. When taking learning style into account it may help researchers discover whether students with different learning styles will perceive different degrees of constructivism being used and would prefer a learning environment other than constructivism.

The perception of CLE by instructors was the only instrument for instructor input. The results were used to compare with student perception of CLE in this study. However, as indicated in previous studies, instructors play the role of facilitators in constructivist learning. Relevant factors that are related to instructors may need further investigation. Simon’s model (1995), which provided several guidelines, such as instructors’ hypotheses about the
development of student learning, may facilitate the model identification for students’
perception of CLE and their learning performance.

The sample selected for this study was drawn from the ITEC program at Iowa State
University. To generalize the results of the study to the discipline of Industrial Technology,
more subjects with diverse characteristics from the same discipline at more Midwest
universities and colleges is recommended. A larger population would provide a better
opportunity to test a model that would help to explain the causal relationship among the
research variables within a context of constructivist learning.
APPENDIX A: CONSTRUCTIVIST LEARNING ENVIRONMENT SURVEY

(INSTRUCTOR VERSION)
Constructivist Learning Environment Survey (Instructor Version)


Dear instructors,

We are conducting a research study in the Department of Industrial Education and Technology, Iowa State University. This questionnaire is designed to further professional understanding about important aspects of the ITEC classroom which you are teaching in this semester. The results of the study will help the faculty of our department better incorporate student-centered teaching into planning and implementing programs for our students. For the improvement of our program, we are asking you to participate in this survey.

Although you need to put your class title, this is used only for matching purposes. All responses and information provided will be kept in strictest confidence. When you have completed the questionnaire please return it to Room 212 Ed II. Thank you for taking your time to assist in this study.

Please circle only one number for each question. Your class is: ITEC  

<table>
<thead>
<tr>
<th>Learning about technology</th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometime</th>
<th>Seldom</th>
<th>Almost Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>In this class…</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>1. Students learn that technology cannot provide perfect answers to problems.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. Students learn that technology has changed over time.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. Students learn that technology is influenced by people's values and opinions.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. Students learn about the different technology used by people in other cultures</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. Students learn that modern technology is different from the technology of long ago</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. Students learn that technology is about inventing theories</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

LEARNING TO SPEAK OUT

<table>
<thead>
<tr>
<th>In this class</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. It's OK for students to ask the instructor &quot;why do I have to learn this?&quot;</td>
<td>5</td>
</tr>
<tr>
<td>8. It's OK for students to question the way they are being taught.</td>
<td>5</td>
</tr>
<tr>
<td>9. It's OK for students to complain about activities that are confusing.</td>
<td>5</td>
</tr>
<tr>
<td>10. It's OK for students to complain about anything that prevents them from learning.</td>
<td>5</td>
</tr>
<tr>
<td>11. It's OK for students to express their opinion.</td>
<td>5</td>
</tr>
<tr>
<td>12. It's OK for students to speak up for their rights.</td>
<td>5</td>
</tr>
</tbody>
</table>
### Learning to learn

In this class...

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Students help the instructor to plan what they are going to learn.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>14. Students help the instructor to decide how well they are learning.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>15. Students help the instructor to decide which activities are best for them.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>16. Students help the instructor to decide how much time they spend on activities.</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>17. Students help the instructor to decide which activities they do.</td>
<td>5</td>
<td>4</td>
<td>3</td>
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<tr>
<td>18. Students help the instructor to assess their learning</td>
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<td>4</td>
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### Learning to communicate

In this class....

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<tbody>
<tr>
<td>19. Students get the chance to talk to other students.</td>
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<td>3</td>
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</tr>
<tr>
<td>20. Students talk with other students about how to solve problems.</td>
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<td>3</td>
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<tr>
<td>21. Students explain their ideas to others.</td>
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<td>2</td>
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<tr>
<td>22. Students ask others to explain their ideas.</td>
<td>5</td>
<td>4</td>
<td>3</td>
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<tr>
<td>23. Some students ask other students to explain their ideas.</td>
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<td>4</td>
<td>3</td>
<td>2</td>
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<tr>
<td>24. Some students explain their ideas to other students.</td>
<td>5</td>
<td>4</td>
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</table>
APPENDIX B: STUDENT QUESTIONNAIRE FOR CONSTRUCTIVIST LEARNING ENVIRONMENT, SELF-DIRECTED LEARNING READINESS, PROBLEM-SOLVING SKILLS, AND TEAMWORK SKILLS
Student Questionnaire for Constructivist Learning Environment, Self-Directed Learning Readiness, Problem-Solving Skills, and Teamwork Skills

Dear students,

We are conducting a research study in the Department of Industrial Education and Technology, Iowa State University. This questionnaire is designed to further professional understanding about important aspects of the ITEC classroom which you are in this semester. The results of the study will help the faculty of our department better incorporate student-centered teaching into planning and implementing programs for our students. For the improvement of our program, we are asking you to participate in this survey.

We need you to write in your ISU email address. This is used only for matching purposes. All responses and information provided will be kept in strictest confidence. When you have completed the questionnaire please return it to your instructor or to the mailbox on the door of Room 212 Ed II by February 28. Thank you for taking your time to assist us in this study.

Your ISU email address @iastate.edu or other account at (Must specify these information)

Please circle only one number for both of Actual and Preferred classroom.

<table>
<thead>
<tr>
<th></th>
<th>Almost Always</th>
<th>Often</th>
<th>Sometime</th>
<th>Seldom</th>
<th>Almost Never</th>
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</table>

Part I. Your perception of learning environment

<table>
<thead>
<tr>
<th>Learning about technology</th>
<th>Actual</th>
<th>Preferred</th>
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</thead>
<tbody>
<tr>
<td>In ITEC program...........</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I learn that technology cannot provide perfect answers to problems.</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
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<tr>
<td>2. I learn that technology has changed over time.</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
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<tr>
<td>3. I learn that technology is influenced by people's values and opinions.</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
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<tr>
<td>4. I learn about the different technology used by people in other cultures</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>5. I learn that modern technology is different from the technology of long ago</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>6. I learn that technology is about inventing theories</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
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</table>

<table>
<thead>
<tr>
<th>Learning to speak out</th>
<th>Actual</th>
<th>Preferred</th>
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<tbody>
<tr>
<td>In ITEC program.....</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. It's OK for me to ask the teacher &quot;why do I have to learn this?&quot;</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
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<tr>
<td>8. It's OK for me to question the way I'm being taught.</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
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<td>9. It's OK for me to complain about activities that are confusing.</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
</tr>
<tr>
<td>10. It's OK for me to complain about anything that prevents me from learning.</td>
<td>5 4 3 2 1</td>
<td>5 4 3 2 1</td>
</tr>
</tbody>
</table>
11. It's OK for me to express my opinion.  
12. It's OK for me to speak up for my rights.  

Learning to learn  

**In ITEC program ......**  
13. I help the teacher to plan what I'm going to learn.  
14. I help the teacher to decide how well I am learning.  
15. I help the teacher to decide which activities are best for me.  
16. I help the teacher to decide how much time I spend on activities.  
17. I help the teacher to decide which activities I do.  
18. I help the teacher to assess my learning  

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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<td>13</td>
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Learning to communicate  

**In ITEC program ......**  
19. I get the chance to talk to other students.  
20. I talk with other students about how to solve problems.  
21. I explain my ideas to other students.  
22. I ask other students to explain their ideas.  
23. Other students ask me to explain my ideas.  
24. Other students explain their ideas to me.  

<table>
<thead>
<tr>
<th></th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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<td>19</td>
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**Part II. Your perception of self-directed learner**  

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<tr>
<th></th>
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<th>Agree</th>
<th>Not Sure</th>
<th>Disagree</th>
<th>Strongly disagree</th>
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</table>
12. I am open to new ideas
13. I need to know why
14. I like to make decisions for myself
15. I am responsible for my own decisions/ actions
16. I prefer to set my own learning goals
17. I evaluate my own performance
18. I have high personal expectations
19. I can find out information for myself
20. I have high beliefs in my abilities

The instrument in part II is developed by Murray Fisher, Jennifer King and Grace Tague (2001)

<table>
<thead>
<tr>
<th>Strongly Agree</th>
<th>Agree</th>
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<th>Strongly Disagree</th>
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Part III. Your problem solving skills

1. When there is a situation that I cannot deal with immediately, I am aware that it could be a problem.
2. When I face a problem, I can specifically figure out what it is.
3. I am confident when figuring out a problem.
4. I am confident in setting up criteria to evaluate alternatives for solving problems.
5. I evaluate advantages and disadvantages of each alternative before I select the most appropriate one to solve a problem.
6. I am able to apply knowledge to choose among various solutions for solving problems.
7. I prefer to take my time to access the appropriateness of the solutions if I have a problem in this course.
8. I try to apply various strategies to collect information to use in coming up with alternatives.
9. I assess the limitation of resources before I generate solutions to problems.
10. I prefer to make a plan before I start to solve a problem.

11. I consider beforehand resources that will be needed for the process of problem solving.
12. I am able to figure out the availability of any resource that may help to solve a problem.
13. When I decide to challenge a problem, I try my best to tackle it no matter how difficult it is.
14. When I confront a problem, I prefer to make decisions intuitively instead of taking time to go through a detailed process.
15. When I face a difficult problem, I look for new possible solutions that will allow me to continue problem solving toward a solution.
16. I care that the problem is solved effectively.
17. I review the outcome after I carry out the solution for a problem.
18. If my ideas do not work out, I try to seek other advice.  
19. Others’ feedback is useful for me to know if I did right or wrong.  
20. I concern with the consequences of solutions after I solve a problem.

<table>
<thead>
<tr>
<th>18</th>
<th>19</th>
<th>20</th>
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<td>5 4 3 2 1</td>
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### IV. Your Teamwork skills

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</table>

| 1. When I work as part of a team, I focus on completing the team task successfully. | 5 4 3 2 1 |
| 2. When I work as part of a team, I teach other team members. | 5 4 3 2 1 |
| 3. When I work as part of a team, I identify possible alternatives. | 5 4 3 2 1 |
| 4. When I work as a member of a team, I attempt to change incorrect information immediately. | 5 4 3 2 1 |
| 5. When I work as part of a team, I organize team activities to complete tasks on time. | 5 4 3 2 1 |
| 6. When I work as part of a team, I use available information to make decisions. | 5 4 3 2 1 |
| 7. When I work as part of a team, I interact cooperatively with other team members. | 5 4 3 2 1 |
| 8. When I work as part of a team, I clearly and accurately exchange information with team members. | 5 4 3 2 1 |
| 9. When I work as part of a team, I try to figure out what the team is thinking so as to solve problems. | 5 4 3 2 1 |
| 10. When I work as part of a team, I acknowledge that I understand the information. | 5 4 3 2 1 |
| 11. When I work as part of a team, I serve as a role model in formal and informal interactions. | 5 4 3 2 1 |
| 12. When I work as part of a team, I respect the thoughts and opinions of others in the team. | 5 4 3 2 1 |
| 13. When I work as part of a team, I lead when appropriate, mobilizing the group for high performance. | 5 4 3 2 1 |


### Demographic Information

What is your:

1. Age _______ years old.
2. Student level: Freshman____ Sophomore_____ Junior___ Senior_____  
3. How many years of work experience do you have? ______ years.
REFERENCES


ACKNOWLEDGEMENTS

I would like to express sincere gratitude to my major professor, Dr. Larry Bradshaw, for his guidance, advice, and encouragement throughout the development of this study. His many hours of counsel and support were important to help me complete my research on time and also I enjoy our discussion, and sharing of ideas.

I would also like to express my thanks to my committee members, Dr. Brian Hand, Dr. Mack Shelley, Dr. Shana Smith, and Dr. Steve Freeman, for their valuable advice and assistance. A special thank you for Dr. Dan Householder who served as my major professor for the two years before his retirement.

My special thanks to Dr. Ching-Chun Shih, for her timely and valuable suggestions in data analysis. Her suggestions really help me complete this research effectively. I am very appreciative of the assistance of Dr. Steve Russell, Dr. Tao Chang, Dr. Frank Peters, and Dr. Doug Jacobson, who helped me pilot test the instrument.

I would like to thank Dennis Kuan, Kris Urbanowicz, Ravindra Thamma, and Victor Susanto, for their assistance in data collection.

I am grateful to my caring family. To my mom, Yu-Ping, and my dad, Yi-Yang, thank you for your love and your care for me throughout my life.

My thanks especially to my husband, Chun-Hui, for his patience, understanding and loving support during my four years away from home. Also, I wish to express my gratitude to my children, Jenny and Michael, for accompanying and supporting me throughout my schooling.