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Conceptual Change Resulting from Experiential Learning with Business Enterprise Software

Thomas F. Rienzo
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CONCEPTUAL CHANGE RESULTING FROM EXPERIENTIAL LEARNING WITH BUSINESS ENTERPRISE SOFTWARE

by

Thomas F. Rienzo

A Dissertation
Submitted to the
Faculty of The Graduate College
in partial fulfillment of
the requirements for the
Degree of Doctor of Philosophy
The Mallinson Institute of Science Education

Western Michigan University
Kalamazoo, Michigan
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This study examined business process concept changes in undergraduate business students through an active learning experience with commercial software that is used by industrial companies to optimize and control their business transaction processing. Students that participated in this study were enrolled in an introductory information technology course that employs enterprise resource planning (ERP) software to demonstrate interactions among business processes involved in purchase and sales processing cycles. Specifically, business process comprehension was examined through three interdisciplinary lenses: (1) conceptual change from the discipline of science education, (2) learning styles from the discipline of business management, and (3) technology acceptance from the discipline of management information systems.

In order to assess conceptual change, data were collected from assessment instruments based on purchase and sales activities of the ERP software, and scored based on student knowledge of components and sequences involved in purchasing and selling. Assessment instruments were administered at three time points: (1) prior to ERP experience, (2) after experiencing ERP software through a simulated purchase (or sales) cycle, and (3) after experiencing ERP software for a second time through a sales (or purchase) cycle. Data relating to student learning styles and technology acceptance were
also collected through established instruments. Student self-assessment opinions concerning the educational value of their ERP experiences were analyzed qualitatively with attention to self-assessed comprehension benefits.

When considering the entire population of the study, analysis of component and sequence scores relating to conceptual change revealed patterns that generally followed typical consumer purchasing or sales experiences, and no significant component or sequence changes to sales or purchasing cycles were seen over the time points of the study. Statistically significant differences were observed over time in subcomponents of purchasing and sales processes more typical of business transactions than consumer transactions. Almost all differences involved the sales transaction cycle rather than the purchasing cycle. Segmentation by learning style revealed statistically significant component or sequence score differences for students exhibiting assimilative and accommodative styles. A positive relationship was found between student self-assessment of their comprehension of business processes, and usefulness factors of the Technology Acceptance Model.
ACKNOWLEDGEMENTS

This is a non-traditional dissertation on at least two levels, (1) my state in life, and (2) my area of study. I came to academic life as a second career after many years of industrial practice, and I am receiving a degree in Science Education but focusing on enterprise business software employed to teach business processes in business schools. If not for the time, effort, and encouragement given to me by my committee members, I could not have completed this process. I will be forever grateful to Drs. William Cobern, Joseph Stoltman, Bernard Han, and Bret Wagner. In particular, Drs. Han and Stoltman took a great deal of time to help me find bridges between business and science education. I am also grateful for the help I received in statistical analysis from Drs. J. C. Wang and Kuanchin Chen.

I appreciate the willingness of the students of the Haworth College of Business at Western Michigan University to participate in the study. I am sure that I have learned much more from my students than they have learned from me. Finally, I am indebted to my wife Peggy for her loving support both in the considerable time that I had to devote to this study, and throughout our marriage. When I was younger, I thought I could change the world. Now I realize that I can only change myself. This dissertation process has changed me, and I am grateful for the experience.

Thomas F. Rienzo
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CHAPTER 1: IDENTIFICATION OF THE PROBLEM

INTRODUCTION

Adapting Education to a Technology-Driven World

In the early 19th century, instruction for students primarily concerned transcribing oral communication into written communication. By the end of the century students imitated simple text forms of writing. The development of the industrial revolution in the early 20th century introduced mass education modeled after the factory system with the goal of empowering large masses of workers with sufficient literacy to follow simple job instructions. The combat demands of World War I also placed basic educational demands upon school systems. The impressive new technologies developed during World War II ushered in a new era of science and technology education during the Cold War (DeBoer, 1991; Rudolph, 2002). Now, in an adaptive and networked global economy, students are expected to understand the current state of their knowledge and to build upon it, improve it, and make decisions in the face of uncertainty (Bransford et al., 2000). ThinkEquity Partners (2002) estimates that 85 percent of US jobs required skilled workers in 2005 compared with 28 percent in the 1950s. Dealing with increasing complexity, modern businesses use technology to integrate their business processes (Kobayashi et al., 2003; Low, 2003). Technological tools help cross-functional teams address problems and opportunities with greater awareness of the holistic business systems that affect commercial success or failure, and organizations that operate with networked teams connected by computer information systems want people with both
specialized expertise and the ability to understand holistic processes (Schelfhauddt & Crittenden, 2005). There is a clearly greater demand upon modern social systems to provide education opportunities that require students preparing for future employment to think in more integrated ways than they have in the past (Ottewill et al., 2005; Schelfhauddt & Crittenden, 2005; Duderstadt, 2004; Ho et al., 2004). Integrated thinking is systems thinking requiring the ability to (a) shift from the parts to the whole, (b) shift back and forth between system levels, and (c) shift from objects to relationships (Capra, 1996). Systems thinking requires the ability to appreciate component parts interacting to produce an outcome or effect. Bransford et al. (2000) advocate a systems approach to promote coordination among activities in learning environments. They state

Traditional curricula often fail to help students “learn their way around” a discipline. The curricula include the familiar scope and sequence charts that specify procedural objectives to be mastered by students at each grade. Though an individual objective might be reasonable, it is not seen as part of a larger network. Yet it is the network, the connections among objectives that is important (p. 139).

There is substantial research investigating how people learn (Bransford et al., 2000; Gardner, 1987) but no universally accepted method of producing integrated learning, the kind of learning that is able to appreciate nuances in relationships of different concepts that frame a domain of knowledge and also bridge different knowledge domains. Chi & Koeske (1983), Ericcson & Simon (1998), Gobert (2000), and Fiore et al. (2003) all suggest that integrated learning comes from superior representations. Computer technology is a representational tool. Papert (1980) sees no limit to the variety of representations available through computer software. The limitless potential of current computer technology offers a vast array of choices to those who intend to employ it to benefit learning. Powerful computing devices bring significant opportunities and
complexity to modern educational systems but the connection between technology and school systems began long before the microchip was invented. Science educators brought media technology of the 1950s and 1960s into the classroom at the height of the Cold War when the National Science Foundation received a mandate from the United States federal government to revitalize science education throughout the country since scientific knowledge was considered essential for national security and the elite scientists developing new curricula judged that science teachers in the classroom needed new tools to help them explain scientific concepts that the teachers did not fully understand (Rudolf, 2002).

Learning With Software

After the launch of satellite Sputnik by the Soviet Union in 1957, technologies began influencing school pedagogy principally in the form of films and television (Rudolph, 2002). The PC revolution, beginning in the 1980s and continuing into the 21st century, makes it possible to give computing technology a central role in pedagogy since computing devices can be made available to every student. Networks of the 1990s further extended the powerful communication capabilities of computerized electronic information systems. School systems in the United States have spent billions on technology systems. Traditionally about 60 percent of education technology money is spent on infrastructure — the hardware, software, and networks that allow high-level programs to run and information to be shared (Angelo, 2002). Possibilities of implementing computerized learning systems have multiplied as computing power has grown exponentially since the invention of the microchip. Extensive options bring complexity and frustration to any implementation process (Iyengar & Lepper, 2000) and choosing effective software to assist learning in educational systems is no trivial task.
The real benefit of utilizing technology to improve learning will be effective customization of representations to support either (a) different types of learning styles; or (b) conceptual frameworks that promote understanding of specific kinds of content. Interest in computer technology supporting educational learning remains strong. The MacArthur Foundation committed $50 million supporting research in the field of digital learning in October 2006 (“Building the Field of Digital Media & Learning”, 2006). In higher education, the lecture format remains a common method of classroom instruction at universities throughout the United States, but new technologies herald an interactive experience in education. Duderstadt et al. (2002, pp. 26-27) write:

Although the classroom is unlikely to disappear, at least as a place where students and faculty can regularly come together, the traditional lecture format of a faculty member addressing a group of relatively passive students is threatened by powerful new tools such as the simulation of physical phenomena, gaming technology, telepresence, and teleimmersion (the ability of geographically dispersed sites to collaborate in real time).

Learning and Technology Acceptance

Complete substitution of the lecture format is unlikely but there is little doubt that the role of lecture will diminish across scholarly disciplines. Software simulations will provide a progressively attractive supplement for lecture format classes. Increasing numbers of business schools are using software employed in business practice in an attempt to teach business processes to both graduate and undergraduate students (Wagner et al., 2000; Corbitt & Mensching, 2000; Nelson & Millet, 2001; Hawking et al., 2002). Incorporation of computer software technology in the classroom is still in its early stages. In order to be effective systems must provide instructional benefits from a faculty perspective and learning benefits for students. New computing technology requires time
to align the architecture and capabilities of technology with the architecture and requirements of educational processes. Davis (1989) adapted the Theory of Reasoned Action to technology in order to measure technology acceptance of people as they incorporated computer programs into their work. The resulting Technology Acceptance Model segments user acceptance of technology into two determinants: ease of use and usefulness. This model has helped businesses judge potential benefits of technology for their processes. It may also help educators make similar judgments.

ENTERPRISE RESOURCE PLANNING SOFTWARE IN BUSINESS AND ACADEMIA

Business corporations have evolved into economic dominance through coordination of nearly-decomposable hierarchical divisions and organizational identification (Simon, 1990). Nearly-decomposable systems maximize component independence and minimize the cost and effort of coordination and communication. Companies have separate and nearly independent departments optimizing sales, production, and logistics. Near-decomposability allows a corporate department to independently change many of its processes and procedures without concern for effects on other departments. As systems become more complex, nearly-decomposable architecture with its hierarchical subdivisions has been shown to be much more effective than architecture with less departmentalized interconnections. Simulations with genetic algorithms have confirmed the dominance of near-decomposability in complex biological ecosystems (Simon, 1990). As effective as nearly-decomposable systems are in business, they minimize rather than eliminate the need for coordination, communication, and control of different departments, divisions, or activities in a business. Coordination, communication, and control are essential for effective business systems. As the quality
focus of the 1970s and 1980s demonstrated, there is wealth to be created, and competitive
advantage to be gained, from coordination and communication of business component
systems. Successful businesses ensure that the products obtained by the purchasing
department perform well in production, and that accounting and sales personnel know
when raw materials are in transit, production is scheduled, shipments are made, deliveries
can be expected, and invoices issued. With increasing frequency, modern corporations
are using enterprise resource planning (ERP) software as one of several methods of
connecting nearly-decomposable business departments and integrating business
processes. Many business schools have adopted ERP software in academic environments
in an attempt to integrate curricula (Markulis et al., 2005; Johnson et al., 2004; Hejazi et
al., 2003; Michaelsen et al., 2000). Joseph & George (2002, p. 51) suggest the
characteristics of ERP software can bring about more effective pedagogy in higher
education enabling deeper understanding of business operations and clearer vision of
interlinked aspects of business activity. In other words, many business schools have
chosen ERP software as a pedagogical representation of interactive business processes.
In the industrial world ERP software integrates companies by distributing data
throughout all departments and divisions of the business. Most research conducted with
integration business software has focused on curriculum implementation, state of the art
in teaching, recommendation for future improvements, and training for faculty and
students (Corbitt & Mensching, 2000; Antonucci et al., 2004; Cannon, Klein et al., 2004,
Draijer & Schenk, 2004; Fedorowicz et al., 2004; Hawking et al., 2004). There is little
research about the way technology helps learners understand business transactions.
Several studies have been conducted investigating the experiential learning perceptions
of students (Donahue, 2000; Graziano, 2000) and faculty (Hannett, 2000) with ERP
software but few attempts have been made to determine student’s understanding of
systems and relationships represented by the software. Wagner et al. (2000) compared student understanding of cross functional knowledge of human resources processes. Some students were guided through human resources modules of ERP systems while others were not. Students receiving training in enterprise systems scored higher in tests measuring knowledge of human resources business practices but results were not statistically significant. Noguera (2000) examined student performance and self-efficacy with different instructional methods, one of which included ERP software. He found no differences in process understanding among students reviewing business processes through a web tutorial compared with actual experience with enterprise software. Nelson & Millet (2001) examined student self-assessments about business processes controlled and optimized by ERP software. They reported statistically significant increases in self-reported business process knowledge on surveys conducted before and after students’ experience with enterprise software. Davis & Comeau (2004) incorporated configuration of ERP software into a capstone undergraduate course and reported higher levels of student understanding of the connectivity of business processes as a result. Results were determined by student and faculty self-assessment surveys. ERP software is increasingly used in the commercial world to integrate business processes. Business schools are increasingly using ERP to provide a framework for the concepts of integrated business processes. Business schools are hoping that ERP will foster a greater process focus in business curricula.

CONCEPTUAL CHANGE

Business schools are being encouraged to use ERP software as an integrating tool to shift student focus from functions to process (Johnson et al., 2004; Antonucci et al., 2004; Joseph & George, 2002). The emphasis of process in addition to traditional concentration on function constitutes a conceptual change for academic business
education. The term conceptual change has become popular in both science education and cognitive psychology literature and is broadly defined as learning that changes some existing conception (Chi et al. 1994, p. 27). Conceptual change is rooted in the developmental learning theories of Jean Piaget. Piaget studied children as they learned, and formulated a learning model with two key components (Tryphon & Voneche, 1996): (a) genetic epistemology, and (b) constructive internalization. Genetic epistemology states that genes determining changes in human bodies also determine changes in human minds. Constructive internalization states that humans construct increasingly autonomous mechanisms of functioning by interacting with objects.

Conceptual models that result from a natural maturing process and personal experience may be naïve. Structured education environments can present more accurate conceptual models and the rational to adopt them. People will change their naïve models if alternatives make more sense than their previous concepts about the ways they interact with the world. Posner et al. (1982) described the following conditions required for conceptual change to occur: (a) dissatisfaction with an existing conception, (b) new conception must be intelligible, (c) new conception must be plausible, and (d) new conception must be fruitful. The adoption of ERP software into business curricula signals a conceptual change among academicians from functional silos of management, finance, marketing, and accounting toward integrated processes. None of the business school studies investigating the adoption of ERP software in the classroom focused on conceptual change. Most conceptual change literature has come from the field of science education and some of the science education studies have involved computer technology. Gorsky & Finegold (1992), Windschitl & Andre (1998) and Tao & Gunstone (1999) used computer software to explore conceptual change in science teaching. All have found computer simulations can affect student conceptions of scientific processes. Gorsky &
Finegold (1992) claimed that computer software can be used to help students recognize the attributes of forces in physics. Windschitl & Andre (1998) found computer technology in conjunction with constructivist learning activities helped students formulate more complex concepts about the operation of the human circulatory system. Tao & Gunstone (1999) found that students uniformly liked learning with software but not all students experienced conceptual change and some of those that did reverted to their previous concepts shortly after their instruction ended. One of the most desirable benefits in employing computer technology to affect conceptual change is the creation of a simulated environment in which students can experience representations of concepts that they are supposed to learn.

EXPERIENTIAL AND ACTION LEARNING

ERP software brings tools of practical business experience in the classroom. John Dewey advocated “an intimate and necessary relation” between experience and education (Kolb, 1984, p. 5). Learning associated with practical experience has been described by Kolb (1984) as experiential learning and by Foy (1977) as action learning. Literature describing both began appearing concurrently with industrial quality movements of the 1970s and 1980s which focused on systems analysis and outcomes. Although both the communication and representation characteristics of computer technology impact experienced-based learning, the representation capabilities of computer software make it possible to provide learners with a multitude of simulated experiences. Businesses have utilized experienced-based learning to help employees understand system components and relationships (Leonard & Swap, 2004). The interactive experience described by Duderstadt that includes simulation, gaming, telepresence, and teleimmersion (p. 3) will be delivered by experiential or active learning.

Kolb (1984) describes four types of basic knowledge developed by experiential
learning: divergent, assimilative, convergent, and accommodative. There are four distinct learning styles associated with each knowledge type (Kolb & Kolb, 2005).

1. Divergent learners view concrete situations from many different points of view. They “brainstorm” well, have broad cultural interests, tend to be imaginative and emotional, and are interested in interpersonal relationships. People with divergent learning styles prefer to work in groups, listen with an open mind, and receive feedback.

2. Assimilative learners assemble a wide range of concepts into concise, logical structures. They tend to be less focused on people and more interested in ideas and abstract concepts. They are often attracted to information intensive activities and science careers. People with assimilative learning styles prefer learning situations in which they have access to readings, lectures, and analytical models. They want time to think things through.

3. Convergent learners want practical uses for ideas and theories. They are interested in solving problems and prefer to deal with technical tasks and problems rather than social and interpersonal issues. Convergent learners are often drawn to specialist and technology careers. In formal learning situations, they like to experiment with new ideas, simulations, laboratory assignments, and practical applications.

4. Accommodative learners want “hands-on” experiences. They like to carry out well defined plans but often prefer not to create them. Accommodative learners prefer to collaborate and trust group decisions even at the expense of their own analyses. They are more prone than other styles to act on “gut” feelings rather than logical and reasonable analysis. Kolb & Kolb (2005) have developed a learning style inventory instrument to assess learning style preferences.
PROBLEM STATEMENT

Integrated learning has been a long held goal of educational processes and business schools have adopted computer technology and enterprise resource planning (ERP) software to represent interconnected business processes in business school curricula. With a process focus, students are expected to understand the relationships and interdependencies of system components and their contribution to system outputs because the ability to shift from parts to the whole and effectively organize multiple hierarchical system levels will help students succeed in a business environment that optimizes holistic systems to maximize the creation of wealth. Business education must promote holistic process understanding as well as recognition of components parts. Integrated software presented in an experiential learning environment is a popular method of demonstrating relationships among component parts of business systems but there is little known about the educational effects of enterprise resource planning software upon student understanding of business processes\(^1\). As yet there is no generally accepted method of assessing business process understanding. This study examines business process understanding through three interdisciplinary lenses: (1) learning styles from the discipline of business management, (2) conceptual change from the discipline of science education, and (3) technology acceptance from the discipline of management information systems. The research approach is illustrated in Figure 1.1.

\(^1\) The enterprise resource planning software used in the study, Microsoft Dynamics GP®, is not designed for instruction. It is production software used by companies to distribute business process data throughout the enterprise. Programmers of the software are not concerned with process understanding of the users.
Figure 1.1  Assessment of Integrated Process Understanding

Examination of business process understanding through these three lenses will help assess the usefulness of enterprise business software as a pedagogical tool.

RESEARCH QUESTIONS

This study was guided by the following research questions:

1. Does “hands-on” experience with ERP software promote conceptual change relative to two business processes (purchasing and sales) among undergraduate business students?

2. Do learning styles as measured by the Kolb Learning Style Inventory have different effects on learning and understanding of business processes after using ERP software?

3. Do experiential learning styles or technology acceptance affect student
self-assessment of their learning, and is self-assessment consistent with comprehension of business processes as indicated by scores on experimental measurements?

SIGNIFICANCE OF THE STUDY

The Association to Advance Collegiate Schools of Business (AACSB), the accrediting agency for business schools, promotes business knowledge across functional areas (Wagner, 2000). Business schools are responding with curricula that includes enterprise resource planning (ERP) software (Eligibility Procedures, 2005). Delivery of effective integrated instruction through software technology requires an understanding of student conceptions of system components and relationships (business processes) as they interact with the software. The effectiveness of this software from the perspective of undergraduate learners has been sparingly studied. Measuring undergraduate conceptions of business processes as a result of interacting with enterprise software will assist in evaluating the efficacy of utilizing enterprise software in the business curricula.

This research is a unique attempt to measure students’ understanding of generic business processes as a result of interacting with enterprise business software. It examines process understanding through (a) empirical measurements, (b) self-evaluations, (c) learning styles, and (d) technology acceptance. Results and analyses in this research can assist efforts of continuous improvement in business education.

The dissertation is organized as follows:

Chapter 1: Identification of the Problem
Chapter 2: Literature Review
Chapter 3: Research Methods
Chapter 4: Results and Analysis
Chapter 5: Discussion and Conclusions
Chapter 6: Limitations and Suggestions for Further Research
CHAPTER 2: LITERATURE REVIEW

SCIENTIFIC AND TECHNOLOGICAL TRANSFORMATIONS

Peter Drucker (1993, p.1) describes transformational periods in western culture that change society in profound ways:

Within a few short decades, society rearranges itself – its worldview; its basic values; its social and political structure; its arts; its key institutions. Fifty years later, there is a new world. And the people born then cannot even imagine the world in which their grandparents lived and into which their own parents were born.

These transformational periods only occur every few hundred years, but they set the stage for dominant domain assumptions of society that become the basic perspectives that drive customs and behaviors. Table 2.1 summarizes transformational periods for western civilization and their consequences as described by Baumgartner (2002), Casanova (1994), Drucker (1993), Donovan (2003), Marszalek (1996), and Targowski & Rienzo (2004):

<table>
<thead>
<tr>
<th>Century</th>
<th>Central Event</th>
<th>Commerce Effect</th>
<th>Culture Effects</th>
<th>Religious Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>13th</td>
<td>European Cities</td>
<td>Expanded trade</td>
<td>Latin to vernacular</td>
<td></td>
</tr>
<tr>
<td>15th</td>
<td>Printing with moveable type</td>
<td>Specialization, business professions</td>
<td>Renaissance, literacy</td>
<td>Secular wisdom/ Protestant Reformation</td>
</tr>
<tr>
<td>18th – 19th</td>
<td>Industrial Revolution/ American Revolution</td>
<td>Capitalism, Communism</td>
<td>Industrial Revolution</td>
<td>Increasing separation of religion from politics, economy, and science</td>
</tr>
<tr>
<td>20th – 21st</td>
<td>Electronic computers</td>
<td>Globalization</td>
<td>Everything on-demand</td>
<td>Re-examination of spirituality</td>
</tr>
</tbody>
</table>

Table 2.1 Transformational Periods of Western Civilization
There has been a steady progression of interest in science, and particularly its utilitarian cousin, technology, in western culture. The industrial revolution began in the late 18th century with the invention of James Watt’s steam engine. Its application in industrial production initiated a relentless spread of technology in the developed world through the middle of the 20th century. The adoption of universal schooling and creation of the modern university in the 19th century spawned an escalating interest in science and technology in everyday life. This interest accelerated in the 20th century propelled by the factory system which produced previously unimaginable quantities of goods, a period of economic prosperity following World War II, and scientific and technological advances triggering new industries and new ways of building wealth. Drucker (1993) claims that the world is currently in the midst of its latest transformational period, which is again realigning values, structures, art, and institutions. The electronic computer lies at its core, and American industry has invested heavily in its promise. Investment in computer equipment and software from 2000 to 2003 exceeded $1.6 trillion (Francis, 2002; Smith et al., 2005). The industrial sector of America is not alone in its technological interest. McKinsey and Company estimated K-12 schools in America spent more than $3.3 billion on hardware, software, networking and related costs in 1995, and increased technology allocations to $5.5 billion by 1998-1999 (Cuban, 2001). Outlays in 2004 exceeded $6 billion (Havenstein, 2004). American colleges and universities spent more than $6 billion for computers, related equipment, software, and technical support in 1994 alone (Cuban, 2001).

EDUCATION TAKES THE PATH OF SCIENCE

Prior to the 19th century education was available primarily to the social elite of society. A classical education demanded familiarity with great works of western civilization literature – the Latin and Greek texts that withstood the test of time to define
civilization as it was perceived in the Western world (DeBoer, 1991). It attempted to train a student’s mind to think, rather than for a specific purpose. It is the antecedent of collegiate liberal arts education, and contrasts directly with knowledge accumulation leading to expertise in specialized practice. Classical education was available only to the upper class, who had the time and resources to intellectually grapple with its philosophical implications without having to spend significant time and energy struggling to survive. Historically, education for the working class allowed them to manage responsibilities of life. Education for the upper class translated into philosophical satisfaction. The 19th century changed dominant views concerning education.

In his 1860 essay “What Knowledge is of Most Worth?” Spencer (1924) determined that education related to the maintenance of good health was most valuable. He declared that reading, writing, and arithmetic were important for employment, but beyond those subjects most of what was taught in school was largely irrelevant to student life. He advocated science as a way to understand manufacturing processes (physics) and maintain health (biology). He argued for practical education in child rearing and using science to instill moral discipline through independent thought and self-responsibility. The second half of the 19th century changed the face of higher education as well. The Land-Grant College Act of 1862 created educational institutions that focused on agriculture and industry, providing higher education opportunities to people who were not part of America’s social elite (Duderstadt, 2002). In the 1890s Thomas Huxley (1901) promoted the teaching of science in schools and universities because it was such an enormous part of all of human knowledge. He emphasized modernization – science was a way to understand the modern world and it permeated every trade and profession. He stated that skills of observation and induction were best developed by science.

The 19th century was a time of great scientific and technological achievement.
Technology spawned by scientific advances began imposing itself upon the lives of people. Prominent examples include cement (1824), telegraph (1837), internal combustion engine (1858), dynamite (1866), telephone (1876), light bulb (1878), steam turbine (1884), and automobile (1885) (“19th Century Inventions”, 2004). Late in the century, the Committee of Ten, a group of ten college and school leaders, was created to standardize college preparation requirements. In its report, the committee recommended four curriculum high school models with science representing 20 percent of a student’s total time in high school (DeBoer, 1991). The professors of science who served on the committee were certainly interested in promoting their own views of the value of science education, especially since they were transforming an education tradition based on the classics that was historically available only to a small, elite group. Science education, particularly science laboratories, played a major role in the introduction of constructivism and guided discovery to high school classrooms (DeBoer, 1991).

THE PRACTICAL NATURE OF TECHNOLOGY AND EDUCATION

At the turn of the 20th century, science was becoming an increasingly important part of university study. The establishment of graduate education gave the university an increasing role in training students for careers (Duderstadt, 2002). With the arrival of the assembly line in 1903 and its accompanying industrial model, the factory system, more scrutiny was given to education on all levels as a means of economic advancement. The practical aspects of education were further enhanced by the experience of World War I with clear military benefits emerging from soldiers who were able to read, write, and follow directions. The percentage of students educated in high school was increasing. In 1890, about 6.7 percent of 14-17 year olds were in high school. In 1920, that percentage had jumped to about 32.3 (DeBoer, 1991). The increasing number of students pressured schools to provide a practical education that students could use no matter what their
professions after high school. Technology in factories generated prolific quantities of goods. Applying technology to cope with an increasing student population was a natural consequence of the success of the factory system. In the 1920s, technology was targeted primarily towards performance assessments. World War II brought astounding implementation of new technologies. A few examples include proximity fuses, solid fuel rockets, synthetic rubber, radar, and the atomic bomb. Scientific advances achieved during the war convinced American political leaders that science was a major factor in national survival for both military and economic reasons (Randolph, 2002). The National Science Foundation (NSF), founded in 1950, coordinated federal government support of university research and catapulted the role of science and technology in the academic community. The NSF remains the only agency of the United States federal government dedicated to the support of education and fundamental research in all scientific and engineering disciplines. Passage of the GI Bill following World War II provided affordable educational opportunities to millions of veterans. Their enthusiastic response greatly expanded the role of higher education in American society. After the launch of satellite Sputnik by the Soviet Union in 1957, technologies began to become incorporated in pedagogy principally in the form of films and television (Randolph, 2002). The PC revolution, beginning in the 1980s and continuing into the 21st century, makes it possible to give computer technology a central role in pedagogy since all students can have access to a computer. Networks of the 1990s further extended the powerful communication capabilities of computerized electronic information systems. New technologies herald an interactive experience in education. Schools will still have classrooms where teachers and students will meet but lectures with passive listeners will give way to active engagement on the part of students with collaborative technologies (Duderstadt et al., 2002). School systems in the United States have spent billions on technology.
Traditionally about 60 percent of education technology money is spent on infrastructure — the hardware, software, and networks that allow high-level programs to run and information to be shared (Angelo, 2002). Return on that investment is still not definitive (Cuban, 2001) but interest in digital learning remains strong. In October 2006, the MacArthur Foundation committed $50 million supporting research in the field (“Building the Field of Digital Media & Learning”, 2006).

TECHNOLOGY SUPPORTING LEARNING

Bransford et al. (2000, p. 207) describe five ways that technologies support learning: (1) bringing exciting curricula based on real-world problems into the classroom; (2) providing scaffolds and tools to enhance learning; (3) giving students and teachers more opportunities for feedback, reflection, and revision; (4) building local and global communities that include teachers, administrators, students, parents, practicing scientists, and other interested people; and (5) expanding opportunities for teacher learning. Roschelle et al. (2000) provide a similar list of ways technology supports fundamental characteristics of learning: (1) active engagement, (2) participation in groups, (3) frequent interaction and feedback, and (4) connections to real-world contexts. They report that simulations have helped students visualize and understand the forces in physics, and provide a sample simulation program, ThinkerTools (Roschelle et al., 2000, p. 87) that helps students visualize concepts of velocity and acceleration. Researchers credit ThinkerTools with advanced understanding of Newtonian physics principles. Software applications have helped high school students successfully learn concepts that govern bird-flocking and highway traffic patterns. Weather map visualizations encourage schoolchildren to reason like meteorologists. Meta-studies reported by Schacter (1999) confirm that the use of technology can improve test scores, but results depend upon the specific technology and the environment in which it is employed.
Employment of graphing calculators in mathematics courses also provided mixed results in student performance (Graham, 2003, Hopkins, 1998).

The learning theories of Piaget and Vygotsky provide an appropriate theoretical perspective for the role of technology in learning. Swiss biologist and psychologist Jean Piaget believed that the brain constructs knowledge as it adapts to its environment. The construction is progressive with time, and leads to stages of learning (Bransford et al., 2000). Russian psychologist Lev Vygotsky believed that learning itself influences human development. He postulated a “zone of proximal development” which raises competence levels of people through interaction with teachers or more capable peers (Bransford et al., 2000). Vygotsky also emphasized the societal aspects of learning, particularly language, while Piaget concentrated on the individual. Both men considered human actions as the genesis of development, but they did not view actions in the same way. For Piaget, action was a natural event occurring in a natural environment. For Vygotsky, action was constructed by history and society (Typhon & Voneche 1996). Computer technology is a tool of construction that can be used both individually and socially to create meaningful learning. It can be a driver of conceptual change among learners as they construct meaning relative to computer representations and related concepts. Business schools are currently developing ways to incorporate computer technology into their curricula. Considerable attention is being given to pedagogical uses of application software that businesses use to control and optimize their processes (Antonucci et al., 2004).

BUSINESS, TECHNOLOGY, AND TECHNOLOGY ACCEPTANCE

Computer technology can only provide benefits if it is used, and it has taken businesses a long time to apply technology in effective ways. Prior to the 1980s, computer technology was highly specialized in business. There was a small cadre of
specialists who interacted with computer systems and provided specialized output to portions of business that they served. During the 1960s and 1970s business computing was accomplished through large, expensive multi-user machines called mainframe computers that were used for mission critical business activities. The cost of mainframe computers often exceeded several million dollars (McCallum, 2002). Only large companies had both the need for their capabilities and the resources to afford them. Software had modest standalone value since it was usually custom created for a specific piece of very expensive hardware (Glass, 2004). The creation and mass marketing of the personal computer in the 1980s transformed software into a real economic market force and prompted a significant technology investment by businesses of all sizes to realize gains in personal productivity. Computer interaction was no longer the domain of specialists. The development of robust networks and the World Wide Web in the 1990s marked another level of business technology investment, again affecting businesses of all sizes. The difficulty of transforming investment into real productivity gains has resulted in the development of the Technology Acceptance Model (TAM) first proposed by Davis (1989). TAM was created to address reasons for underutilized computer systems and less than expected results from technology investments. It has been used to explain and predict user acceptance of technology at work (Venkatesh & Davis, 2000). Developers of TAM adapted the Theory of Reasoned Action to technology (Dishaw & Strong, 1999) to segment user acceptance of technology into two determinants: (a) ease of use and (b) usefulness. Higher ease of use and perceived usefulness produces more system utilization which businesses expect to translate into higher levels of productivity. The TAM model has been used on specialized software (Davis, 1989; Mathieson, 1991; Venkatesh & Davis, 2000) and general communication technology systems like e-mail and the World Wide Web (Szajna, 1996; Gefen & Straub, 1997; Lederer et al., 2000).
Industrial organizations have employed TAM as an indicator of worker acceptance of technology business processes. In an academic setting greater technology acceptance may foster greater degrees of learning with computer software. One major challenge of teaching with business software is the creation of exercises that transfer understanding of interconnected processes through software designed to enable interconnection rather than teach it.

REPRESENTING BUSINESS PROCESSES THROUGH TECHNOLOGY

Modern businesses solve business problems by using technology to integrate and connect their business processes (Kobayashi et al., 2003; Low, 2003). Technological tools help cross-functional business teams address problems and opportunities with greater awareness of holistic business systems that affect commercial success or failure. Organizations that operate with networked groups connected by computer information systems want people with both specialized expertise and the ability to understand holistic processes (Schelfhaudt & Crittenden, 2005). There is clearly a modern social demand to provide education opportunities that require students preparing for future employment to think in more integrated ways than they have in the past (Ottewill et al., 2005; Schelfhaudt & Crittenden, 2005; Duderstadt, 2004; Ho et al. 2004) in order to solve business problems. Problem-solving processes, whether human or mechanical, exhibit highly selective trial-and-error search techniques using rules of thumb, or heuristics, as bases for their selectivity. Superior problem solvers in a particular area have more powerful heuristics and they will produce adequate solutions with less search, or better solutions with equivalent search as compared with less competent persons. Superior heuristics come from superior representation, or as Herbert Simon (1966, p. 27) tells it: “Leeuwenhoek and his microscope, Galileo and his telescope, Lawrence and his cyclotron, and so on. God is on the side of the highest resolution”. Solutions to
problems are highly dependent upon the way problems are represented. Ericsson & Simon (1998, p. 187) state:

The problem solver is unlikely to use calculus in solving a problem unless he or she is drawn from a culture that is familiar with it, or to paraphrase Shakespeare or the poetry of Jorge Borges, without previous social interactions that stored memories of them, including in those memories familiar patterns to evoke them when these patterns reappear in the current situation.

Representations are instantiated in models, which can be (a) propositional statements, (b) spatial images, (c) abstract flow charts and formulas, or (d) programs like differential equations and computer software. Models and representation are important in problem solving, understanding, and learning (Ericsson & Simon, 1998). Papert (1980, p. vii) states “what an individual learns, and how he learns it, depends on what models he has available.” Simon (1975, p. 22) concurs: “Most problems are capable of being represented in a variety of ways, and problem difficulty may be greatly affected by the representation chosen.” Increasingly, businesses are incorporating software in the way they represent their problems and processes.

Turkle (1995, p. 9) describes the versatility of computer models that can be applied to learning: “…the computer offers us both new models of mind and a new medium on which to project our ideas and fantasies.” Computers “facilitate pluralism in styles of use” (Turkle, 1995, p. 45). In our modern technological world, boundaries are eroding between what is real and what is virtual. People are learning to interact with the computer at “interface value” (Turkle, 1995, p. 23) permitting them to enter and comfortably engage in simulated experiences that represent reality. The benefit of using the computer at interface value is an almost limitless representation of environments that could assist learning and understanding. Computers can provide concrete (or at least more concrete) representations of abstractions like atomic structure, quantum mechanics, physical forces, electricity and magnetism, black holes, weather patterns, and ocean
currents. This is an opportunity unprecedented in human history. The enormous storage and processing power of computers can both represent well established concepts in extraordinary detail and explore heretofore unknown relationships. Their ability to increase resolution is extraordinary. In businesses, computers not only collect and compile millions of transactions for financial reporting and decision-making, but highly sophisticated software can reveal buying or selling relationships that were impossible to discern prior to computerized data mining. In 2004 Wal-Mart used data mining to predict which products would have higher than normal demand in Florida as a result of hurricane activity. Software discerned a relationship between approaching hurricanes and large spikes in both breakfast tarts and beer sales (Hays, 2004). Computers can create simulations about real experiences that provide more understanding about the processes involved in those experiences, and allow learners to practice in safe virtual environments before engaging in potentially dangerous real experiences like driving a car or flying an airplane. In business curricula, use of business process software can permit students to deal with business processes as they would in real-world businesses without the consequences of ineffective management or erroneous execution. Many business schools have adopted enterprise computer software that companies use to integrate their business processes in the academic environment to attempt integrate curricula (Markulis et al., 2005; Johnson et al., 2004; Hejazi et al., 2003; Michaelsen et al., 2000). Most research conducted with integration business software has focused on curriculum implementation, state of the art in teaching, recommendation for future improvements, and training for faculty and students (Corbitt, & Mensching, 2000; Antonucci et al., 2004; Cannon et al., 2004, Draijer & Schenk, 2004; Fedorowicz et al., 2004; Hawking et al., 2004). Relatively little attention has been given to the assessment of student learning as a result of using enterprise systems in the classroom. Wagner et al. (2000) compared student
understanding of cross functional knowledge of human resources processes. Some students were guided through human resources modules of ERP systems while others were not. Students receiving training in enterprise systems scored higher in tests measuring knowledge of human resources business practices but results were not statistically significant. Noguera (2000) examined student performance and self-efficacy with different instructional methods, one of which included ERP software. He found no differences in process understanding among students reviewing business processes through a web tutorial compared with actual experience with enterprise software although he did find statistically significant differences between students who had no computerized instruction compared with those who did. Nelson & Millet (2001) examined student self-assessments about business processes controlled and optimized by ERP software. They reported statistically significant increases in self-reported business process knowledge on surveys conducted before and after students’ experience with enterprise software. Davis & Comeau (2004) incorporated configuration of ERP software into a capstone undergraduate course and reported higher levels of student understanding of the connectivity of business processes as a result. Results were determined by student and faculty self-assessment surveys. Incorporation of ERP software into business curricula is less than 10 years old for the early adopters (Corbitt & Mensching, 2000) and many schools have less than 5 years experience with ERP software in the classroom. Business schools introduce the software into courses to (a) familiarize students with software used by an increasing number of businesses to integrate their business processes; (b) demonstrate relationships among logistics, operations, financial accounting and business transactions; and (c) provide students with basic skills in the use of enterprise software to position them for more sophisticated training at a future date. The relatively few studies described above that examined the
effectiveness of enterprise software have indicated that ERP software can increase student self-assessment of their understanding of integrated processes but no empirical measurement of business process knowledge has been found supporting that assessment. Kolb & Kolb (2005), Dunn (1984) and Simon (2002) suggest that learning improves when instruction is matched to learning styles. Perhaps learning style segmentation could help provide empirical evidence supporting integrated process learning.

LEARNING STYLES

Experiential Learning

Learning is enhanced when the systems studied are relevant to the lives of the learners (Bova & Kroth, 2001; Bransford et al., 2000). For at least the last one hundred years, life relevance of content knowledge delivered in typical school environments have been questioned by educators and non-educators alike. In the early part of the 20th century John Dewey advocated education that integrated academic and vocational knowledge (Braundy, 2004). Academic knowledge (learning in school) provides awareness and sensitivities that encourage new connections and the creation or development of new systems and relationships. Vocational knowledge (learning in the world) provides the tools and skills that accomplish essential tasks in life. Learning in the world occurs when learners are in situations in which they have an unambiguous link between their own goals and the specific information, concepts, or knowledge available to them. It is centered in experience. From a learning perspective, the world has a clear advantage over schools. It is practical, immediate, specific, and concrete. On the other hand school tends to be theoretical, gradual, general, and abstract. Bridges are needed between school and the world, between academic and vocational teaching and learning.
Bosco (2004) has suggested technology as a bridge. The characteristics of computer technology that are most frequently cited by educators to connect school and the world include communication capabilities that are largely independent of location and the limitless variety of representations of reality that are capable of being created (Papert, 1980; Turkle & Papert, 1992; Bransford et al., 2000; Roschelle et al., 2000). Chi & Koeske (1983), Ericcson & Simon (1998), Gobert (2000), and Fiore et al. (2003) all suggest that integrated learning comes from superior representations. Computer technology is a representational tool. Papert (1980) sees no limit to the variety of representations available through computer software. If computers are able to bridge school and the world, they will build that bridge through their power of simulation in which students interact with computers to experience virtual processes or events in ways similar to those in which they interact with the real world. Sherry Turkle (1985) describes these interactions as dealing with computers at “interface value.” The interactive experience described by Duderstadt that includes simulation, gaming, telepresence, and teleimmersion will be delivered by experiential learning.

Kolb Basic Knowledge Forms

Learning associated with practical experience has been described by Kolb (1984) as *experiential learning* and (Foy, 1977) as *action learning*. Literature describing both began appearing concurrently with industrial quality movements of the 1970s and 1980s which focused on systems analysis and outcomes. Kolb (1984) agrees with John Dewey that “there is an intimate and necessary relation between the processes of actual experience and education” and proposes an experiential learning model based on the
philosophical pragmatism of Dewey, the Gestalt psychology of Kurt Lewin, and nature and development of intelligence proposed by Jean Piaget (Kolb, 1984, p. 12). The Kolb model\(^1\) (Kolb, 1984, p. 42) is presented in Figure 2.1. Experiential learning is a four-stage process: (a) concrete experience; (b) reflective observation; (c) abstract conceptualization; and (d) active experimentation.

![Figure 2.1 Kolb Basic Knowledge Forms](Image)

**Figure 2.1 Kolb Basic Knowledge Forms**

Experiential learning begins with a concrete experience and progresses through a stage of reflection to abstract conceptualization – the integration of reflection into generalizations or theories. The theories of abstract conceptualization are tested in active experimentation (action) which leads to more complex concrete experiences (Lewis & Williams, 1994). Kolb envisions four knowledge forms resulting from a grasp or representation of experience and a mental transformation of that representation. The
representation and transformation processes are accomplished through (Kolb, 1984, p. 41): (a) apprehension – tangible or felt qualities of immediate experience, (b) comprehension – symbolic representation, (c) intention – internal reflection, and (d) extension – manipulation of the external world.

Table 2.2 shows Kolb’s representation and transformation factors contributing to experiential learning and their resulting basic knowledge forms. Kolb insists that learners must grasp experience with figurative representations through apprehension or comprehension and transform them through intention or extension. Both representation and transformation must occur to produce learning.

<table>
<thead>
<tr>
<th>Representation Factor</th>
<th>Transformation Factor</th>
<th>Experiential Learning Stages</th>
<th>Resulting Knowledge Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apprehension</td>
<td>Intention</td>
<td>Concrete experience</td>
<td>Divergent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reflective observation</td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>Intention</td>
<td>Reflective observation</td>
<td>Assimilative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Abstract Conceptualization</td>
<td></td>
</tr>
<tr>
<td>Comprehension</td>
<td>Extension</td>
<td>Abstract Conceptualization</td>
<td>Convergent</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Active Experimentation</td>
<td></td>
</tr>
<tr>
<td>Apprehension</td>
<td>Extension</td>
<td>Active Experimentation</td>
<td>Accommodative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concrete experience</td>
<td></td>
</tr>
</tbody>
</table>

Table 2.2   Experiential Learning and Resulting Knowledge Forms

Two of Kolb’s knowledge types follow the Piagetian concepts of assimilation and accommodation. In Piagetian constructivism, assimilation occurs when new experiences are perceived in terms of existing mental structures or schemas. Accommodation occurs when internal mental structures are changed to create consistency with perceived external reality (Bhattacharya & Han, 2001). From the Kolb perspective, assimilation requires the symbolic representation of comprehension transformed by internal reflection (intention) with both operating on the experiential learning stages of reflective observation and
abstract conceptualization. Accommodation requires the tangible qualities of apprehension transformed by manipulation of the external world (extension) with both operating on the experiential learning stages of active experimentation and concrete experience. In addition to assimilative and accommodative knowledge, Kolb includes knowledge descriptions originally proposed as thinking styles by Hudson (1966): convergent and divergent knowledge. Convergent knowledge structures a variety of concepts to address a single topic or problem. In the Kolb model, convergent knowledge requires the representation of comprehension transformed by manipulation of the external world (extension) with both operating on the experiential learning stages of abstract conceptualization and active experimentation. It is associated with problems that have demonstrably correct (or optimal) answers. Many mathematics and science problems can be solved by convergent thinking. Divergent knowledge generates different concepts from an initial source (Atherton, 2005). In the Kolb model, divergent knowledge requires the tangible qualities of apprehension transformed by internal reflection (intention) with both operating on the experiential learning stages of concrete experience and reflective observation. It is associated with creative arts and can rarely be classified as “right” or “wrong”.

Kolb & Kolb (2005, pp. 11-12) associate the basic knowledge forms of Figure 2.1 and Table 2.2 with learning styles. Figure 2.2 adds learning styles to the knowledge forms of Figure 2-1.
**Figure 2.2 Kolb Knowledge Forms and Learning Styles**

Divergent learners view concrete situations from many different points of view. They “brainstorm” well, have broad cultural interests, tend to be imaginative and emotional, and are interested in interpersonal relationships. People with divergent learning styles prefer to work in groups, listen with an open mind, and receive feedback.

Assimilative learners assemble a wide range of concepts into concise, logical structures. They tend to be less focused on people and more interested in ideas and abstract concepts. They are often attracted to information and science careers. People with assimilative learning styles prefer learning situations in which they have access to readings, lectures, analytical models. They want time to think things through.

Convergent learners want practical uses for ideas and theories. They are interested in solving problems and prefer to deal with technical tasks and problems rather than social
and interpersonal issues. Convergent learners are often drawn to specialist and technology careers. In formal learning situations, they like to experiment with new ideas, simulations, laboratory assignments, and practical applications. Accommodative learners want “hands-on” experiences. They like to carry out well defined plans but often prefer not to create them. Accommodative learners prefer to collaborate and trust group decisions even at the expense of their own analysis. They are more prone than other styles to act on “gut” feelings rather than logical and reasonable analysis. Kolb & Kolb (2005, p.12) report that learning styles may be more nuanced than those shown in the quadrants of the learning style model. Researchers have postulated at least five additional learning styles resulting from blended characteristics of the four basic knowledge forms. A very desirable and powerful attribute of technology is that its limitless variety of representations makes it possible to address characteristics of every learning style.

In addition to considering the four quadrants of the Kolb learning style model, research has also focused on two learning style factors (Kayes, 2005): Concrete Experience vs. Abstract Conceptualization and Active Experimentation vs. Reflective Observation. Two factor analyses effectively segment the learning style model into hemispheres rather than quadrants as displayed in Figure 2.3. Lynch (1998) found higher scores on multiple choice examinations for medical students with abstract orientations (southern hemisphere) compared with concrete orientations (northern hemisphere). Bostrom et al. (1990) reported that abstract learners produced higher comprehension and accuracy scores when learning software than concrete learners. Terrell & Dringus (2000) reported that abstract learners may have better chances of completing graduate studies
than concrete learners. Thomas et al. (2002) found that more reflective (eastern hemisphere) learning styles scored higher on exams and more experimental (western hemisphere) styles scored better on coursework.

![Figure 2.3  Kolb 2-Factor Learning Styles](image)

CONNECTING BUSINESS AND BUSINESS EDUCATION THROUGH EXPERIENTIAL LEARNING

Businesses have long utilized experienced-based learning to help employees understand system components and relationships (Leonard & Swap, 2004), and software is playing an increasing role in their efforts. Zbigniew Gackowski (2003) advocates experiential learning as a means of overcoming the gap between school and real-world activity. Gackowski applies the four Kolb learning stages to his capstone information
systems course at California State University Stanislaus. The great variety of representations possible with computer software offers opportunities for (a) concrete experiences in virtual worlds which may make it particularly attractive to accommodative and divergent learners; and (b) frameworks for models of connected concepts which may be particularly attractive to assimilative and convergent learners. In business education, computer software representations are most commonly delivered through Enterprise Resource Planning software (ERP) systems. Some universities have made significant progress in integrating ERP courses in their curricula. At the close of the year 2000, the business school at California State University, Chico had 23 courses using ERP software (Corbitt & Mensching, 2000). In three years faculty involvement in enterprise software grew from 10 to 25 percent. In 2004 Victoria University of Melbourne, Australia had 25 subjects at undergrad and graduate levels that incorporated ERP (Hawking et al., 2004). ERP software is routinely used in the commercial world to control and optimize business processes, and its presence in both industrial and academic settings may provide ways of connecting the academy and industry. ERP systems provide businesses with greater visibility of processes (Scherpenseel, 2003). Greater visibility means improved data and information for problem solving, and practicing managers are using this visibility to transform modern businesses into information-driven enterprises (Alvord, 1999). Increasing implementation of these software systems in business demonstrate that managers agree with Herbert Simon (1966): God is on the side of the highest resolution.

When business schools begin ERP instruction, they invariably start with concrete, hands-on exercises that simulate actual business processes (Draijer & Schenk, 2004; Fedorowicz et al., 2004; Grenci & Hull, 2004). The development of representative
exercises is not trivial. It requires access to enterprise software, which may come from local servers at the college or university, or hosted at a remote location and made available through a high-speed network connection. Either choice requires a commitment of resources although in-house software hosting requires non-trivial hardware and administrative expenses. Software installation, network connectivity, and system maintenance comprise the infrastructure that allows educators to build sophisticated learning systems. Infrastructure is both critical and expensive, but without it higher level systems cannot evolve. After the software infrastructure is in place, designers of hands-on exercises need training in program features. Then significant faculty time is needed to create hands-on exercises. All of this is needed just to introduce students to a concrete business processes through ERP. Initial concrete exercises can be followed by the next three stages of experiential learning. The HES Amsterdam School of Business in the Netherlands has created four simulated companies that use ERP. After students familiarize themselves with the software through step by step exercises, they join product teams and engage in business activities that reflect the business processes of the simulated enterprises (Draijer & Schenk, 2004). As the students work through various business processes, the checks and balances of the software insure that connected processes have logical integrity. In other words, students (a) cannot ship what is not in stock; (b) cannot make product without materials and schedules; and (c) cannot post revenues without invoicing. John Carroll University relates ERP implementation to the stages of the Systems Development Life Cycle. Students research failures of several companies that attempted to implement ERP, looking for common patterns (Grenci & Hull, 2004). Curriculum design of Queensland University emphasizes problem-based
learning, creating a public administration computerized process model that includes business processes before ERP implementation, newly designed processes based on ERP reference models, new system configuration, and testing (Stewart & Rosemann, 2001).

ERP AND LEARNING OUTCOMES

ERP software is production software, not instructional software. It is introduced in core undergraduate business courses to familiarize students with software tools used by an increasing number of businesses to integrate their business processes, demonstrate relationships among business systems, and provide students with sufficient skills in the use of enterprise software to make business decisions in higher level classes. While the software was designed to track and facilitate business processes, subsequent learning by students in schools of business is an expected result of its utilization. The educational importance of the software and its influence upon the cognitive process of student learning need to be evaluated. Bloom et al. (1956) laid the groundwork necessary to study the cognitive effects of ERP. He categorized educational objectives according to their cognitive level, using a taxonomy of educational objectives created by a committee of university examiners. The categories are: (a) knowledge; (b) comprehension; (c) application; (c) analysis, (d) synthesis; and (e) evaluation. Knowledge consists of factual information. Comprehension indicates an understanding of a message of communication. Application implies the use of principles and concepts in appropriate contexts. Analysis breaks down problems into manageable component parts and synthesis builds parts into a unified whole. Evaluation involves values and judgment. Human thinking is a complex process and attempting to define outcomes of thinking is also complex. At least 19
alternative frameworks for educational outcomes have appeared in the literature since the original publication by Bloom et al. (Anderson, 2001). All involve a semantic process of transforming facts or data through patterns, categorization, relationships, and rules into meaningful decisions. Since ERP is an integrating tool, educational objectives of incorporating the software into academic courses include stages of the Bloom model that focus on application through synthesis; however, these objectives cannot realistically be met in courses that initially introduce ERP software. Introductory courses focus more on (a) components; (b) sequences; and (c) relationships of business processes controlled and optimized by the ERP software. Introductory assignments using ERP software involve the knowledge, comprehension, and application levels of the Bloom taxonomy (Draijer & Schenk, 2004; Fedorowicz et al., 2004).

Smith & Ragan (1999, p. 66) describe 8 learning outcomes, presented in Table 2.3: (1) declarative knowledge, (2) procedural knowledge, (3) discrimination, (4) concrete concepts, (5) defined concepts, (6) principles, (7) procedures, and (8) problem solving. While the inclusion of ERP software into business school curricula is ultimately aimed at problem solving, the focus in core business courses in which the software is initially presented to students is primarily declarative knowledge, concepts, and procedures. Declarative knowledge is factual knowledge. While it is not sophisticated it provides the building blocks for higher level thinking (Smith & Ragan, 1999).
<table>
<thead>
<tr>
<th><strong>Outcome</strong></th>
<th><strong>Description</strong></th>
<th><strong>Example</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Declarative Knowledge</td>
<td>Factual knowledge</td>
<td>Multiplication tables</td>
</tr>
<tr>
<td>Procedural Knowledge</td>
<td>Apply knowledge to new instances</td>
<td>How many sandwiches should be made for a picnic to have enough for everyone to have two?</td>
</tr>
<tr>
<td>Discrimination</td>
<td>Recognize differences</td>
<td>Round and square</td>
</tr>
<tr>
<td>Concrete Concepts</td>
<td>Physical Classification</td>
<td>Geometric shapes</td>
</tr>
<tr>
<td>Defined Concepts</td>
<td>Abstract definition</td>
<td>Differential calculus</td>
</tr>
<tr>
<td>Principles</td>
<td>Relational if-then</td>
<td>F=ma</td>
</tr>
<tr>
<td>Procedures</td>
<td>Order of steps</td>
<td>Calculating a mean</td>
</tr>
<tr>
<td>Problem Solving</td>
<td>Application of multiple rules</td>
<td>Theorems and proofs</td>
</tr>
</tbody>
</table>

**Table 2.3 Learning Outcomes**

Through the ERP system, students encounter electronic representations of standard business processes like orders, receipts, payments, and posting. They work with the subcomponents of those processes. Defined concepts like chart of accounts, inventory, and order fulfillment are incorporated into ERP processes. Procedures are clearly important in ERP systems, since the order of steps is important to virtually every business process.

**INTEGRATION AND CONCEPTUAL CHANGE**

Changing business school education from functional silos to integrated processes requires a more integrated and connected perspective on the part of business students and instructors than schools have promoted in the past (Ottewill *et al.*, 2005). Viewing business processes as more integrated and connected necessarily requires a more systemic view of business processes with more expansive structures and relationships. A focus on integrated processes requires making new connections between and among concepts. The aim of ERP software as a business school instructional tool is an
experience with process integration that will allow students to understand business processes by re-structuring or extending their prior knowledge. Experiential learning with ERP software is intended to help expand business knowledge beyond traditional courses in marketing, management, finance, accounting, and information systems. Business schools are hoping students can combine their prior knowledge with direct experience of business processes through ERP software to produce new systemic connections. Learning by applying prior knowledge to experience is a basic tenet of constructivism and conceptual change (Brown, 2005, p.28). Conceptual change has been addressed most prominently by science educators (Driver, 1983, diSessa, 1993, Chi et al. 1994, Tyson et al., 1997, Carey, 2000). Conceptual change theory is an outgrowth of Piagetian developmental epistemology which views knowledge as a process of continuously generating and testing alternative propositions through interaction with objects (Tyson et al., 1997). Conceptual change theory was first proposed by Posner et al. (1982) adapting the Piagetian view of assimilation and accommodation. Posner et al. believed that assimilation occurred when existing concepts were used to cope with new data or new experiences, and accommodation occurred when central concepts were re-organized to reconcile anomalies between theory and experience. They determined that the process of accommodation brings about conceptual change in an individual in ways that are similar to changes that occur in scientific communities when scientific theories must be revised to accommodate anomalies as described by Kuhn (1996). They listed four conditions that had to be present for conceptual change to occur: (1) dissatisfaction with an existing conception, (2) new conception must be intelligible, (3) new conception must be plausible, and (4) new conception must be fruitful. A number of revisions to the
conceptual change viewpoint of Posner et al. (1982) have been made, including some by the original authors. The literature of conceptual change refers to both weak and strong revision of concepts, and the role of motivation and the learning environment (Tyson et al., 1997). Table 2.4 presents language used by theorists to describe conceptual change (Tyson et al., 1997, p. 390). While no uniform definition of conceptual change exists within the research community, science educators generally accept that conceptual change has occurred when students recognize that they have re-organized concepts in their minds to create new models of scientific reality that better fit observable data.

<table>
<thead>
<tr>
<th>Theorist</th>
<th>Addition</th>
<th>Degree of Conceptual Change</th>
<th>Strong Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posner et al. (1982)</td>
<td>Accretion</td>
<td>Weak Revision</td>
<td>Strong Revision</td>
</tr>
<tr>
<td>Strike &amp; Posner (1992)</td>
<td></td>
<td>Assimilation</td>
<td></td>
</tr>
<tr>
<td>Carey (1985)</td>
<td>Knowledge accumulation</td>
<td>Weak restructuring</td>
<td>Strong restructuring</td>
</tr>
<tr>
<td>Vosniadou (1994)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dykstra (1992)</td>
<td>Differentiation</td>
<td>Class extension</td>
<td>Reconceptualization</td>
</tr>
<tr>
<td>Hewson &amp; Hewson (1992)</td>
<td></td>
<td>Conceptual capture</td>
<td>Conceptual exchange</td>
</tr>
<tr>
<td>Schwedes &amp; Schmidt (1992)</td>
<td>Addition to nuclear rules / ideas</td>
<td>Change in relationships in nuclear rules / concepts</td>
<td>New nucleus of concept</td>
</tr>
<tr>
<td>Thagard (1992)</td>
<td>Belief revision</td>
<td>New partial or kind relation, new concept</td>
<td>Branch jumping or tree switching</td>
</tr>
<tr>
<td>Chi et al. (1994)</td>
<td>No change in concept ontological membership</td>
<td>Concept shift within categories of ontological tree</td>
<td>Shift in ontological tree</td>
</tr>
<tr>
<td>White (1994)</td>
<td>Addition</td>
<td>Knowledge change</td>
<td>System change</td>
</tr>
</tbody>
</table>

Table 2.4  Language of Conceptual Change

Conceptual change literature in scientific education describes a number of different ways to consider the creation and retention of knowledge. Driver (1987) describes alternative frameworks that satisfy student’s common sense views of the world.
Vosniadou (1994) claims students have internally consistent but sometimes incorrect models of the physical reality that surrounds them. Andrea diSessa (1993) describes knowledge in small chunks which she call phenomenological primitives (p-prims) that form the basis for naïve theories of the way the world works. All researchers of conceptual change concede that erroneous models of reality, however developed, may be very difficult to change. Cobern (1994) suggests that there may be no compelling reason for students to spend the time and energy re-orienting their worldviews to those that are more scientifically compatible if their current worldviews satisfy their current needs.

There is an analogy with scientific revolutions described by Thomas Kuhn. Kuhn claims all of science works under paradigms – major examples in science that consists of theory, method, instruments, and metaphysical commitments (assumptions which cannot be proven). These paradigms are not easily rejected or replaced since they have been developed by a community of science practitioners over a long period of time and they come closer than any other explanations to describe ontological truth. They are only displaced when sufficient anomalies are exposed that cannot be explained by current paradigms. Putting individual conceptions in a similar framework takes us back to the first requirement of Posner et al. (1982), that of dissatisfaction. There can be no radical shift of perspective unless there is sufficient discomfort to motivate the effort of reorientation.

Fortunately, conceptual change literature does not demand shifts in perspectives as radical those Kuhn describes as scientific revolutions. Conceptual change can occur by refining current knowledge just as science knowledge can be refined without replacing a current paradigm. Tyson et al. (1997) suggest that conceptual change can be
considered in three categories: (a) addition; (b) weak revision; and (c) strong revision. In
the Posner view, additive conceptual change occurs when students add additional
knowledge to previously established frameworks of thinking without altering the
frameworks. Weak revision occurs when students add additional “scaffolds” to
previously held conceptual frameworks but maintain their original architectural design.
Strong revision occurs when concepts are re-organized to create new models of reality
that better fit observable data. Chi et al. (1994) adopt a different perspective. Additive
conceptual change occurs when concepts are enriched without changing their ontological
category membership, weak revision occurs when concepts shift within categories of the
same ontological root, and strong revision occurs when concepts are re-assigned across
ontologically distinct categories.

CONCEPTUAL CHANGE AND ONTOLOGICAL CATEGORIES

Chi et al. (1994, p. 28) propose a theory of conceptual change in science
education dependent upon three suppositions: (a) epistemology involving the nature of
conceptions of entities in the world, (b) metaphysics involving the nature of certain
science concepts, and (c) psychology involving student naïve conceptions. These
suppositions are presented as three ontological categories, which are described as trees,
framing the epistemology of the nature of entities in the world: (a) matter, (b) processes,
and (c) mental states. Hierarchies of subcategories flow from these three trees. Matter
can be natural or artificial and processes may be procedures, events, or constraint-based
interactions. Subcategories inherit the defining properties of their parent categories
similar to the inheritance of class properties inherited by objects instantiated from them
in object oriented programming. Different trees offer different attributes. Matter has mass, processes occur over time or have cause and effect relationships, and mental states reflect intentions or emotional conditions. The Chi et al. (1994, p. 29) model of the nature of conceptions based on ontological trees is presented in Figure 2.4.

Figure 2.4 Chi et al. Model of an Epistemological Supposition of the Nature of Conceptions

Distinctions in ontological categories can be judged by associating attributes of one category with a member of another category to see if it makes sense. For example, associating the time characteristics of a process with an animal (a member of the matter ontological tree) results in a proposition like “an elephant is 60 seconds long” which does not make sense. Attribute/member combinations within a single ontological tree may be incorrect but do not present the incongruence of cross-tree associations. The proposition
that “an elephant is highly polished” may be incorrect but it cannot be described as categorically nonsensical.

The sensibility test of cross-tree associations is not necessarily obvious. The statement “a traffic jam occupies space” may not appear incongruous to many people because most people associate a traffic jam (process) with the cars (matter) that compose it, and cars clearly occupy space. Certainly “the dog is fearful” would not present a logical inconsistency even though the dog (matter) is associated with an emotional state (mental state). The fact that the feeling of fear is associated with the mind of the dog rather than its physical body does not present an obvious anomaly because the words “dog” and “human” can be used to refer to mental states as well as physical bodies.

Chi et al. (1994, p. 32) contend that the properties associated with members of the matter category often present problems with explanations of processes that involve matter components:

Confusion may arise, because Constraint-Based Interactions involve components of other ontological categories, especially MATTER. Returning to the example of electrical current, the MATTER components include moving particles, wires, batteries, and so on. But the involvement of these components does not imply that electrical current belongs in the same category with them. It remains neither a substance, nor a property of one of the component substances. It is simply a process which involves these substances. The current remains a process that is influenced by or is a component of Events that have beginnings and ends, but there is no intrinsic time course to the PROCESS itself.

Chi et al. (1994) focus on the differences between the matter and processes ontological trees, differentiating the concrete attributes of matter with the more abstract attributes of processes. They state that conceptual change occurs “when a concept has to be re-assigned to an ontologically distinct category (across trees)” (p. 31), and they claim that
scientific concepts characterized by constraint-based interactions are particularly difficult to learn. Constraint-based processes can be particularly confusing because they are more complex than the other process categories of procedure and events. The order, time, and sequence attributes of procedures and events are generally straightforward. There may be many steps in a procedure and many components and causes of events, but someone attempting to understand them would not likely re-assign concepts across ontologically distinct categories. Assimilation would be the most likely path to understanding procedures and events. Constraint-based interactions are much less straightforward. Constraints are often not readily apparent and often involve tricky analogies. The electrical current example described above is a good example. Current could be considered to “flow” through wire like water flows through pipes but a scientifically accurate understanding of current would require a student to re-assign the concept of electricity from matter (water) to process (constraint-based interaction) and recognize that, unlike water in pipes, electrons have no mass, there is no pressure differential in the wire, and no flow attributes similar to water.

Students learning business processes like sales order to payment (sales process) or material need to payment (purchase process) may also encounter some confusion where matter (goods) are also involved in constraint-based processes (economic evaluation). Malone et al. (1999) describe business process system dependencies falling in three categories: (1) flow, (2) fit, and (3) sharing. A flow dependency has a time dependence, precedent or antecedent. Flow relationships organize process components in chronological order. An order has to be placed before goods can be received. A fit dependency is established between two or more components that “fit” together to create
another process component. Sales forecast, item identification, and vendor identification are combined to produce a purchase order. A sharing dependency occurs when one process component shares resources with one or more other components. Warehouse facilities serve both shipping requirements of sales orders and receiving requirements of purchase orders. Flow, fit, and sharing relationships may involve any level of conceptual change (additive, weak revision, or strong revision) depending upon component classifications and relationships.

LEARNING THEORY

Jean Piaget introduced the developmental learning processes of assimilation and accommodation. Assimilation occurs when new experiences are perceived in terms of existing mental structures. Accommodation occurs when internal mental structures are changed to provide consistency with perceived external reality. Strike & Posner (1992) associated assimilation with weak revision conceptual change and accommodation with strong revision conceptual change. Kolb (1985) included the Piagetian models of assimilation and accommodation in two of his four learning styles. Assimilative learners assemble a wide range of concepts into concise, logical structures. They tend to be less focused on people and more interested in ideas and abstract concepts. Accommodative learners want “hands-on” experiences. They like to carry out well defined plans but often prefer not to create them. Accommodative learners prefer to collaborate and trust group decisions even at the expense of their own analysis. The Kolb view of accommodation does not concern itself with the mental structures present in the Strike & Posner view. Accommodators in the Kolb style are “hands-on” experience people who
interpret the world through active experimentation and concrete experience. If conceptual change requires assimilation and accommodation, learners who favor those learning styles should more likely exhibit evidence of conceptual change. Chi et al. (1994) provide a mechanism of measuring strong and weak revision conceptual change, i.e., strong conceptual change occurs when concepts are re-assigned from one ontological tree to another and weak conceptual change occurs when concepts shift in categories of the same ontological tree.

CONCLUSION

Since the 19th century education has been increasingly influenced by science and technology. Advances in computing technology since the 1990s make it possible for computer hardware and software to take a central role in current education pedagogy. Modern businesses connect (integrate) their business processes of logistics, operations, transactions, and accounting through enterprise resource planning (ERP) software. Business schools have adopted this software to help teach integration among business processes. Previous research indicates that students develop increased awareness of interconnected business processes when they use ERP software, but the claims for improved learning are based on student and faculty surveys, i.e., they are based on student opinions of their own learning or faculty opinions of student learning. Attempts to obtain empirical assessment data not based on surveys have shown few significant improvements of business process understanding when instruction includes ERP software compared to instruction without it. Differences between this study and previous research involving ERP software in business education are summarized in Table 2.5.
Table 2.5 Comparison of Current Study with Previous Research

<table>
<thead>
<tr>
<th>Topic</th>
<th>Wagner</th>
<th>Nelson &amp; Millet</th>
<th>Noguera</th>
<th>Davis &amp; Comeau</th>
<th>Rienzo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self assessment – high level overview</td>
<td>☑️</td>
<td>✗</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Self assessment – specific business processes</td>
<td>☑️</td>
<td>✗</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple choice questions specific to ERP software</td>
<td></td>
<td></td>
<td>✗</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple choice component/sequence questions generic to business processes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Qualitative Comments</td>
<td>☑️</td>
<td>✗</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Previous research studies included Likert scale survey questions concerning student self-assessment of their knowledge of business processes. This study assessed business process knowledge through component and sequence inquiries administered as short answer or multiple choice questions. Likert scale questions were used in the current study but only to determine self-assessment of overall improvements in business process knowledge. Students were also given an opportunity to comment on the benefits of ERP software in this study, providing a qualitative component to the analysis.

When previous research studies investigated process knowledge without using self-assessment surveys, questions were specific to the operation of the ERP software. Component and sequence questions administered during this study were generic to the business transaction processes involved although they were represented in the ERP software. In addition, this study employed the following interdisciplinary perspectives in examining business process knowledge resulting from experiential learning with ERP.
software:

1. Technology Acceptance Model (TAM) of Management Information Systems evaluating technology acceptance as a predictor for student self-assessment of learning,

2. learning styles of business management examining learning characteristics of students who may have tendencies and preferences particularly suitable for learning with software, and

3. conceptual change of Science Education investigating student conceptual models of business processes.

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2 Reprinted from Learning and Instruction, 4, Chi, Slotta, de Leeuw, "From Things to Processes,” page 29, Copyright 1994, with permission from Elsevier
CHAPTER 3: RESEARCH METHODS

This research project focuses on conceptual change, learning styles, and technology acceptance of undergraduate business students exposed to enterprise resource planning (ERP) business software in an introductory management information systems course. Conceptual change theory is an outgrowth of Piagetian developmental epistemology which views knowledge as a process of continuously generating and testing alternative propositions (Tyson et al., 1997). This study examines conceptual change from three perspectives:

1. Posner et al. (1982) view strong conceptual change driven by accommodation when central concepts are re-organized to reconcile anomalies between theory and experience. Weak conceptual change occurs through assimilation when existing concepts were used to cope with new data or new experiences.

2. Chi et al. (1994) view strong conceptual change occurring when concepts are re-assigned from one ontological tree to another. Weak conceptual change occurs when concepts shift in categories on the same ontological tree.

3. Kolb (1984) views accommodation and assimilation within a framework of learning styles. Accommodators are “hands-on” experience people who interpret the world through active experimentation and concrete experience and assimilators are people who assemble a wide range of concepts into concise, logical structures and interpret the world through reflective observation and abstract conceptualization.
The treatment of assimilation and accommodation from Piaget through Chi is shown in Figure 3.1.

![Diagram of Learning and Conceptual Change]

**MEASURING CONCEPTUAL CHANGE**

Chi *et al.* (1994) have reported student difficulties in learning concepts associated with constraint-based scientific processes. They suggest that confusion may stem from difficulties encountered in distinguishing constraint-based processes from the materials, procedures, and events involved in them. Demonstrations of electric current require batteries, wires, and light bulbs. Materials have to be connected, and that connection process has a defined beginning and end, but the current itself has no time course. Materials are clearly visible and the process of connecting battery, wires, and light bulbs
is straightforward. The electrical current process is hidden. Its characteristics are inferred from the behavior of the light bulbs when associated materials or events are changed. For instance, light bulbs can be arranged in parallel or series and placed in a pattern that puts bulbs in large differential distances from the battery. The order of connection of wires, battery, and bulbs could be varied. Constraint-based interactions are important in economics and business processes as well as in science. Production planning seeks to optimize profit within the constraints of limited resources. Managerial Science uses computer programs to optimize schedules or product mix. Economic value is the very basis of business and it is assigned to goods and services through complex interactions of buyers, sellers, governments, events, and availability of information. The process portion of the Chi et al. (1994) model (see Chapter 2, Figure 2.5, page 43) is extended in Figure 3.2 to include purchasing and sales business processes typically associated with enterprise software. Business processes like purchasing and sales that are optimized and controlled by Enterprise Resource Planning (ERP) software have easily understood materials that are shipped and received, but they also involve procedures with routine steps to create purchase and sales order documents and match invoices to goods receipt documents. Enterprise software records events with defined beginnings and endings that require communication and interaction like sales forecasts, order fulfillment, and payment receipts. The software also tracks economic valuation of the materials throughout the purchase or sales life-cycle, and assignments of purchased or sold goods to corporate accounts are not apparent from materials, procedures, and events that are obvious in the business process. Chi et al. (1994) have noted that understanding scientific processes involving constraint-based interactions are challenging to students.
Those same challenges may be present in constraint-based business processes, and the characteristics of ERP software may help student understanding of economic valuation processes that businesses associate with purchasing and sales.

Figure 3.2 Typical Purchasing and Sales Business Processes

The ERP Purchasing Process

The purchasing business process represented by enterprise software is presented in Figure 3.3. The matter and process ontological categories presented by Chi et al. (1994) are included in the graphic. A business purchase is an event with a defined
beginning (creation of the purchase order) and defined ending (payment for goods received).

Figure 3.3 Purchasing Business Processes

There are many procedures involved in a business purchase. A purchase order (PO) must be created to initiate the purchase, but the standard procedure that results in a purchase order does not begin until vendor choice and sales forecast events are complete. After the purchase order is created, standard procedures enable the following activities: (a)
release PO to the vendor, (b) receive goods, (c) post goods receipt to accounting documents, (d) match invoice to goods received, (e) post invoice to accounting documents, (f) pay invoice, and (g) post payments to accounting documents. Many procedures deal directly with the request, receipt, or payment of materials needed. Constraint-based processes are associated with the economic value system tracked through the business chart of accounts. They result from negotiated monetary values largely set by free markets. Economic valuation is not experienced directly during the purchasing process, but it is inferred through the accounting tracking system. The basic purchasing event is straightforward and easily relatable to students – order an item from a vendor, receive the item, and pay for it. The software reveals the many sub-procedures and processes that are needed for tracking and matching financial accounts with physical inventory.

The ERP Sales Process

The sales business process represented by enterprise software is presented in Figure 3.4. The matter and process ontological categories presented by Chi et al. (1994) are included in the graphic. A business sale is an event with a defined beginning (creation of the sales quote) and defined ending (payment for goods shipped).
There are many procedures involved in a business sale. A sales quote or sales order must be created to initiate the sale process, but the standard procedure that results in a sales order does not begin until an inquiry is received from a customer. After the sales order is created, standard procedures enable the following activities: (a) release
sales order, (b) fulfill the sales order (pick, pack ship), (c) create invoice, (d) post invoice to accounting documents, (e) receive payment, and (f) post payment to accounting documents. Like purchasing, many procedures deal directly with the request, organization, shipment, or payment of materials needed. Constraint-based processes are associated with the economic value system and tracked through accounting documents. Economic valuation is not experienced directly during the sales order fulfillment process, but it is inferred through the accounting tracking system. The basic sales event is straightforward and easily related to students. They receive an inquiry from a customer, get the item and send it to customer, and receive payment. The software reveals the many sub-procedures and processes that are needed for tracking the sales process and measuring the financial performance of the business.

Validation of the Purchase Order and Sales Order Processes

Enterprise Resource Planning (ERP) software is widely regarded as representing best practices in business processes (Soh, 2000; Dillard, 2006). Commercial companies use the software to control and optimize their transaction processes and coordinate timely distribution of data throughout the company. Global spending on ERP software in 2005 by companies around the world amounted to about $25 billion (“SAP Ranked #1”, 2006). Its strengths are its ability to connect purchasing, sales, human resources, production, and accounting data; and distribute that data throughout the commercial enterprise wherever it is needed. Its shortcomings may be its complexity and resource requirements. Its use in an academic environment is the focus of this research. Purchasing and sales
chronology of events and sequence of procedures detailed in the software can be considered authoritative, as can financial or economic valuations.

ASSESSMENT INSTRUMENTS

Question sets, based on business purchasing and sales processes represented in Microsoft Dynamics Great Plains® ERP software, were developed to measure student comprehension of process components and sequences. These question sets will be described as well as a rationale for their scoring. Purchasing and sales order processes have been well established in business for many years and the question sets required research participants to pick subprocesses shown in Figures 3.3 and 3.4 from a mixed list, associate them with purchasing or sales, and put them in correct sequential order. Research participants were also asked to choose subcomponents associated with specific purchasing and sales subprocesses, and also to pick the ten purchasing and sales activities they considered most important from a list. Question sets were administered at three time points: (1) after lecture descriptions of purchasing and sales business processes (time $t_0$), (2) after completing a purchasing or sales order ERP exercise (time $t_1$), and (3) after completing a second ERP exercise (time $t_2$) complementary to the first, i.e. participants completing the purchasing exercise at $t_1$ completed the sales exercise at $t_2$ and vice versa. Standard quantitative methods of paired $t$ tests and repeated measurement ANOVAs compared student subprocess, sequence, and subcomponent scores computed for time periods $t_0$ through $t_2$ and their interactions with potential factors influencing those scores: (a) Kolb learning style, and (b) assignment order. After the subprocess and subcomponent question sets were completed at time $t_2$, research participants were asked
to self-assess the value of the ERP software in helping them improve their knowledge of business processes. Regression analysis was used to determine if perceived software ease of use and usefulness predicted the value participants assigned to ERP software in helping them understand business processes. Analysis of variance was employed to determine if Kolb learning style affected the perceived benefits of ERP software. Standard qualitative techniques were also used to categorize student explanations of changes in their business process knowledge.

RESEARCH QUESTIONS AND DESIGN

Research activities conducted during this study were guided by the following research questions:

1. Does “hands-on” experience with ERP software promote conceptual change relative to two business processes (purchasing and sales) among undergraduate business students?

2. Do learning styles as measured by the Kolb Learning Style Inventory have different effects on learning and understanding of business processes after using ERP software?

3. Do experiential learning styles or technology acceptance affect student self-assessment of their learning, and is self-assessment consistent with comprehension of business processes as indicated by scores on experimental measurements?

The research design relationships of question set results to research questions are shown in Figure 3.5. The Kolb learning style has an established survey instrument distributed by the Hay Group Inc. of Boston, MA. Survey questions patterned after the
Technology Acceptance Model (TAM) of Davis (1989) were created to measure technology ease of use and usefulness.

![Research Design Diagram]

This research approach was unique in its attempt to empirically measure...
declarative knowledge, concepts, discriminatory knowledge, and procedural knowledge gained over time from an introductory experience with ERP software. Previous research has attempted to connect Kolb learning styles with ERP software experiences (Noguera, 2000) and analyze student self-assessment of knowledge gained through ERP exercises (Nelson & Millet, 2001; Wagner et al., 2000) but no attempts were made to objectively measure business process knowledge. This is the first study to address learning with ERP software from a conceptual change perspective, and the first to associate ERP software with generic business process knowledge involving measurements combining (a) declarative and procedural knowledge, (b) self-assessment of business process knowledge, and (c) qualitative commentary about the value of the software. Obtaining data for process knowledge measurement was a significant undertaking requiring two to four weeks of teaching the purchasing and sales enterprise ERP software assignments in the computer laboratory, grading assignment submissions, administering three repeated measurement instruments for subprocess and subcomponents, one learning style survey and one technology acceptance survey. Of the 125 initial participants, 105 (84 percent) provided usable data and 82 (65 percent) provided data for all instruments. The distinctive features of this study include:

- examination of conceptual change as students progress through business process assignments with ERP software.
- measurement of purchasing and sales process knowledge over time as students complete business processes through ERP software
- comparison of objective measurements of increases in declarative, procedural and discriminatory knowledge compared to self reported increases in understanding.
DATA COLLECTION PROCESS

Conceptual change occurring in undergraduate business students as a result of exposure to purchasing and sales business processes represented in enterprise software was explored through student responses to question sets inquiring about process components and sequences represented by ERP software. Exposure to enterprise software consisted of two required assignments, one utilizing enterprise software in a step-by-step approach to accomplish a complete purchasing cycle from sales forecast to payment. The following subprocesses were included: (a) sales forecast, (b) check inventory, (c) choose vendor, (d) create purchase order and release to vendor, (e) receive goods and post goods receipt, (f) receive invoice and match against goods received, (g) post invoice, and (h) pay invoice and post payment.

A second assignment utilized enterprise software to accomplish a complete sales order cycle from customer inquiry to payment. The following subprocesses were included: (a) receive customer inquiry, (b) check customer credit, (c) check inventory, (d) create sales quote, (e) create sales order, (f) fulfill sales order, (g) create and post invoice, and (h) receive and post payment. Each assignment presented students with subcomponents of the enterprise software system that connected with the main subprocesses shown above. For example, checking inventory included product identification, quantity, and site identification. Sales orders included product identification, quantity, site identification, sales commissions and freight. Quotes, orders, receipts, invoices, and payments all had tracking numbers.

Question sets inquiring about sequence, subprocesses, and subcomponents used the same terminology encountered in the ERP software assignments. These question sets resulted in either scores obtained by comparing submitted responses with optimum responses determined by the ERP software, or counts when students were asked to
choose business activities in sales and purchasing processes that they considered most important. Data involving potential covariate factors of gender, course grade, and undergraduate major were obtained from course records. Kolb learning style was determined for each research participant from an established learning style survey instrument distributed by the Hay Group, Inc. of Boston, MA. Technology ease of use and usefulness were also measured by survey, with slightly modified versions of established instruments created by Davis (1989). Reliability and principal component analyses were conducted with these instruments and component scores were created from student responses. Students were also asked to self-assess their understanding of business purchase and sales order processes as a result of their experience with the ERP assignments and comment on the benefit of using the ERP software.

All research participants were undergraduate students at a large mid-western university taking an introductory management information systems course required for all business majors and minors. The study was conducted as a case study in four summer semester sections with 105 students. All students accomplished a complete purchase cycle and complete sales order cycle through enterprise software using the same software functionality employed in commercial businesses. Question sets were developed from the subprocesses, sequences, and subcomponents of the software assignment to measure declarative and procedural knowledge of purchasing and sales order business processes. Enterprise Resource Planning software is production software, not instructional software. It is introduced in core undergraduate business courses for three reasons: (1) familiarize students with software used by an increasing number of businesses to integrate their business processes; (2) demonstrate relationships among logistics, financial accounting, and document tracking business systems, and (3) provide students with sufficient skills in the use of enterprise software to make business decisions in higher level classes.
The process of purchasing is common to everyone. Sales activities may not be quite as frequent but they are mirror images of purchasing experiences, and readily associated with them. In addition to personal selling events students might have experienced like selling back used textbooks to bookstores or selling a used car or computer, consumer on-line auction selling is commonplace at websites like eBay. The point of interest in process knowledge assessment was to find evidence of conceptual change, relative to purchasing and sales, occurring in student perspectives as a result of seeing the disciplined and data intensive processes businesses use to enable and track their purchases and sales. The purchasing and sales business processes of the study are directly relatable to the buying and selling experiences of the research participants. The familiarity of buying and selling would make it unlikely that business software would trigger complete reconstruction of purchasing and sales concepts but the added complexity of business sales and purchasing processes compared to similar consumer processes could cause sufficient dissatisfaction with prior knowledge to prompt additive or assimilative conceptual change with respect to buying and selling transactions. The data and tracking requirements for business transactions are much more rigorous than consumers experience when they buy or sell. ERP software may produce extensions of prior purchasing and sales concepts through the experience of document control, account maintenance, prediction, logistics control, and validation of receipt prior to payment. The development of question sets focused on declarative, procedural, and discriminatory knowledge and mirrored the activities encountered by the students as they used the ERP system to complete purchase and sales processes. Three processes segments were targeted: (a) subprocesses of purchasing and sales, (b) subprocess sequences, and (c) process subcomponents. Responses to question sets were collected across three time intervals: (1) after a lecture introduction of purchasing and sales but before exposure to
enterprise software purchasing or sales exercises, (2) after completing the first assigned ERP exercise, either purchasing or sales, and (3) after completing the second ERP exercise, either purchasing or sales.

Subprocess Data

Students were given the following list of 15 business subprocesses, 6 exclusive to purchasing and 6 exclusive to sales order processing represented by Microsoft Dynamics Great Plains® ERP software. Subprocess (13), checking inventory quantity, and subprocess (7), checking credit limits, were common to both. Subprocess (14), Update Buyer Employee Benefits, was irrelevant to both.

1. Create Sales Order
2. Create Sales Quote
3. Select Supplier
4. Review Sales Forecast
5. Receive Goods
6. Receive Payment
7. Check Credit Limit
8. Pay Invoice
9. Fulfill Order
10. Match Invoice / Receipts
11. Receive Customer Inquiry
12. Create Invoice
13. Check Inventory Quantity
14. Update Buyer Employee Benefits
15. Create Purchase Order

Students were not told which subprocesses were associated with purchasing and which were associated with sales. They were asked to choose correct purchasing subprocesses from items on the list and put them in correct sequence. They were also asked to make choices for business sales subprocesses using the same list and put them in correct procedural order. A model of subprocess data collection is shown in Figure 3.6. The model refers to subprocess categories (purchasing or sales) as activities and correct
procedural order as *sequence*. Purchasing and sales assignments were not given to all students in the same order. Two sections (Group A) completed the EPR purchasing assignment first followed by the sales assignment. Two sections (Group B) completed the ERP sales assignment first followed by the purchasing assignment. Both sections were given the same instructions to pick subprocesses and put them in correct sequence. Time $t_0$ in Figure 3.6 refers to question sets administered before the ERP purchasing or sales exercises. Time $t_1$ refers to questions sets administered after the first ERP exercise and time $t_2$ marks the completion of the second ERP exercise.

Figure 3.6 Subprocess and Subcomponent Data Collection
Subcomponent Data

In the assessment for subcomponent knowledge of purchasing and sales process steps, students were given 10 choices of subcomponents involved in purchasing or sales in multiple choice questions and asked to check all that applied to the following 12 subprocesses:

1. Checking Inventory
2. Creating a Sales Invoice
3. Matching Invoice/Receipts
4. Order Fulfillment
5. Payment
6. Purchase Order
7. Receiving Goods
8. Receiving Payment
9. Sales Forecast
10. Sales Order
11. Sales Quote
12. Selecting Supplier

Subcomponents are also represented in the model shown in Figure 3.6. Question sets related to subcomponents follow the same administration pattern as those involving subprocesses.

Students were also given a list of 21 purchasing or sales activities that could be segmented in the matter and process ontological trees of Chi et al. (1994) and asked to choose 10 that were most important to the purchase process and 10 most important to sales. Activities and ontological tree classifications are shown in Table 3.1.
Since question sets primarily addressed declarative and procedural knowledge, two questions were added in an attempt to measure application and synthesis knowledge resulting from interaction with the ERP software. Research participants were asked to choose documents needed to either make a payment for an item (purchase process) or close a sale (sales order process) from the following list:

1. sales order
2. payment receipt
3. purchase order
4. customer address
5. goods receipt
6. invoice
7. inventory item number

In order to answer these questions, students would have to connect document tracking
throughout the purchase or sales process with account posting and payments. Data was collected in time intervals previously described.

Scoring Question Sets

Optimum subprocess, sequence, and subcomponent responses to question sets were determined by the enterprise software itself. Enterprise software is widely recognized to be written to incorporate best business practices (Soh, 2000; Dillard, 2006).

Scoring Subprocess Activity Question Sets

Research participants were given a list containing 15 business subprocesses, asked to choose those involved in a business purchasing process and put them in sequential order. A second question provided an identical 15 item list requesting subprocesses and sequencing for a business sales process. The list was based upon the purchasing or sales activities carried out in the enterprise resource planning (ERP) software and included 6 purchasing activities carried out in the ERP software, 6 sales activities accomplished in with the software, two activities common to both purchasing and sales, and one activity irrelevant to both. Student responses were compared to optimum subprocesses and sequences as represented in the enterprise software package. Responses to subprocesses chosen from the 15 item list were compared to subprocesses used in the ERP purchasing and sales assignments. Every correct response received 1 point and every incorrect response received -1.25 points to minimize guessing. Points were added to each score to obtain a true zero and normalized to 15.

Sequence scores were computed by an algorithm calculating the position of each correct student activity choice in the optimum sequence represented in the ERP software
that determined if activity choices to its right and left were similarly positioned in the optimum sequence. A sample calculation appears in Table 3.2.

<table>
<thead>
<tr>
<th>Column</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>Total Score</th>
</tr>
</thead>
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<tr>
<td>Weight</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>Raw</td>
</tr>
<tr>
<td>Optimum Sequence</td>
<td>11</td>
<td>7</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>9</td>
<td>2</td>
<td>1</td>
<td>Normalized</td>
</tr>
<tr>
<td>Student Response</td>
<td>11</td>
<td>13</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>12</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Subprocess Activity Score</td>
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<td>1</td>
<td>-1.25</td>
<td>1</td>
<td>1</td>
<td>-1.25</td>
<td>1</td>
<td></td>
<td>2.5</td>
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<tr>
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</tr>
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<td>5</td>
<td>0</td>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.2 Subprocess Activity and Sequence Scoring

In the sample student response in row 4 of Table 3.2, activities 11, 13, 2, 1, and 12 appeared in the optimum sequence represented in the ERP software. Each received one point in row 5 (Subprocess Activity Score). Choices 3 and 4 resulted in a 1.25 point penalty for each activity, creating a total raw score of 2.5. Since the highest possible score was 8 and the lowest was -8.75, the raw score was transformed into a 15 point scale by adding 8.75 to the raw total, dividing by 16.75 and multiplying by 15, resulting in a normalized score of 10.07. The right side sequence scoring in column 1 of Table 3.2 recognized that student responses 13, 2, 1, and 12 appeared to the right of activity 11. Weighted points (Weight, row 2) for these activities (6, 5, 4, 2) were assigned to the student response of 11. Each remaining student choice was scored in the same way. The left side sequence scoring in column 7 of Table 3.2 recognizes that student responses 11, 7, 2, and 1 appear to the left of activity 12 resulting in weighted points 4, 5, 6, and 8 filling the left side sequence rows of column 7. The highest possible sequence score was
252 and the raw score was transformed into a 15 point scale by dividing the raw total by 252 and multiplying by 15 resulting in a normalized sequence score of 5.95. The sequence scoring algorithm is shown in flowchart form in the Appendix D. Weighted points were assigned depending upon the position of each component in the optimum sequence. The highest weights were given to the earliest components in the sequence. In right side scoring, all selections to the right of a given subprocess in a student sequence that appeared to the right of that same subprocess in the optimum sequence were given weighted points assigned to their optimum sequence positions. Scoring was similar for left side scoring. In cases where two components could logically be done in either order, multiple correct sequences were scored and students received their maximum computed scores. A sample spreadsheet cell formula used to calculate sequence scores appears in Appendix C.

**Scoring Subcomponent Process Knowledge**

Research participants were given multiple choice questions involving 12 subprocesses covered in the ERP sales and purchasing assignments. Each subprocess had a list of 10 possible subcomponents and students were asked to choose all subcomponents that applied to that subprocess. The subcomponent list was identical for all 12 questions:

a. Storage Location (Site ID)
b. Product (Item ID)
c. Commission
d. Vendor (Vendor ID)
e. Document Identifier (Document ID)
f. Customer (Customer ID)
g. Quantity
h. Account Changed (Account Posting)
i. Trade Discount
j. Freight
Scoring was straightforward. Students were given 1 point for each correct choice. In order to discourage guessing, each incorrect choice resulted in a deduction of 1.25 points. Subcomponent choices primarily addressed knowledge, comprehension and application in Bloom’s (1956) taxonomy. In order to examine the Bloom categories of analysis and synthesis, an additional two multiple choice questions were administered asking students to choose documents needed for a business to pay for an item or close a sale. Answering these questions requires an integrated understanding of the way businesses track their purchase and sales processes (see p. 240).

Scoring Factors

Kolb Learning Style

The Kolb Learning Style Inventory (LSI) is an established assessment instrument designed to help identify how individuals learn from experience. As of 2005, more than 6900 people had completed the learning style assessment instrument (Kolb & Kolb, 2005). It is distributed by the Hay Group, Inc. of Boston, MA which controls its application and use. Learning style categories were computed from the sums and differences of various parts of the LSI instrument as directed by Hay Group document MCB200D (Kolb, 2005).

Technology Ease of Use, Technology Usefulness, Self-assessment

A validated technology acceptance model (TAM) survey instrument (Davis, 1989) was modified to obtain scores from Likert scale responses ranging from “strongly disagree” to “strongly agree”. TAM measures user perception of two constructs that have influenced technology utilization in the workplace (Venkatesh & Davis, 2000): (a)
technology ease of use, and (b) technology usefulness. Since the Likert scale had 7 levels, points varying from -3 to 3 were assigned to survey responses. Cronbach’s Alpha was calculated to insure ease of use and usefulness questions were sufficiently interrelated to measure the same construct. Principal components analysis was used to reduce ease of use and usefulness questions into factors representing underlying constructs. The TAM survey also asked students to rank their improvement of business purchase or business sales understanding on the same 7 point Likert scale used for TAM questions. Scores for self-assessment responses were assigned points varying from -3 to 3.

Towards the latter part of the study, the TAM survey also included one question asking students to describe changes in their understanding of business purchase or sales processes relative to their ERP experience. This qualitative question was added because preliminary analyses indicated no substantive differences in subprocess or subcomponent scores as students progressed through the ERP purchasing and sales assignments, yet self-assessment scores overwhelmingly indicated survey participants believed their knowledge of purchasing and sales increased as a result of working with ERP software. Survey participants in the earlier parts of the study who did not have an opportunity to address this question during the TAM survey were asked to describe changes in their understanding of business purchasing and sales processes by electronic mail.
SCOPE OF ANALYSIS

Repeated Measures ANOVA

Repeated Measures Analysis of Variance (ANOVA) was used to evaluate significant differences among mean values of the same measurements made several times on research subjects. Repeated measurements examined during this study included scores for the following subprocesses and subcomponents: (a) subprocesses: activity and sequence, and (b) subcomponents: component choices for subprocesses listed on page 66-67. Repeated Measures ANOVA examines data from each time period measurement and calculates a “within-subjects” factor to test for statistical significance. All Repeated Measures ANOVA calculations in this study were performed thorough SPSS for Windows software, release 14 (SPSS, 2005). When calculating Repeated Measures ANOVA, the SPSS software also includes a multivariate analysis of variance (MANOVA) performed on the calculated factor representing measurement time differences and provides a measure of statistical significance for that factor. Assumptions of Repeated Measures ANOVA include (Leech, Barrett, & Morgan, 2005): (a) normal distribution of dependent data, and (b) sphericity – equal variances and covariances for each level of within subjects variables. The SPSS software provides methods to test for normality and sphericity. ANOVA is a robust statistical test and the SPSS software provides mechanisms to make adjustments when assumptions are violated to obtain valid statistical comparisons.
Paired Samples t Test

Paired Samples t Tests were used to compare means of two repeated measurements made on the same subjects. Paired Samples t Tests were used to clarify differences discovered in Repeated Measurements ANOVA or to investigate mean differences for two time points (e.g. t_2 and t_0) rather than three points (t_0, t_1, t_2). Assumptions for Paired Samples t Test include (Morgan, Leech, Gloeckner, & Barrett, 2005): (a) paired, dichotomous independent variables (associated with t_0, t_1, t_2 in this study), and (b) normal distribution of the dependent variables. SPSS software has methods of conducting Paired Samples t Tests and testing for assumptions.

Principal Components Analysis

Principal components analysis uses correlations among variables to reduce related variables into subsets representing underlying constructs. Principal components analyses were conducted on technology acceptance responses through SPSS software.

Linear Regression

Linear regression minimizes the sum-of-squared differences between a response (dependent) variable and a weighted combination of predictor (independent) variables that fit the following formula (SPSS, 2005)

\[ y_i = b_0 + b_1 x_{i1} + \ldots + b_p x_{ip} + e_i, \]

where

- \( y_i \) is the value of the \( i \)th case of the dependent variable
- \( p \) is the number of predictors
- \( b_j \) is the value of the \( j \)th coefficient, \( j = 0, \ldots, p \)
- \( x_{ij} \) is the value of the \( i \)th case of the \( j \)th predictor
- \( e_i \) is the error in the observed value for the \( i \)th case
Estimated coefficients reflect how changes in predictors affect response. Regression calculations were also carried out by SPSS statistical software.

Qualitative Analysis

Qualitative descriptions of student changes in their understanding of business purchasing and sales processes were analyzed from an interpretive orientation (Berg, 2004, p. 266) seeking patterns of meaning. Since there is only one qualitative question, analysis was limited to thematic coding and interpretation of manifest content expressed in student responses.

SUMMARY

This study examined conceptual change and learning styles in undergraduate business students interacting with enterprise resource planning (ERP) software. The concepts of accommodation and assimilation were examined with respect to business process knowledge through the perspectives of Posner et al. (1982), Chi et al. (1994) and Kolb (1984). They are shown in Table 3.3. Consideration of learning styles included accommodation and assimilation as well as divergent (generation of different concepts from an initial source) and convergent (structures a variety of concepts to address a single topic) methods of interpreting experience. Quantitative statistical methods of analysis of variance (ANOVA), Repeated Measures ANOVA, and paired t tests were used to connect conceptual change and learning styles to business process knowledge.
Table 3.3 Accommodation and Assimilation

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Accommodation</th>
<th>Assimilation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Posner <em>et al.</em></td>
<td>central concepts re-organized to reconcile anomalies between theory and experience</td>
<td>existing concepts used to cope with new data or new experiences</td>
</tr>
<tr>
<td>Chi <em>et al.</em></td>
<td>concepts re-assigned from one ontological tree to another</td>
<td>concepts shift in categories on the same ontological tree</td>
</tr>
<tr>
<td>Kolb</td>
<td>“hands-on” learning experience and interpretation through active experimentation and concrete experience</td>
<td>wide range of concepts in concise, logical structures and interpretation through reflective observation and abstract conceptualization</td>
</tr>
</tbody>
</table>

Self-assessments of improvements of business process knowledge as a result of interactive experiences with ERP software were also examined with respect to (a) learning style through ANOVA, and (b) the Technology Acceptance Model through linear regression. Finally, qualitative comments from ERP software users concerning the connection between the software and their business knowledge were examined for common themes and emerging trends.
CHAPTER 4: RESULTS AND ANALYSIS

INTRODUCTION

Data analysis is presented in this chapter. Results related to assessment of conceptual change were collected through question sets that asked students to categorize and sequence purchasing and sales business subprocesses, identify their subcomponents, and choose purchasing and sales activities they considered important. Question sets were organized as follows:

1. Students were presented with a list of business processes (see p. 64) and asked to associate items in the list with either business purchasing or business sales processes. Scores for these questions are presented as subprocess activities in this chapter.

2. Students were requested to arrange items from the list described above in either sequential purchasing order or sequential sales order. Scores for these questions are presented as subprocess sequences in this chapter.

3. Students were presented with 12 purchasing or sales subprocesses (see pp. 68-69) and asked to choose appropriate subcomponents of these subprocesses (see pp. 71-72). Scores for these questions are presented as subcomponents in this chapter.

4. Students were presented with a list of 21 purchasing or sales activities (see p. 70) and asked to choose 10 they considered most important for purchasing and most important for sales. Scores for these questions are presented as matter or process choices in this chapter.
Scores for subprocess activities, subprocess sequences, subcomponents, and matter/process choices were examined at three time points for statistical significance: (1) after lecture introduction of business purchasing and sales processes, but before students experienced enterprise resource planning (ERP) software; (2) after the first ERP assignment, either purchasing or sales; and (3) after the second ERP assignment, either purchasing or sales. The first time point is designated \( t_0 \) in this chapter, the second \( t_1 \) and the third \( t_2 \). Scoring differences were analyzed (a) with respect to all students in the study, (b) using Kolb learning styles as a between-subject factor, and (c) using assignment order as a between-subject factor.

Student self-assessments of changes in their understanding of business purchasing and sales processes were collected after \( t_2 \) and evaluated with respect to learning styles and technology acceptance.

CONCEPTUAL CHANGE

Answers to Research Question One

Does “hands-on” experience with ERP software promote conceptual change relative to two business processes (purchasing and sales) among undergraduate business students?

Question one was answered by analyzing student scores for subprocess activities, subprocess sequences, subcomponents, and matter/process choices at the three time points mentioned above with repeated measures ANOVA. Differences between two time periods \( (t_0 - t_1, t_0 - t_2, \text{ or } t_1 - t_2) \) were examined through paired \( t \) tests.
Subprocess Activities and Sequences

Descriptive statistics for purchasing and sales subprocess activities and sequences are shown in Table 4.1. The first column of the table shows labels of subprocesses with (a) transaction type, either purchasing (Pur) or sales (Sal); (b) data type, either activity (Act) or sequence (Seq); and (c) time point, either \( t_0 \), \( t_1 \), or \( t_2 \). For example, the first entry, PurAct_\( t_0 \), indicates that row 1 statistics refer to purchasing subprocess activities at time \( t_0 \). All scores were based on a 15 point scale. Sequence scores showed uniformly lower means and higher ranges and standard deviations than activity scores. Mean scores for purchasing and sales subprocess activities varied between 10.44 and 11.04 for all time points of the study. Standard deviations were 23 to 26 percent of mean values. Mean scores for purchasing and sales subprocess sequences varied between 5.63 and 6.61, but standard deviations were 53 to 62 percent of mean values. Analysis of score skewness indicated that student score distributions for all activity subprocesses were near normal since they all fell between -1 and 1 (Morgan et. al., 2005). Skewness of sequence subprocess scores were also in the -1 to 1 range, but the high standard deviation to mean ratio suggested a low likelihood of significant differences and careful consideration of normality when making inferences.
Table 4.1 Descriptive Statistics for Purchasing and Sales Subprocesses

<table>
<thead>
<tr>
<th>Subprocess</th>
<th>Statistic</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PurAct (_t_0)</td>
<td></td>
<td>101</td>
<td>4.03</td>
<td>15.00</td>
<td>10.44</td>
<td>2.702</td>
<td>-0.304</td>
</tr>
<tr>
<td>PurAct (_t_1)</td>
<td></td>
<td>102</td>
<td>3.13</td>
<td>15.00</td>
<td>10.55</td>
<td>2.517</td>
<td>-0.482</td>
</tr>
<tr>
<td>PurAct (_t_2)</td>
<td></td>
<td>97</td>
<td>5.82</td>
<td>15.00</td>
<td>10.58</td>
<td>2.458</td>
<td>-0.296</td>
</tr>
<tr>
<td>PurSeq (_t_0)</td>
<td></td>
<td>101</td>
<td>0.00</td>
<td>14.82</td>
<td>6.21</td>
<td>3.868</td>
<td>0.423</td>
</tr>
<tr>
<td>PurSeq (_t_1)</td>
<td></td>
<td>102</td>
<td>0.00</td>
<td>15.00</td>
<td>5.92</td>
<td>3.580</td>
<td>0.483</td>
</tr>
<tr>
<td>PurSeq (_t_2)</td>
<td></td>
<td>97</td>
<td>0.00</td>
<td>15.00</td>
<td>5.63</td>
<td>3.424</td>
<td>0.495</td>
</tr>
<tr>
<td>SalAct (_t_0)</td>
<td></td>
<td>101</td>
<td>4.93</td>
<td>15.00</td>
<td>10.70</td>
<td>2.664</td>
<td>-0.289</td>
</tr>
<tr>
<td>SalAct (_t_1)</td>
<td></td>
<td>102</td>
<td>5.15</td>
<td>15.00</td>
<td>11.04</td>
<td>2.643</td>
<td>-0.392</td>
</tr>
<tr>
<td>SalAct (_t_2)</td>
<td></td>
<td>96</td>
<td>4.03</td>
<td>15.00</td>
<td>10.66</td>
<td>2.727</td>
<td>-0.417</td>
</tr>
<tr>
<td>SalSeq (_t_0)</td>
<td></td>
<td>101</td>
<td>0.00</td>
<td>14.70</td>
<td>6.41</td>
<td>3.638</td>
<td>-0.125</td>
</tr>
<tr>
<td>SalSeq (_t_1)</td>
<td></td>
<td>102</td>
<td>0.00</td>
<td>14.46</td>
<td>6.61</td>
<td>3.515</td>
<td>0.035</td>
</tr>
<tr>
<td>SalSeq (_t_2)</td>
<td></td>
<td>96</td>
<td>0.00</td>
<td>13.93</td>
<td>5.99</td>
<td>3.600</td>
<td>0.130</td>
</tr>
</tbody>
</table>

Repeated Measures Analysis of Variance (ANOVA) was used to evaluate significant differences in a calculated within-subjects time factor for subprocess scores at points \(_t_0\), \(_t_1\), and \(_t_2\). No statistically significant differences were observed for the purchasing subprocess activity measurements over time. Similarly, no statistically significant differences were seen for either purchasing or sales subprocess sequences. Only sales subprocess activities generated statistically significant \(p\) values less than 0.05. Results for the multivariate analysis of variance statistic Hotelling’s Trace and repeated measures ANOVA for sales subprocess activity scores (SalAct\(_{t_0t_1t_2}\)) are presented in Table 4.2.

Table 4.2 Repeated Measures ANOVA for Sales Subprocess Activities

<table>
<thead>
<tr>
<th>SalAct(_{t_0t_1t_2})</th>
<th>N</th>
<th>Hotelling’s Trace</th>
<th>Rep Meas ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Value</td>
<td>(F)</td>
</tr>
<tr>
<td>SalAct(_{t_0t_1t_2})</td>
<td>89</td>
<td>0.07</td>
<td>3.11</td>
</tr>
</tbody>
</table>

Multivariate analysis of sales subprocess activities indicated a significant difference of scores over time, Hotelling’s Trace = 0.07, \(F\) (2, 87) = 3.11, \(p = 0.049\), multivariate \(\eta^2 =\)
0.067. This suggests that student choices for components of the business sales process were affected by the ERP assignments, although an $\eta$ value of 0.259 indicate a small difference using Cohen’s (as cited in Leech et al., 2005) guidelines. Working with the ERP software did not change student choices involving components or sequences of the business purchasing process, nor were choices about sequences of the business sales process affected. Even the statistical significance of the multivariate analysis for sales activities was not compelling evidence of differences in sales subprocess activities since repeated measures ANOVA did not show statistically significant differences, $F(2,176) = 2.67$, $p = 0.072$, and $\eta^2 = 0.029$. The Mauchly Test of Sphericity was not significant. With sphericity assumed, repeated measures ANOVA are generally assumed to be more discerning than MANOVA statistics (Leech et al., 2005). In addition to the non-significant $p$ values of repeated measures ANOVA, Hotelling’s Trace value (0.072) in the multivariate analysis was almost equal to Pillai’s Trace value (0.067). Equality of Hotelling’s Trace to Pillai’s Trace often suggests little comparative differences among measurements (Leech et al., 2005).

Repeated measured ANOVA was run for sales subprocess activity scores with Assignment Order as a factor to examine effects of the order in which ERP assignments were completed. Results of the ANOVA are shown in Table 4.3. There was no interaction effect of assignment order upon sales activity scores, $F(2,174) = 1.362, p = 0.259$, and $\eta^2 = 0.015$. Students who completed the ERP sales assignment first made no different choices for components of the business sales process at either $t_1$ or $t_2$ than students who completed the ERP purchasing assignment first.
Table 4.3  Repeated Measures ANOVA for Time Factor / Assignment Order Interaction for Sales Subprocess Activities

Analysis of subprocess activity and sequence scores showed no striking educationally meaningful effect of ERP software assignments upon the ability of students to assign purchasing or sales categories to business processes, and no effect upon the ability of students to place business purchasing and sales subprocesses in correct sequential order.

Subcomponents

Subcomponent questions examined student understanding of constituent parts of 12 purchasing or sales subprocesses. Table 4.4 lists processes involved in subcomponent choices, labels that appear in tables and charts of this chapter, and whether the subprocess serves business purchasing or sales (see p. 72 for subcomponent choices for each subprocess). The last row of Table 4.4 displays a composite subcomponent average, i.e. the grand average of subcomponent scores for all 12 subprocesses. The same 10 subcomponent choices were available for each subprocess. Students picked all that applied, and scores were calculated from those choices. For example, row 1 shows that scores for “Inventory” come from subcomponent choices which students associated with the subprocess of checking product quantities in inventory. The “Inventory” subprocess was involved in both the purchasing and sales ERP assignment.
<table>
<thead>
<tr>
<th>Subprocess</th>
<th>Label</th>
<th>Applies to</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check product quantities in inventory</td>
<td>Inventory</td>
<td>Purchasing / Sales</td>
</tr>
<tr>
<td>Create an invoice for a customer</td>
<td>Invoice</td>
<td>Sales</td>
</tr>
<tr>
<td>Match an invoice to goods received</td>
<td>MatchInvoice</td>
<td>Purchasing</td>
</tr>
<tr>
<td>Pick, pack, and ship an order</td>
<td>OrderFulfill</td>
<td>Sales</td>
</tr>
<tr>
<td>Pay an invoice</td>
<td>Pay</td>
<td>Purchasing</td>
</tr>
<tr>
<td>Create a purchase order</td>
<td>PO</td>
<td>Purchasing</td>
</tr>
<tr>
<td>Receive goods from a supplier</td>
<td>RcvGoods</td>
<td>Purchasing</td>
</tr>
<tr>
<td>Receive payment from a customer</td>
<td>ReceivePay</td>
<td>Sales</td>
</tr>
<tr>
<td>Check a sales forecast to compare with inventory</td>
<td>SalesForc</td>
<td>Purchasing</td>
</tr>
<tr>
<td>Create a sales order</td>
<td>SalesOrder</td>
<td>Sales</td>
</tr>
<tr>
<td>Creating a sales quote</td>
<td>SalesQuote</td>
<td>Sales</td>
</tr>
<tr>
<td>Select a supplier</td>
<td>SelSupplier</td>
<td>Purchasing</td>
</tr>
<tr>
<td>Composite Average of Previous 12 components</td>
<td>CompObj</td>
<td>Purchasing / Sales</td>
</tr>
</tbody>
</table>

Table 4.4 Subprocesses Involved in Subcomponent Choices

Descriptive statistics for subcomponent scores appear in Tables 4.5 through 4.7. Purchasing subcomponent scores appear in Table 4.5. Sales subcomponent scores appear in Table 4.6. Subcomponent scores for business processes that apply to both purchasing and sales appear in Table 4.7. Labels for subprocesses include $t_0$, $t_1$, or $t_2$ suffixes to indicate the three time points of the study. All scores were based on a 15 point scale.

Purchasing subcomponent scores are shown in Table 4.5. Analyses of data skewness indicated that student score distributions were near normal since they all fell between -1 and 1 (Morgan et. al., 2005). Mean values ranged from 7.93 for subcomponents of vendor payments at $t_1$ to 10.44 for supplier selection at $t_2$. Standard deviations were 21 to 26 percent of mean values except for vendor payments where standard deviations measured 32 to 36 percent of mean values. Higher standard deviations for payments may have resulted from confusion about (a) making a payment...
for a purchase, and (b) receiving a payment for a sale. Payment data is discussed on pages 137.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>MatchInvoice$\text{t}_0$</td>
<td>101</td>
<td>0.00</td>
<td>15.00</td>
<td>9.64</td>
<td>2.128</td>
<td>-0.864</td>
</tr>
<tr>
<td>MatchInvoice$\text{t}_1$</td>
<td>101</td>
<td>4.29</td>
<td>15.00</td>
<td>9.88</td>
<td>2.397</td>
<td>-0.176</td>
</tr>
<tr>
<td>MatchInvoice$\text{t}_2$</td>
<td>100</td>
<td>1.71</td>
<td>13.28</td>
<td>9.53</td>
<td>2.091</td>
<td>-0.668</td>
</tr>
<tr>
<td>Pay$\text{t}_0$</td>
<td>101</td>
<td>2.87</td>
<td>15.00</td>
<td>8.84</td>
<td>2.824</td>
<td>-0.035</td>
</tr>
<tr>
<td>Pay$\text{t}_1$</td>
<td>102</td>
<td>2.87</td>
<td>15.00</td>
<td>7.93</td>
<td>2.771</td>
<td>0.22</td>
</tr>
<tr>
<td>Pay$\text{t}_2$</td>
<td>100</td>
<td>2.87</td>
<td>15.00</td>
<td>8.44</td>
<td>3.029</td>
<td>0.015</td>
</tr>
<tr>
<td>PO$\text{t}_0$</td>
<td>101</td>
<td>2.79</td>
<td>13.60</td>
<td>9.07</td>
<td>2.227</td>
<td>-0.288</td>
</tr>
<tr>
<td>PO$\text{t}_1$</td>
<td>102</td>
<td>4.19</td>
<td>15.00</td>
<td>9.92</td>
<td>2.192</td>
<td>0.036</td>
</tr>
<tr>
<td>PO$\text{t}_2$</td>
<td>100</td>
<td>4.19</td>
<td>15.00</td>
<td>9.58</td>
<td>2.327</td>
<td>-0.425</td>
</tr>
<tr>
<td>RcvGoods$\text{t}_0$</td>
<td>101</td>
<td>3.53</td>
<td>15.00</td>
<td>9.85</td>
<td>2.614</td>
<td>-0.483</td>
</tr>
<tr>
<td>RcvGoods$\text{t}_1$</td>
<td>102</td>
<td>3.97</td>
<td>15.00</td>
<td>9.77</td>
<td>2.383</td>
<td>-0.083</td>
</tr>
<tr>
<td>RcvGoods$\text{t}_2$</td>
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<td>3.53</td>
<td>15.00</td>
<td>9.66</td>
<td>2.516</td>
<td>-0.408</td>
</tr>
<tr>
<td>SalesForc$\text{t}_0$</td>
<td>101</td>
<td>2.55</td>
<td>15.00</td>
<td>10.07</td>
<td>2.771</td>
<td>-0.681</td>
</tr>
<tr>
<td>SalesForc$\text{t}_1$</td>
<td>102</td>
<td>2.55</td>
<td>15.00</td>
<td>10.24</td>
<td>2.386</td>
<td>-0.547</td>
</tr>
<tr>
<td>SalesForc$\text{t}_2$</td>
<td>100</td>
<td>2.87</td>
<td>15.00</td>
<td>10.34</td>
<td>2.775</td>
<td>-0.355</td>
</tr>
<tr>
<td>SelSupplier$\text{t}_0$</td>
<td>101</td>
<td>4.64</td>
<td>15.00</td>
<td>10.43</td>
<td>2.108</td>
<td>-0.354</td>
</tr>
<tr>
<td>SelSupplier$\text{t}_1$</td>
<td>102</td>
<td>4.64</td>
<td>15.00</td>
<td>10.39</td>
<td>2.158</td>
<td>-0.511</td>
</tr>
<tr>
<td>SelSupplier$\text{t}_2$</td>
<td>100</td>
<td>3.57</td>
<td>15.00</td>
<td>10.44</td>
<td>2.347</td>
<td>-0.427</td>
</tr>
</tbody>
</table>

Table 4.5 Descriptive Statistics for Purchasing Subcomponent Scores

Descriptive statistics for sales subcomponent scores are shown in Table 4.6. As with purchasing subcomponent scores, skewness data indicated normal score distribution. Mean values ranged from 8.20 for subcomponents of sales orders at $t_0$ to 10.07 for order fulfillment at $t_1$. Standard deviations ranged from 22 to 30 percent of mean values except for payment receipts (ReceivePay) at time points $t_1$ and $t_2$ where standard deviations measured about 34 percent of mean values. As previously mentioned, greater standard deviations for payment data may be related to confusion about paying for an item in the
purchasing business process and receiving payment for an item in the sales business process (see pp. 137, 149).

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Subprocess</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invoicet0</td>
<td>101</td>
<td>1.58</td>
<td>15.00</td>
<td>9.03</td>
<td>2.700</td>
<td>-0.369</td>
<td></td>
</tr>
<tr>
<td>Invoicet1</td>
<td>102</td>
<td>3.55</td>
<td>13.42</td>
<td>9.45</td>
<td>2.093</td>
<td>-0.385</td>
<td></td>
</tr>
<tr>
<td>Invoicet2</td>
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<td>0.00</td>
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<td>9.26</td>
<td>2.534</td>
<td>-0.822</td>
<td></td>
</tr>
<tr>
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<td>101</td>
<td>1.67</td>
<td>13.67</td>
<td>9.44</td>
<td>2.634</td>
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</tr>
<tr>
<td>OrderFulfillt1</td>
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<td>10.07</td>
<td>2.231</td>
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<td></td>
</tr>
<tr>
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<td>13.67</td>
<td>10.04</td>
<td>2.176</td>
<td>-0.325</td>
<td></td>
</tr>
<tr>
<td>ReceivePayt0</td>
<td>101</td>
<td>4.15</td>
<td>15.00</td>
<td>8.93</td>
<td>2.633</td>
<td>0.341</td>
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</tr>
<tr>
<td>ReceivePayt1</td>
<td>102</td>
<td>1.60</td>
<td>15.00</td>
<td>8.88</td>
<td>3.037</td>
<td>0.144</td>
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</tr>
<tr>
<td>ReceivePayt2</td>
<td>100</td>
<td>2.87</td>
<td>15.00</td>
<td>8.89</td>
<td>2.997</td>
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</tr>
<tr>
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</tr>
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<td>9.48</td>
<td>2.422</td>
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<td>100</td>
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</tr>
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<td>15.00</td>
<td>9.35</td>
<td>2.392</td>
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</tr>
<tr>
<td>SalesQuotet2</td>
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<td>13.57</td>
<td>8.96</td>
<td>2.444</td>
<td>-0.131</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.6 Descriptive Statistics for Sales Subcomponent Scores

Descriptive statistics for subcomponent scores pertaining to both purchasing and sales are shown in Table 4.7. Data distributions for inventory were negatively skewed at time points $t_1$ and $t_2$, which indicated normal distribution of inventory scores before the ERP assignments but non-normal distribution of inventory scores after ERP assignments (Morgan et. al., 2005). The negatively skewed distribution could mean subcomponents of inventory became more recognizable to students after the ERP assignments, clustering more scores at the higher end of the scoring scale. Inventory also produced the highest mean values of the subcomponent study, ranging from 11.80 at $t_0$ to 12.27 at $t_2$. Since CompObj was a grand average of all subcomponent scores, its standard deviation values were the least, measuring about 10 to 12 percent of mean values.
Sales Orders, Sales Quotes, and Subcomponent Composite

Repeated Measures Analysis of Variance (ANOVA) was used to evaluate the effect of ERP assignments on subcomponent choices for 12 purchasing or sales subprocesses measured at time points $t_0$, $t_1$, and $t_2$. Differences were observed for subcomponent scores involving (a) sales order, $F(2, 184) = 9.03, p < 0.001$, and $\eta^2 = 0.090$; (b) sales quote, $F(2, 184) = 8.286, p < 0.001$, and $\eta^2 = 0.083$; and (c) the composite subcomponent average, $F(1.8, 165.7) = 7.215, p = 0.001$, and $\eta^2 = 0.073$. The Mauchly Test of Sphericity was significant for CompObj, requiring a Huynh-Feldt correction for the composite component average. Means and standard deviations for subcomponent scores related to these subprocesses, ordered by time points of the study, are shown in Table 4.8. Examination of these means suggests that the first ERP assignments prompted higher subcomponent scores, i.e. scores that were more consistent with the purchasing or sales processes represented by the ERP software. But improvements did not continue through the second ERP assignment. In fact, scores following the second ERP assignment uniformly dropped although not to the original levels at $t_0$. Values for $\eta$ ranged from 0.27 to 0.3 for the three subcomponent scores.

<table>
<thead>
<tr>
<th>Subprocess</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>CompObjt0</td>
<td>101</td>
<td>5.72</td>
<td>12.55</td>
<td>9.46</td>
<td>1.004</td>
<td>-0.025</td>
</tr>
<tr>
<td>CompObjt1</td>
<td>102</td>
<td>7.82</td>
<td>12.99</td>
<td>9.80</td>
<td>0.986</td>
<td>0.703</td>
</tr>
<tr>
<td>CompObjt2</td>
<td>100</td>
<td>6.12</td>
<td>12.89</td>
<td>9.69</td>
<td>1.144</td>
<td>0.044</td>
</tr>
<tr>
<td>Inventoryt0</td>
<td>101</td>
<td>4.47</td>
<td>15.00</td>
<td>11.80</td>
<td>2.457</td>
<td>-0.659</td>
</tr>
<tr>
<td>Inventoryt1</td>
<td>102</td>
<td>3.19</td>
<td>15.00</td>
<td>12.19</td>
<td>2.586</td>
<td>-1.065</td>
</tr>
<tr>
<td>Inventoryt2</td>
<td>100</td>
<td>3.83</td>
<td>15.00</td>
<td>12.17</td>
<td>2.646</td>
<td>-1.136</td>
</tr>
</tbody>
</table>

Table 4.7 Descriptive Statistics for Subcomponent Scores for Purchasing and Sales
Using Cohen’s (as cited in Leech et al., 2005) guidelines, there were moderate differences across the three time points.

<table>
<thead>
<tr>
<th>Subprocess</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>SalesOrdert₀</td>
<td>8.20</td>
<td>2.449</td>
</tr>
<tr>
<td>SalesOrdert₁</td>
<td>9.48</td>
<td>2.422</td>
</tr>
<tr>
<td>SalesOrdert₂</td>
<td>8.87</td>
<td>2.501</td>
</tr>
<tr>
<td>SalesQuotet₀</td>
<td>8.21</td>
<td>2.305</td>
</tr>
<tr>
<td>SalesQuotet₁</td>
<td>9.35</td>
<td>2.392</td>
</tr>
<tr>
<td>SalesQuotet₂</td>
<td>8.96</td>
<td>2.444</td>
</tr>
<tr>
<td>CompObjt₀</td>
<td>9.46</td>
<td>1.004</td>
</tr>
<tr>
<td>CompObjt₁</td>
<td>9.80</td>
<td>0.986</td>
</tr>
<tr>
<td>CompObjt₂</td>
<td>9.69</td>
<td>1.144</td>
</tr>
</tbody>
</table>

Table 4.8 Means and Standard Deviations for Subcomponent Scores

Polynomial contrasts supported this parabolic effect with significant quadratic trends for all three subprocesses; (a) sales order, $F(1, 92) = 17.25, p < 0.001$, and $\eta^2 = 0.158$; (b) sales quote, $F(1, 92) = 10.88, p = 0.001$, and $\eta^2 = 0.106$; the composite subcomponent average, $F(1, 92) = 14.06, p < 0.001$, and $\eta^2 = 0.133$. Parabolic trends for the three subprocesses can be seen in the plot of marginal means with time, shown in Figure 4.1. Sales quotes and sales orders are very similar processes, and students recognized that similarity as they changed subcomponent choices as a result of completing the ERP assignments.

Assignment Order

Repeated measures ANOVA were conducted for subcomponent scores involving sales order, sales quote, and the composite subcomponent average including assignment order as a factor. There were no significant interaction effects for (a) sales order, $F(2, 182) = 1.98, p = 0.141$, and $\eta^2 = 0.021$; (b) sales quote, $F(2, 182) = 0.122, p = 0.885$, and $\eta^2 = 0.106$; and (c) the composite subcomponent average, $F(2, 182) = 0.174, p = 0.840$,.
and $\eta^2 = 0.002$. Assignment order had no effect upon subcomponent choices for the 12 subprocesses measured in this study.

**Figure 4.1** Subcomponent Marginal Means for Sales Order, Sales Quote, and Composite Subcomponent Average

**Paired $t$ tests**

Paired or correlated samples $t$ tests conducted on subcomponent scores from combinations of the three time points in the study involving sales order, sales quote, and the composite subcomponent average (CompObj) indicated that student subcomponent scores were higher at either $t_1$ or $t_2$ compared with $t_0$. Paired $t$ statistics for subcomponent scores of the three subprocesses appear in Table 4.9. Using Cohen’s (as cited in Leech et al., 2005) guidelines, differences for $t_1 - t_0$ sales order and sales quote scores were medium. Differences for all remaining score comparisons were small.
<table>
<thead>
<tr>
<th>Subprocess</th>
<th>Time period</th>
<th>$t$</th>
<th>$df$</th>
<th>$p$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales Order</td>
<td>$t_1 - t_0$</td>
<td>4.377</td>
<td>97</td>
<td>&lt; 0.001</td>
<td>0.525</td>
</tr>
<tr>
<td>Sales Order</td>
<td>$t_2 - t_0$</td>
<td>2.137</td>
<td>95</td>
<td>0.035</td>
<td>0.270</td>
</tr>
<tr>
<td>Sales Quote</td>
<td>$t_1 - t_0$</td>
<td>4.244</td>
<td>97</td>
<td>&lt; 0.001</td>
<td>0.462</td>
</tr>
<tr>
<td>Sales Quote</td>
<td>$t_2 - t_0$</td>
<td>2.413</td>
<td>95</td>
<td>0.018</td>
<td>0.288</td>
</tr>
<tr>
<td>CompObj</td>
<td>$t_1 - t_0$</td>
<td>3.871</td>
<td>97</td>
<td>&lt; 0.001</td>
<td>0.340</td>
</tr>
<tr>
<td>CompObj</td>
<td>$t_2 - t_0$</td>
<td>1.977</td>
<td>95</td>
<td>0.051</td>
<td>0.216</td>
</tr>
</tbody>
</table>

Table 4.9  Paired $t$ Statistics for Subcomponent Scores

Initial exposure to ERP assignments, either purchasing or sales processes, did a measurable change of medium effect upon a small subset of subcomponent scores: (a) sales order, (b) sales quote, and (c) the composite subcomponent average. Significant changes occurred overwhelmingly between time period $t_0 - t_1$. The most pronounced differences occurred with the sales order process. A paired $t$ test also indicated that sales order scores at time point $t_1$ were higher than scores at time point $t_2$, $t (96)=2.053$, $p=0.043$, $d=0.247$. According to Cohen (as cited in Leech et al., 2005) this is a small difference.

Subcomponent Choices

Percentages of subcomponent choices for the sales order subprocess at the three time points of the study are shown in Figure 4.2. Students were asked to pick subcomponents of a sales order from the following list: (a) storage location (site ID), (b) product (item ID), (c) commission, (d) vendor (vendor ID), (e) document identifier (document ID), (f) customer (customer ID), (g) quantity, (h) account changed (account posting), (i) trade discount, and (j) freight. Letters corresponding to the previous choices appear on the abscissa of the figure. Clearly, ERP assignments completed after $t_0$ and $t_1$ did not change responses for every subcomponent choice, but several subcomponents
changed by more than 10 percentage points at times $t_1$ or $t_2$ compared with $t_0$: (1) document identifier (e), (2) trade discount (i), and (3) freight (j).

![Figure 4.2 Percentages of Subcomponent Choices for Sales Order](image)

Percentages of subcomponent choices for the sales quote subprocess at the three time points of the study are shown in Figure 4.3. Students were asked to pick subcomponents of a sales quote from the same list previously described for sales orders. Once again, ERP assignments completed after $t_0$ and $t_1$ did not disrupt the patterns established at $t_0$ but customer (f) and freight (j) changed by more than 10 percentage points. More modest increases were observed for commissions (c), document identifiers (e), and account posting (h).
Repeated measures ANOVA also detected differences over time in subcomponent scores involving subprocesses needed to pick, pack, and ship a sales order (order fulfillment), and create a purchase order. Both order fulfillment, $F(2, 184) = 3.049, p = 0.05, \eta^2 = 0.032$, and creating a purchase order, $F(2, 184) = 3.104, p = 0.047, \eta^2 = 0.033$, yielded subcomponent mean scores that increased after the first ERP assignment and declined slightly after the second. Means and standard deviations for subcomponent scores related to these subprocesses, ordered by time points of the study, are shown in Table 4.10. The data pattern is similar to that of sales order, sales quote, and the composite subcomponent average already discussed. Scores increase after the first ERP
assignment and decline following the second ERP assignment although not to the original levels at \( t_0 \). Values for \( \eta \) ranged from 0.179 to 0.182 for the two subcomponent scores. Using Cohen’s (as cited in Leech et al., 2005) guidelines, there were small differences across the three time points.

<table>
<thead>
<tr>
<th>Subprocess</th>
<th>Mean</th>
<th>Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>OrderFulfill(t_0)</td>
<td>9.44</td>
<td>2.634</td>
</tr>
<tr>
<td>OrderFulfill(t_1)</td>
<td>10.07</td>
<td>2.231</td>
</tr>
<tr>
<td>OrderFulfill(t_2)</td>
<td>10.04</td>
<td>2.176</td>
</tr>
<tr>
<td>PO(t_0)</td>
<td>9.07</td>
<td>2.227</td>
</tr>
<tr>
<td>PO(t_1)</td>
<td>9.92</td>
<td>2.192</td>
</tr>
<tr>
<td>PO(t_2)</td>
<td>9.58</td>
<td>2.327</td>
</tr>
</tbody>
</table>

Table 4.10 Means and Standard Deviations for Subcomponent Scores

Marginal means for order fulfillment and purchase order subcomponent scores can be seen in Figure 4.4. Polynomial contrasts did not support a parabolic effect, in contrast to previously described sales order and sale quote subprocesses. Quadratic trends for order fulfillment, \( F (1, 92) = 3.126, p = 0.08, \eta^2 = 0.033 \), and purchase order creation, \( F (1, 92) = 3.642, p = 0.059, \eta^2 = 0.038 \), were not significant.

Assignment Order

A repeated measures ANOVA analysis was conducted for subcomponent scores involving order fulfillment and purchase order subprocesses including assignment order as a factor. There were no significant interaction effects for purchase order creation, \( F (2, 182) = 0.632, p = 0.533, \eta^2 = 0.007 \), but there was a significant interaction between assignment order and subcomponent order fulfillment scores, \( F (2, 182) = 3.055, p = 0.050, \eta^2 = 0.032 \). Students who completed the ERP sales assignment first achieved
higher subcomponent scores order fulfillment at time $t_1$ than students who completed the ERP purchasing assignment first.

Figure 4.4 Subcomponent Marginal Means for Order Fulfillment and Purchase Order

Marginal means of subcomponent scores for order fulfillment segmented by assignment order are plotted in Figure 4.5. Order fulfillment is a sales subprocess. Students completing the sales ERP assignment as their first assignment would have recently encountered order fulfillment in the ERP system at time $t_1$. Students who completed purchasing as their first assignment would have dealt with order fulfillment just before $t_2$. The plot follows time proximity to ERP exercises, i.e. scores improve immediately following the ERP sales assignment, but students who completed sales as
the first ERP assignment revert back to $t_0$ levels by the time they take the $t_2$ research instrument.

Figure 4.5 Subcomponent Marginal Means for Order Fulfillment By Assignment Order

**Paired $t$ tests**

Paired or correlated samples $t$ tests conducted on subcomponent scores from combinations of the three time points in the study involving order fulfillment and creating a purchase order indicated that student subcomponent scores were higher at time point $t_1$ than $t_0$. Paired $t$ statistics for subcomponent scores appear in Table 4.11. Using Cohen’s (as cited in Leech *et al.*, 2005) guidelines, $t_1 – t_0$ differences were small.

<table>
<thead>
<tr>
<th>Subprocess</th>
<th>Time period</th>
<th>$t$</th>
<th>df</th>
<th>$p$</th>
<th>$d$</th>
</tr>
</thead>
<tbody>
<tr>
<td>OrderFulfill</td>
<td>$t_1 – t_0$</td>
<td>2.208</td>
<td>97</td>
<td>0.030</td>
<td>0.259</td>
</tr>
<tr>
<td>PO</td>
<td>$t_1 – t_0$</td>
<td>2.485</td>
<td>97</td>
<td>0.015</td>
<td>0.382</td>
</tr>
</tbody>
</table>

Table 4.11 Paired $t$ Statistics for Subcomponent Scores
Subcomponent Choices

Percentages of subcomponent choices for the order fulfillment subprocess at the three time points of the study are shown in Figure 4.6. Students were asked to pick subcomponents of a sales order from the following list: (a) storage location (site ID), (b) product (item ID), (c) commission, (d) vendor (vendor ID), (e) document identifier (document ID), (f) customer (customer ID), (g) quantity, (h) account changed (account posting), (i) trade discount, and (j) freight. Letters corresponding to the previous choices appear on the abscissa of the figure. ERP assignments did not alter the general pattern of responses from students, but document identifier (e) and customer id (f) increased by about 10 percentage points for assessments at times $t_1$ and $t_2$ (after ERP assignments were completed) compared with $t_0$. 

![Figure 4.6 Percentages of Subcomponent Choices for Order Fulfillment](image-url)
Percentages of subcomponent choices for the purchase order subprocess at the three time points of the study are shown in Figure 4.7. Students were asked to pick subcomponents of a sales quote from the same list previously described for order fulfillment. Responses that changed more than 10 percentage points after the ERP assignments included storage location (a) and trade discount (i). Document identifier (e) increased 20 percentage points after the first ERP assignment, but returned to $t_0$ levels after the second ERP assignment.

![Figure 4.7 Percentages of Subcomponent Choices for Purchase Orders](image)

**Figure 4.7** Percentages of Subcomponent Choices for Purchase Orders

**Segmenting Subcomponent Composite Scores**

Since three sales process subcomponents, one purchasing subcomponent, and the subcomponent composite average showed statistically significant differences in repeated measurements ANOVA, the CompObj score was disaggregated into purchasing and sales
components. Descriptive statistics of purchasing and sales subcomponents are shown in Table 4.12. The grand mean for purchasing subcomponents (PurComp) was 10.01 and the grand mean for sales (SalComp) was 9.63. Skewness data indicated normal distributions with values between -1 and 1 (Morgan et. al., 2005).

<table>
<thead>
<tr>
<th>Statistic</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>PurComp(_t_0)</td>
<td>101</td>
<td>5.648</td>
<td>13.182</td>
<td>9.955</td>
<td>1.132</td>
<td>-0.735</td>
</tr>
<tr>
<td>PurComp(_t_1)</td>
<td>102</td>
<td>7.507</td>
<td>13.080</td>
<td>10.047</td>
<td>1.120</td>
<td>0.438</td>
</tr>
<tr>
<td>PurComp(_t_2)</td>
<td>100</td>
<td>6.201</td>
<td>13.424</td>
<td>10.036</td>
<td>1.272</td>
<td>-0.008</td>
</tr>
<tr>
<td>SalComp(_t_2)</td>
<td>100</td>
<td>4.379</td>
<td>12.995</td>
<td>9.713</td>
<td>1.438</td>
<td>-0.545</td>
</tr>
<tr>
<td>SalComp(_t_1)</td>
<td>102</td>
<td>7.323</td>
<td>12.755</td>
<td>9.904</td>
<td>1.327</td>
<td>0.152</td>
</tr>
<tr>
<td>SalComp(_t_0)</td>
<td>101</td>
<td>5.907</td>
<td>13.324</td>
<td>9.266</td>
<td>1.223</td>
<td>0.144</td>
</tr>
</tbody>
</table>

Table 4.12  Descriptive Statistics for Purchasing and Sales Subcomponent Composites

Repeated measures ANOVA with a Huynh-Feldt correction were conducted to determine differences in purchasing and sales subcomponent scores at time points \(t_0\), \(t_1\), and \(t_2\). The analyses indicated significant effects of time for sales subcomponents, \(F(1.92, 176.4) = 12.99, p < 0.001, \eta^2 = 0.124\), but not for purchasing subcomponents, \(F(1.96, 179.8) = 0.549, p = 0.575, \eta^2 = 0.006\). Mean values of sales subcomponent scores rose from \(t_0\) to \(t_1\) and then dropped at \(t_2\) suggesting that ERP prompted an increase in sales subcomponent scores after the first assignment but no improvement from the second. In fact, there was a downward trend after completion of the second assignment, although scores at \(t_2\) were higher than original scores at \(t_0\). The sales subcomponent value for \(\eta\) was 0.352. Using Cohen’s (as cited in Leech et al., 2005) guidelines, there were medium differences across the three time points. Since the only significant interaction of assignment order with score differences over time occurred with order
fulfillment, it did not matter if the first ERP assignment was the sales or purchasing assignment. Polynomial contrasts for sales subcomponents suggested a parabolic effect with a significant quadratic trend, \( F (1, 92) = 22.39, p < 0.001, \) and \( \eta^2 = 0.196 \). Marginal means of purchasing and sales subcomponent scores plotted in Figure 4.8.

![Figure 4.8 Marginal Means of Purchasing and Sales Subcomponents](image)

Paired \( t \) tests confirmed that, compared with original scores at \( t_0 \), sales subcomponent scores were higher at \( t_1, t (97) = 5.41, p < 0.001, d = 0.533, \) and \( t_2, t (95) = 2.813, p = 0.006, d = 0.313 \). There was no statistically significant difference between scores at \( t_2 \) compared to \( t_1 \). Completing the first ERP assignment boosted sales subcomponent scores but no benefit was derived from the second. Using Cohen’s (as cited in Leech et al., 2005) guidelines, differences between \( t_0 \) and \( t_1 \) were medium. Differences between \( t_0 \) and \( t_2 \) were small.
Matter and Process Choices

Students were asked to choose 10 most important purchasing and sales activities from a list of 21 subprocesses and subcomponents they encountered in the ERP software assignments. Of the 21 choices, 12 (57%) had characteristics of matter and 9 (43%) had characteristics of processes. The average number of matter or process choices at $t_0$, $t_1$, and $t_2$ plotted in Figure 4.9. A slight decline in sales matter choices and slight increase in sales process choices are evident in the plot.

Figure 4.9  Ten Important Purchasing / Sales Business Activities

A repeated measures ANOVA analysis was conducted to assess differences in the average number of matter or process choices made with time. There were no significant differences in matter or process for either sales or purchasing choices. Although Figure 4.9 indicates ERP assignments prompted a slight trend toward sales process choices with time, differences are not significant using repeated measures ANOVA. Paired $t$ tests
indicated that ERP assignments may have influenced lower matter sales choices at \( t_2 \) compared with \( t_1 \), \( t(81) = 2.02, p = 0.047, \) and \( d = 0.245 \). Using Cohen’s (as cited in Leech et al., 2005) guidelines, the effect was small.

Application and Synthesis Knowledge in the Bloom Taxonomy

In an attempt to measure student responses in the analysis and synthesis categories of the Bloom taxonomy, repeated measures ANOVA were conducted to determine differences with time in subcomponent scores for questions asking for (a) documents needed to pay for a purchased item, and (b) documents needed to close a sale. Differences were not significant.

Evidence of Conceptual Change

Lack of measurable change in purchasing and sales subprocesses, and all but one purchasing subcomponent suggests that accommodation as described by Posner et al. (1982) in which central concepts are re-organized to reconcile anomalies between theory and experience did not occur as a result of student experience with ERP software. Neither accommodation (concepts re-assigned from one ontological tree to another) nor assimilation (concepts shifting in categories on the same ontological tree) as described by Chi et al. (1984) resulted from ERP software assignments since there was no evidence of movement from matter to process for purchasing scores and only a small difference in matter choices for sales. Medium to large changes involving subcomponents may indicate assimilation as suggested by Posner et al. (1982) in which existing concepts are used to cope with new data or new experiences. Changes with time in subcomponent
scores could also be considered *addition* as described by Tyson *et al.* (1997) which includes accretion, enrichment, and addition to nuclear rules or ideas.

**Summary of Answers to Research Question One**

There are no statistically significant differences with time in student scores measuring declarative and procedural knowledge of business purchasing and sales subprocess activities or sequences as a result of completing a purchase or sale through ERP software. Some statistically significant moderate differences exist in one purchasing and three sales subcomponents. Sales measurements seem to have experienced more change than purchasing, showing increased awareness of document identification, trade discounts, freight charges, commissions, and account posting. When composite subcomponent scores were disaggregated into sales and purchasing categories, only sales produced statistically significant differences. Changes in important sales activity choices were significant for sales matter choices but not for sales process or for purchasing matter or process choices. ERP software did not prompt accommodation as described by either Posner *et al.* (1982) or Chi *et al.* (1984) but measurable differences for four subcomponents and the subcomponent composite average suggest assimilation as described by Posner *et al.* (1982). Subcomponent score differences with time could also be labeled as *addition* (Tyson *et al*., 1997).

When a change occurred after the first ERP assignment, there was no improvement after the second assignment. Assignment order did not affect subcomponent differences with one exception. Order fulfillment had a significant assignment order interaction with subcomponent scores over time. Students who
completed the sales ERP assignment nearest to time $t_2$ achieved order fulfillment scores higher at $t_2$ than $t_0$.

KOLB LEARNING STYLES

Answers to Research Question Two

Do learning styles as measured by the Kolb Learning Style Inventory affect student understanding of purchase and sales processes after experiencing these processes through ERP software?

Question two was answered by analyzing student scores for subprocess activities, subprocess sequences, and subcomponents at the three time points of the study with learning styles used as a between-subjects factor in repeated measures ANOVA. Differences between two time periods ($t_0 - t_1$, $t_0 - t_2$, or $t_1 - t_2$) were examined through paired t tests, segmented by learning styles.

Kolb learning style frequencies are presented in Table 4.13. Of the 105 study participants, 88 completed the learning style survey. Every learning style represented at least 20 percent but no more than 30 percent of the total. The divergent (DI) and accommodative (AC) learning styles comprised about 28 to 30 percent of survey respondents, while assimilative (AS) and convergent (CO) styles categorized 20 to 22 percent of study participants who completed research surveys. Learning styles popularity, ordered from greatest to least, was as follows: DI > AC > CO > AS.
Learning Style | Number | Percent
--- | --- | ---
AC | 25 | 28.41
AS | 18 | 20.45
CO | 19 | 21.59
DI | 26 | 29.55
Total | 88 | 100.00

Table 4.13  Kolb Learning Style Frequencies

Learning Styles and Business Process Scores

Repeated Measures Analysis of Variance (ANOVA) revealed no statistically significant interactions of the four Kolb learning styles with subprocess or subcomponent score differences over the three time points of data collection. One significant interaction did occur when Kolb learning styles were segmented as hemispheres rather than quadrants, combining accommodative and divergent learners under the category of “Concrete Experience” and convergent and assimilative learners under the category of “Abstract Conceptualization”. The convergence of learning styles is shown in Figure 4.10. A repeated measures ANOVA with Huynh-Feldt correction conducted on the subcomponent composite average showed a statistically significant interaction of hemispheric learning styles with subcomponent score differences over the three time points of the study, $F(1.89,155) = 6.898$, $p = 0.002$, $\eta^2 = 0.139$. The subcomponent composite average value for $\eta$ was 0.373. Using Cohen’s (as cited in Leech et al., 2005) guidelines, there were large differences across the three time points.
Estimated marginal means of the subcomponent composite average, segmented by concrete experience or abstract conceptualization are shown in Figure 4.11. Polynomial contrasts showed a significant linear trend for the interaction of learning style with score changes of the subcomponent composite average, $F (1, 82) = 5.37, p = 0.023$, and $\eta^2 = 0.061$. When considering the aggregate of subcomponent scores, the significant linear trend suggests that the ERP assignments were more helpful to learning styles that relied upon concrete experience (accommodative and divergent) than abstract concepts (convergent and assimilative). As previously observed, increased scores were only seen after the first ERP assignment.
Even though learning styles showed no significant factor interaction with repeated measures ANOVA, there were significant paired \( t \) tests among two time periods that can be linked to learning styles. Only the Assimilative (AS) and Accommodative (AC) learning styles showed significant differences in subprocess or subcomponent mean scores. Students with assimilative learning styles scored higher in sales subprocess activities at both \( t_1 \) and \( t_2 \) compared with \( t_0 \) scores. Sales subprocess sequence scores were higher at \( t_1 \) compared with \( t_0 \). Paired \( t \) statistics for subprocess scores appear in Table 4.14. Using Cohen’s (as cited in Leech et al., 2005) guidelines, differences for subprocess activity scores were small while those of subprocess sequence scores were medium. ERP assignments seemed to have increased subprocess knowledge of assimilative learners to a small to medium degree. The previous pattern of the largest change appearing after completion of the first ERP assignment continued.
Students with accommodative learning styles scored higher in sales subprocess activities after the first ERP assignment ($t_1$) than after the second ($t_2$) but scores at either time point were not significantly different from sales subprocess activity scores before the ERP assignments were attempted ($t_0$). For accommodative learners, the most significant differences occurred with scores calculated from subcomponent composite averages. The ERP assignment prompted higher subcomponent scores at $t_1$ and $t_2$ compared with $t_0$. The largest differences occurred at $t_1$. Disaggregation of subcomponent composite scores into purchasing and sales components showed statistically significant differences over time for the sales segment (SalesComp) but not for purchasing. Difference effects for the sales segment were higher than those for subcomponent composite averages. Paired $t$ statistics appear in Table 4.15. Using Cohen’s (as cited in Leech et al., 2005) guidelines, differences for subprocess activity scores were small while those of subcomponent composites were medium to large.
Summary of Answers to Research Question Two

Repeated measures ANOVA revealed no significant interactions of standard Kolb learning styles with subprocess or subcomponent scores over the $t_0 - t_2$ time periods of the study, but a significant interaction did occur between the subcomponent composite scores and learning styles relying on concrete experience. When considering the aggregate of subcomponent scores, ERP assignments were more helpful to learning styles that relied upon concrete experience than abstract concepts.

Paired $t$ tests demonstrated significant differences in scores for two learning styles: accommodative and assimilative. Assimilative learning styles showed significant differences in sales activity subprocess scores. ERP assignments seemed to have increased subprocess knowledge of assimilative learners to a small to medium degree. Accommodative styles showed significant differences in subcomponent composite scores, and even larger differences when the subcomponent composite averages were separated into their purchasing and sales constituent parts. Differences in subcomponent scores changing for accommodative learners after completing ERP assignments over time for were isolated to sales rather than purchasing subcomponents.
Do experiential learning styles or technology acceptance affect student self-assessment of their learning, and is self-assessment consistent with comprehension of business processes as indicated by scores on experimental measurements?

Question three was answered by regression analysis conducted on (a) the two factors of the Technology Acceptance Model, ease of use and usefulness, and (b) subprocess and subcomponent scores as predictors for learning self-assessment scores. The effect of learning style upon self-assessment was evaluated through a one-way ANOVA. Self-reported reasons for self-assessment scores were also analyzed qualitatively for dominant themes.

Technology Acceptance Model

Research participants completed a Technology Acceptance Model (TAM) survey, adapted from Davis (1989) that consisted of seven questions measuring technology ease of use (EOU) and eight questions measuring technology usefulness (USE). Principal component analysis with varimax rotation was conducted on ease of use and usefulness responses to TAM survey questions to create predictor variables for regression with student self-assessment scores. One factor was extracted from the seven EOU questions indicating a single EOU construct. The extracted factor accounted for 51% of score variance. Items and factor loadings are shown in Table 4.16. The two highest loadings for the EOU factor involved questions directly asking students if the ERP software was “easy to use” and if they were able to use it successfully. The smallest loading came from a question about general comfort with technology. Cronbach’s alpha was computed
in order to assure that the seven items that created the EOU factor formed a reliable scale. The alpha for EOU components was 0.829 indicating reasonable internal consistency.

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfort with Technology</td>
<td>0.468</td>
</tr>
<tr>
<td>Clear and understandable interaction with ERP software</td>
<td>0.757</td>
</tr>
<tr>
<td>Interaction with ERP software does not require a lot of mental effort</td>
<td>0.600</td>
</tr>
<tr>
<td>ERP software system easy to use</td>
<td>0.827</td>
</tr>
<tr>
<td>ERP system easy to obtain desired outcome</td>
<td>0.815</td>
</tr>
<tr>
<td>Easy to describe ERP results</td>
<td>0.712</td>
</tr>
<tr>
<td>Results of ERP software are apparent</td>
<td>0.730</td>
</tr>
</tbody>
</table>

Table 4.16  Factor Loadings for Ease of Use

Principal component analysis with varimax rotation extracted two factors for usefulness responses to the Technology Acceptance Model survey. Items and factor loadings are shown in Table 4.17. The two factors emerging from the analysis dealt with broad themes of social influence and future job performance. The four questions contributing to the job performance factor all had high loading effects. Highest loadings in the social influence factor came from questions involving expectations of influential people. Cronbach’s alpha was also computed for the eight items that created the two USE factors, social influence and job performance. The alpha value for job performance USE components was 0.903 and alpha for social influence was 0.809, showing internal consistency similar to that of EOU scores.
Table 4.17  Factor Loadings for Usefulness Rotated Factors

Descriptive statistics for the single EOU factor (Ease of Use), the two USE factors (Social Influence and Job Performance), and student self-assessment scores are shown in Table 4.18. Values for the three computed TAM factors were based on a standard normal distribution with means of zero and standard deviations of one. Self-assessment scores represent student opinions of their increased knowledge of business purchasing (ERPPurch) and sales (ERPSales) processes.

Table 4.18  Descriptive Statistics of TAM and Self-Assessment
Learning Self-assessment

After completion of both ERP assignments, students were asked to respond to a statement that ERP assignments increased their understanding of business purchasing and sales processes. There were seven Likert scale responses ranging from “Strongly disagree” to “Strongly agree”. Responses were scored by assigning points from -3 for a “Strongly disagree” response to +3 for a “Strongly agree” response. A “Neutral” response received 0 points. Separate questions addressed perceived understanding of purchasing processes and sales processes. Distribution of purchasing self-assessment (ERPPurch) responses is shown in Figure 4.12. About 86 percent of responses were in the “somewhat agree” to “strongly agree” segments (scores 1 to 3).

![Figure 4.12 Distribution of ERP Purchasing Self-assessment Responses](image)

Similar trends were observed for responses to sales self-assessment (ERPSales) which are shown in Figure 4.13. About 83 percent of all responses fell in the “somewhat agree”
to “strongly agree” segments with more than 33 percent of respondents strongly agreeing that their ERP experience increased their understanding of business purchasing and sales processes.

![Figure 4.13 Distribution of ERP Sales Self-assessment Responses](image)

**Figure 4.13** Distribution of ERP Sales Self-assessment Responses

Linear Regression of TAM and Student Self-assessment

Multiple regression was conducted to determine the best linear combination of TAM factors for predicting student self-assessment scores. The use of all three factors (Ease of Use, Job Performance, and Social Influence) significantly predicted purchasing and sales self-assessment scores, but collinearity statistics indicated potential unreliability of regression results because Ease of Use and Job Performance contained much of the same information. Ease of Use was removed from the analysis with no loss in statistical significance and a slight improvement in adjusted $R$ squared values. Means,
standard deviations, and intercorrelations for the regression of Job Performance and Social Influence on purchasing self-assessment scores (ERPPurch) are shown in Table 4.19. This combination of variables significantly predicted purchasing self-assessment scores, $F(2, 92) = 20.63, p < 0.001$, with both variables contributing significantly to the prediction.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Intercorrelations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPPurch</td>
<td>1.747</td>
<td>1.263</td>
<td>0.411** 0.375**</td>
</tr>
<tr>
<td><em>Predictor Variable</em></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Social Influence</td>
<td>0.000</td>
<td>1.000</td>
<td>- 0.000</td>
</tr>
<tr>
<td>2 Job Performance</td>
<td>0.000</td>
<td>1.000</td>
<td>0.000 -</td>
</tr>
</tbody>
</table>

**p < 0.001

Table 4.19 Mean, Standard Deviation, and Intercorrelations of Purchasing Self-assessment and Predictor Variables (N=95)

Beta weights, presented in Table 4.20, suggest that both higher expectations of improved job performance and social pressure to learn the enterprise software were likely to result in more favorable learning self-assessments. The adjusted $R$ squared value was 0.3 indicating that 30 percent of the variance in purchasing self-assessment was explained by the model. Using Cohen’s (as cited in Leech *et al.*, 2005) guidelines, this was a large effect.
Table 4.20  Multiple Regression Summary for Social Influence and Job Performance Predicting Learning Self-assessment of Purchasing Business Processes (N=95)

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SEB</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Influence</td>
<td>.52</td>
<td>.11</td>
<td>.411**</td>
</tr>
<tr>
<td>Job Performance</td>
<td>.48</td>
<td>.11</td>
<td>.375**</td>
</tr>
<tr>
<td>Constant</td>
<td>1.747</td>
<td>.11</td>
<td></td>
</tr>
</tbody>
</table>

R²=0.3; F(2,92)=20.63, p < 0.001 **p<0.01

Means, standard deviations, and intercorrelations for the regression of Job Performance and Social Influence on sales self-assessment scores (ERPSales) are shown in Table 4.21. This combination of variables was statistically significant in predicting sales self-assessment scores, $F(2, 92) = 26.05, p <0.001$, with both variables contributing significantly to the prediction.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev</th>
<th>Intercorrelations</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPSales</td>
<td>1.64</td>
<td>1.312</td>
<td>0.420** 0.382**</td>
</tr>
<tr>
<td><strong>Predictor Variable</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Social Influence</td>
<td>0.000</td>
<td>1.000</td>
<td>- 0.000</td>
</tr>
<tr>
<td>2 Job Performance</td>
<td>0.000</td>
<td>1.000</td>
<td>0.000 -</td>
</tr>
</tbody>
</table>

**p < 0.001

Table 4.21  Mean, Standard Deviation, and Intercorrelations of Sales Self-assessment and Predictor Variables (N=95)

Beta weights, presented in Table 4-22, suggest that both higher expectations of improved job performance and more social pressure to learn the enterprise software were likely to result in more favorable learning self-assessments. The adjusted $R$ squared value was 0.31, indicating that 31 percent of the variance in purchasing self-assessment was explained by the model. Using Cohen’s (as cited in Leech et al., 2005) guidelines, this was large effect.
### Table 4.22

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SEB</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Influence</td>
<td>.551</td>
<td>.11</td>
<td>.420**</td>
</tr>
<tr>
<td>Job Performance</td>
<td>.601</td>
<td>.11</td>
<td>.382**</td>
</tr>
<tr>
<td>Constant</td>
<td>1.642</td>
<td>.11</td>
<td></td>
</tr>
</tbody>
</table>

$R^2=0.31; F(2,92)=26.05, p < 0.001$

**p<0.01

#### Learning Styles and Self-assessment

A One-Way ANOVA was conducted to compare mean values of purchasing (ERPPurch) and sales (ERPSales) self-assessments for the four Kolb learning styles. The mean scores for neither purchasing learning self-assessments, $F(3, 79) = 1.935, p = 0.131$, nor sales learning self-assessments, $F(3, 79) = 2.005, p = 0.120$, were statistically significant. Learning self-assessment scores were not affected by Kolb learning style.

#### Self-assessment and Business Process Measurements

Only one business process score demonstrated a significant regression relationship with self-assessment scores — subcomponent composite score differences between times $t_0$ and $t_1$. Means, standard deviations, and intercorrelations for the regression of composite score differences between $t_0$ and $t_1$ (ComObjt1t0) on purchasing (ERPPurch) and sales (ERPSales) self-assessments are shown in Table 4.23. Subcomponent score differences significantly predicted purchasing, $F (1, 88) = 3.97, p = 0.049$, and sales, $F (1, 88) = 7.2, p < 0.01$, self-assessment scores. Beta weights of 0.2 (purchasing) and 0.275 (sales) indicate that larger differences in subcomponent object scores between $t_0$ and $t_1$ were likely to result in more favorable learning self-assessments. Even though predictions were statistically significant, adjusted $R$ squared values were
0.03 to 0.045 indicating that 3 to 4.5 percent of the variance in self-assessment was explained by the model. Using Cohen’s (as cited in Leech et al., 2005) guidelines, this was a small effect.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Purch</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPPurch</td>
<td>1.72</td>
<td>1.28</td>
<td>0.208*</td>
<td></td>
</tr>
<tr>
<td>ERPSales</td>
<td>1.63</td>
<td>1.29</td>
<td>0.275*</td>
<td></td>
</tr>
</tbody>
</table>

* p < 0.03

Table 4.23 Mean, Standard Deviation, and Intercorrelations of Self-assessment with Subcomponent Score Differences

Values for $R^2$ were marginally elevated when using only the purchasing component of subcomponent composite scores. Means, standard deviations, and intercorrelations for the regression of the purchasing composite score differences between $t_0$ and $t_1$ (PurchCompt1t0) on purchasing (ERPPurch) and sales (ERPSales) self-assessments are shown in Table 4.24. Subcomponent score differences significantly predicted purchasing, $F(1, 88) = 5.43$, $p = 0.022$, and sales, $F(1, 88) = 8.7$, $p < 0.004$ self-assessment scores. Beta weights of 0.241 (purchasing) and 0.3 (sales) suggest that larger differences in purchasing subcomponent object scores between time $t_0$ and $t_1$ were likely to result in more favorable learning self-assessments. Adjusted $R^2$ squared values increased to 0.047 to 0.08 indicating that 5 to 8 percent of the self-assessment variance was explained by the regression model. Using Cohen’s (as cited in Leech et al., 2005) guidelines, this was a small effect.
### Table 4.24  Mean, Standard Deviation, and Intercorrelations of Self-assessment with Purchasing Subcomponent Score Differences

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Purch</th>
<th>Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERPPurch</td>
<td>1.72</td>
<td>1.28</td>
<td>0.241*</td>
<td></td>
</tr>
<tr>
<td>ERPSales</td>
<td>1.63</td>
<td>1.29</td>
<td></td>
<td>0.300*</td>
</tr>
<tr>
<td>PurchCompt120</td>
<td>0.150</td>
<td>1.278</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.03

#### Qualitative Self-assessment

Dominant themes of 34 student descriptions of changes in their understanding of business purchasing and sales processes as a result of their experience with ERP software appear in Table 4.25. Gender representation of the subset of students providing explanations of their understanding reflected the study population, 69 percent male and 31 percent female.

<table>
<thead>
<tr>
<th>Theme</th>
<th>N</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>more granularity – seeing steps</td>
<td>22</td>
<td>61.1%</td>
</tr>
<tr>
<td>appreciation for whole</td>
<td>5</td>
<td>13.9%</td>
</tr>
<tr>
<td>complexity</td>
<td>7</td>
<td>19.4%</td>
</tr>
</tbody>
</table>

#### Table 4.25  Student Changes in Understanding Business Processes

The overriding theme, mentioned by over 60 percent of respondents, was greater granularity, i.e. comprehending the many subprocesses of purchasing or sales in a connected sequence. Often the increased granularity came from the steps of the ERP exercises. Some examples of student explanations of their appreciation of purchasing and sales granularity follow:

- It helped me realize the steps that need to occur, and the different ways of making the orders. Before this I had no clue to the order of steps that needed to occur other than what common sense said.
Showed me the steps that are used specifically in sales or purchase processes and helped me to understand what was most important about each step along the way.

It has really broken down the exact purposes for every aspect of sales and purchasing, I feel I also have a better understanding of the differences between each. For example, parts like invoicing, and inventory checking.

In general it exposed me to the steps that were required to make a purchase or sale. I learned more about the process when something went wrong in the exercise. Up until something going wrong I was just following steps from the book, which did not require much effort on my part. But once the next steps didn't work I had to back track and think about what I was trying to accomplish. In doing so I had to understand the purchase or sale process. Most of the information I needed to do this was in the instructions or background information provided in the work book.

I never knew exactly what steps and what the documents of business processes really looked like.

The word “steps” appears in 36 percent of responses, but student explanations indicated more than just a breakdown of steps. There was an undertone of parts engineered to form a larger whole. An additional 14 percent of respondents expressed a new appreciation for holistic purchasing or sales processes whether or not they explicitly mentioned step components, expressing opinions like these:

- I now understand how business transactions take place outside of retail stores, in home offices and in distribution centers.
- Using enterprise has helped me understand more about sales and purchases. I believe that this will help me further in life.
- My experience with Enterprise software has significantly increased my understanding of business sales processes and purchase processes because the projects showed the many areas of business affected just by a simple sales or purchase order.
- ERP helped me understand things better in many ways. When I was working through the steps I really came to understand how things are put together and how a business works. Going through and actually seeing the sales processes and business purchase visually instead of physically made me realize what actually happens while these processes are being made. The invoices, customer client lists, and different menus helped me to really understand everything in ERP!!!

Taken together 75 percent of students claimed they were making better connections in their own minds between the parts and the whole because of ERP software. Finally, there
is the theme of complexity. Almost 20 percent of students responding to the self-assessment explanation question indicated a greater awareness of the complexity of modern business transactions. They expressed that increasing awareness in a variety of ways:

- I never knew how much there was to a simple purchase or shipment of goods. It keeps things very organized for the company to go through their records and see what they shipped, for how much, where it came from, and where it went.
- It has increased my knowledge of how the processes are completed and information is stored, not lost.
- Well I guess I could say that it helped me see the ordering aspect of a business. I have been on the receiving side of a business environment for a long time. It was nice to deal with software that gave me a look into the way they may be ordering things to send to us. Also in how the suppliers, buyers, warehouses, and stores all can rely on one system. Being exposed to that kind of put things into perspective I'd say.

In summary, student responses suggested that the biggest impression made by ERP was system architecture, the connection of constituent pieces to serve the larger whole.

Summary of Answers to Research Question Three

Kolb learning styles did not significantly impact student self-assessments of their understanding of business purchasing and sales processes as a result of interacting with ERP software, but technology usefulness as measured by the Technology Acceptance Model predicted self-assessment scores reasonably well. A statistically significant relationship was found between student self-assessment scores and differences between $t_1$ and $t_0$ of the purchasing segment of the subcomponent composite average. Student self-evaluations of improvements in purchasing and sales knowledge were not consistent with minor differences in subprocess and subcomponent score measurements. Self-assessments indicated improved knowledge of business purchasing and sales transactions
as students completed purchasing and sales transactions through ERP software assignments. Subprocess and subcomponent scores indicated sporadic changes in declarative and procedural knowledge over the time period of the study with respect to sales subcomponents, although accommodative learners experienced some large changes with respect to subcomponent composite averages. Qualitative survey responses suggested that students’ knowledge improvements stemmed from an increased comprehension of purchasing and sales process architecture – the connection of individual components engineered into systems that create a larger whole.
CHAPTER 5: DISCUSSION AND CONCLUSIONS

Results of this study are discussed in this chapter and related to prior research findings. Except for statistically significant changes observed with purchase order subcomponents, all significant differences seen in the study involved sales subprocesses or subcomponents. This chapter presents a more granular examination of subprocess and subcomponent choices made during the study, and offers explanations for changes in sales related processes that are rooted in science education literature. Science education also provides insight into the parabolic learning effect, i.e. scores rising after the first ERP assignment and falling after the second. Significant differences segmented by learning style are explained through business management literature. The relationship observed between student self-assessment and technology usefulness is addressed through Management Information System literature. A model of student conceptions of business purchasing and sales processes relative to Enterprise Resource Planning software is offered. The last section of the chapter describes limitations of the study and recommendations for future research.

INFORMATION SYSTEMS COURSE AND ERP

Students participating in this research attended four sections of an introductory course covering computerized information systems in business. The course is required for all business majors and minors. About 72 percent of research participants were either business majors or intending to be business majors. Duration of the course was eight weeks during a summer session. The course focused on the role of computerized
information systems in modern business processes. Enterprise Resource Planning (ERP) software was introduced as a primary method that businesses use to connect logistics with accounting, procurement, production, and sales. The software was operational software rather than instructional software, but its subjects are familiar to every research participant – buying and selling. Students participated in computer assignments that engaged them in a complete purchasing and sales process, step-by-step, with ERP software. ERP software assignments included purchasing and sales business processes that represented best practices in business processes. The intention of the assignments was to have students learn about business processes by performing business processes. Education literature, particularly science education literature, has addressed conceptual frameworks that students use to construct knowledge as they learn (Driver, 1983; Tyson, 1997; Carey, 2000). This research project assumed that students had buying and selling life experiences that established mental frameworks for purchasing and sales processes. The increased rigor involved in business purchasing and sales (document control, account maintenance, formalized prediction, logistics control, validation of receipt before payment) are not part of typical consumer buying and selling experiences. The first research question asked if students’ experiences with business processes through ERP software, which are more complex than the ones familiar to them, had induced conceptual changes related to buying and selling

CONCEPTUAL FRAMEWORKS

Science education literature contrasts student conceptions of scientific phenomena with established expert consensus explaining those phenomena. Driver (1983) claims
that students simultaneously interpret and construct their knowledge about the world directly through their experiences. In Driver’s interpretation of knowledge construction, prior experiences of buying and selling should build conceptual frameworks of purchasing and sales that students bring into their coursework, and into their ERP assignments. The study was conducted assuming all research participants had established concepts of purchasing and sales before interacting with enterprise software. Chi and Roscoe (2002) suggest that students often miss parts of scientifically accepted paradigms in their understanding of scientific concepts but they are not tabula rasa — blank slates void of content. They bring established concepts to their educational experiences, however naïve. Science educators have found that naïve conceptions can interfere with more formal processes and paradigms accepted by the scientific community (diSessa, 1993; Carey, 2000; Chi & Roscoe, 2002; Vosniadou, 1994; Brown, 2005). Science educators have been particularly sensitive to student misconceptions because they deal with concepts that do not fall easily into normal everyday experience – concepts like point masses, normal force, inertia, photosynthesis, respiration, electrical charges, and chemical equilibrium. The ERP assignments are not intended to radically re-shape student views of purchasing and sales but are intended to add new levels of complexity to existing frameworks, expanding student conceptions of purchasing and sales to include:

- sales forecasting data that guide procurement practices;
- credit information specific to vendors or customers that can be verified before conducting purchasing or sales transactions;
- document creation that tracks each step of the purchasing or sales process;
• features associated with purchasing and sales documents (e.g., trade discounts and freight charges appearing in sales and purchasing documents, and commissions appearing in sales documents);

• transactional sequence between goods receipt, invoicing, and payments;

• links between transactions and chart of accounts (account posting).

While radical accommodation of concepts is not necessary to appreciate the added complexity of business purchasing and sales compared with their consumer analogues, attaching account posting to the buying and selling process is not far removed from adding friction to an inertial Newtonian object or explaining the highest velocity achieved when hitting a baseball occurs when the ball first separates from its contact with the bat. The work of diSessa (1993) may be particularly relevant to the perspective of adding complexity to an existing mental framework. Following the pattern of scientific inquiry initiated by Descartes of breaking the whole into constituent parts, diSessa breaks cognition into hypothetical knowledge structures that she labels phenomenological primitives (p-prims) which she describes as follows (p. 112):

The name, phenomenological primitive, is meant to capture several of the more important characteristics of these objects. They are phenomenological in the sense that they often originate in nearly superficial interpretations of experienced reality. They are also phenomenological in the sense that, once established, p-prims constitute a rich vocabulary through which people remember and interpret their experience. They are ready schemata in terms of which one sees and explains the world. There are also two sense of primitiveness involved. P-prims are often self-explanatory and are used as if they need no justification. But also, primitive is meant to imply that these objects are primitive elements of cognitive mechanism – nearly as atomic and isolated mental structure as one can find.

P-prims are small, elementary structures of rule sets typically containing only a few components and relationships. One example diSessa (1993, p. 129) provides is “force as
a mover” which states that movement will result when force is applied. Rules sets that are established by experiences of buying and selling may not be able to be reduced to the degree of primitiveness involved in “force causes movement,” but purchasing experiences readily lend themselves to the following primitives:

- needs or desires result in requests or orders;
- orders result in goods received;
- goods received require payments to supplier.

Sales primitives may be describes as follows:

- needs or desires result in requests or orders;
- orders result in goods sent;
- goods sent require payments from customers.

Conceptual changes induced by the ERP software experience would be expected to be more assimilative than accommodative. One of the challenges of attempting to use an actual business practice in an academic setting to induce conceptual change is generating the four conditions described by Posner et al. (1982) for conceptual change to occur: (a) dissatisfaction with an existing conception, (b) new conception must be intelligible, (c) new conception must be plausible, and (d) new conception must be fruitful. The nearly universal familiarity with purchasing and sales activities should make intelligibility and plausibility readily achievable. Creating dissatisfaction with students’ well established prior frameworks that cause no difficulties for students because they do not adversely affect their lives can be daunting task. The EPR assignments provide no compelling reason for students to include the added complexity of business processes in what Cobern
(1994) would call a worldview of buying and selling. Students are no more or less capable of attending to purchasing and sales responsibilities in their everyday lives after completing the ERP assignments then they were before. Driver (1997) speaks of a “learning demand” in science education – the difference between prior ideas that students bring to their lesson and the nature of the scientific ideas they are supposed to learn. The learning demand for added complexity that can be expected to occur naturally as a result of an experiential encounter with ERP software may not be very robust. In addition, knowledge gained during ERP assignments depends solely upon experiencing purchasing and sales business processes as they are experienced in commercial business transactions. Driver (1983) expresses some concern about science teaching that is wholly dependent upon experience:

The slogan "I do and I understand" is commonly used in support of practical work in science teaching. We have classrooms where activity plays a central part. Pupils can spend a major portion of their time pushing trolleys up runways, marbles are rattled around in trays simulating solids, liquids and gases, batteries and bulbs are clicked in and out of specially designed circuit boards. To what end? In many classrooms, I suspect, "I do and I am even more confused".

The ERP business software may have to be coordinated in a larger teaching and learning system to significantly impact detailed knowledge of business purchasing and sales processes.

There was some evidence of conceptual changes in occurring in research participants as a group, but subprocess and subcomponent score differences with time did not suggest accommodation or assimilation as described by Chi et al. (1984). Measurable differences for four subcomponents and the subcomponent composite average could be labeled assimilation as described by Posner et al. (1982) or addition
according to Tyson et al. (1997). The ERP assignments placed purchasing and sales subprocesses in a structured, sequential framework with precedent and dependent steps. The structure had modest impact on the students as a whole relative to assessment performance scores. Multivariate analysis revealed one statistically significant difference for sales subprocesses but its effect was small and the same data evaluated by repeated measures ANOVA showed no statistically significant differences. Relationships of sales forecasting to procurement, sales invoice to payments received, and purchasing invoices to payments made should be reflected in subprocess assessment scores. There was no evidence of measurable change in these areas, although some significant differences were observed when scores were segmented by learning style (see pp. 160-164). Recognition of sales commissions, document identifiers, account posting, trade discounts and freight should be reflected in subcomponent scores. These are the only areas that suggested assimilation or addition for the research group as a whole.

PURCHASING SUBPROCESSES

Confidence intervals at $\alpha=0.05$ for mean scores of purchasing subprocess choices made by research participants are shown in Figure 5.1. Purchasing subprocess activities (PurAct) and sequences (PurSeq) display similar patterns before the introduction of ERP assignments ($t_0$), after the first assignment ($t_1$), and after the second ($t_2$). Subprocess activity score means range from about 10 to 11 out of a possible 15, and sequence means range from about 5 to 7 out of a possible 15. The relatively high scores for purchasing activities at $t_0$ suggest that, prior to their experience with EPR software, students have an
established framework for purchasing activities that match the purchasing business process reasonably well.

Research study participants chose business subprocesses relevant to purchasing from a list of 15 possibilities and put their choices in sequential order. The first seven sequence choices are plotted in Figures 5.2 through 5.8. The abscissa (x-axis) on all plots represents the following business subprocesses: (1) create sales order, (2) create sales quote, (3) select supplier, (4) review sales forecast, (5) receive goods, (6) receive payment, (7) check credit limit, (8) pay invoice, (9) fulfill order, (10) match invoice / receipts, (11) receive customer inquiry, (12) create invoice, (13) check inventory quantity, (14) update buyer employee benefits, and (15) create purchase order. The subprocess most appropriate to the optimum sequential position as represented in the ERP software is circled. The ordinate (y-axis) shows the percentage of students choosing each subprocess. Figure 5.2 shows response percentages for position one purchasing subprocesses. Figure 5.3 shows position two subprocesses. The pattern continues through position 6.
The three dominant subprocesses in position one remained for all three time periods: (a) select supplier (3), (b) review sales forecast (4), and (c) check inventory quantity (13). These are all early stages of the business purchasing process. Normally a sales forecast (4) would be reviewed first to determine products of interest. The sales forecast was the first activity mentioned in the ERP purchasing assignment but students did not actually view a sales forecast in the assignment. They were advised of sales demand for a specific product. Subsequent steps involved checking inventory (13) and selecting a supplier (3), but the order in which they are accomplished is arbitrary. The $t_2$ time period does show about a drop of about 10 percentage points for supplier selection as the first purchasing subprocess, possibly indicating an effect of the two ERP exercises on process sequence judgment. Checking inventory held steady through all three time periods with about 26 percent of the students selecting it as the first step in business
purchases. The most appropriate subprocess choice for position one was reviewing a sales forecast (4). The ERP assignments did not improve student recognition of this subprocess as first in the purchasing sequence.

Purchasing subprocess choices for position two appear in Figure 5.3. The dominant subprocesses were: (a) select supplier (3), (b) check credit limit (7), (c) check inventory quantity (13), and (d) create purchase order (15). Checking inventory (13) and selecting suppliers (3) are normally done in the early stages of making a purchase. Credit limits cannot be checked and purchase orders cannot be created until a supplier is chosen. Supplier selection (3) for position two increased after the completion of the ERP assignments by about 7 percentage points. Sales forecast (4) choices dropped more than 10 percentage points and credit limit checks (7) held steady through all three time periods. Checking inventory was the second process (following sales forecast information) in the ERP purchasing assignment and the one most appropriate to position two. It nearly doubled with time, a desirable trend. Creating a purchase order (15) showed almost a 10 percentage point decrease at \( t_1 \) (desirable) but returned near the \( t_0 \) score at time \( t_2 \). Creating a purchase order was actually the fifth item in the ERP purchase sequence, following a supplier credit limit check.
Purchasing subprocess choices for position three appear in Figure 5.4. Creating purchase orders (15) was the dominant subprocess of position three, chosen by 20 to 28 percent of the respondents. It increased about ten percentage points after the first ERP assignment and dropped three after the second. In the ERP assignment, purchase orders were created after obtaining sales forecast data, checking inventory, and selecting a supplier. Selecting suppliers (3) and receiving goods (5) accounted for 15 to 20 percent of subprocess choices. Supplier selection was the third sequential subprocess of the ERP purchasing assignment, and the most appropriate choice for position three. Checking inventory (13) declined a little over 5 percentage points with time.
Purchasing subprocess choices for position four appear in Figure 5.5. The three most popular choices were: (a) goods receipt (5), (b) create purchase order (15), and (c) pay invoice (8). The fourth sequential subprocess in the ERP purchasing assignment was a credit limit check (7). Goods receipt (5), the most popular position four response, sequentially follows creation and release of purchase orders in the ERP purchasing assignment, and it almost doubled from $t_0$ to $t_2$. Between 17 and 22 percent of students created purchase orders in position 4 and 10 to 15 percent paid for items they purchased.
The first four sequential subprocesses in the ERP purchasing assignment were: (a) review sales forecast, (b) check inventory, (c) select supplier, and (d) check credit limit. Selecting suppliers and checking inventory were popular choices for the first two sequential steps of the purchasing process in the subprocess assessment. The sales forecast and credit limit checks were less popular selections. Students who missed these subprocesses placed purchase order creation, receipt of goods, and payment at earlier stages than their appearance in the ERP assignment.

Purchasing subprocess choices for position five appear in Figure 5.6. The fifth sequential subprocess in the ERP purchasing assignment was a creation of a purchase order (15). Goods receipt (5) remained a steady choice for about 20 percent of students. Invoice payment (8) and matching goods receipt to invoices (10) both accounted for 12 to
17 percent of responses. Invoice matching followed receipt of goods in ERP purchasing. Roughly 10 percent of students created purchase orders in position 5. About 7 to 12 percent chose invoice creation (12). An invoice is created in the sales process and received in the purchasing process. The ten percent of respondents who chose invoice creation may have been confused by the distinction of invoice receipt in purchasing and invoice creation in sales. About 3 to 4 percent of students received payment at position 5. Payment is made in the purchasing process, but received in the selling process. Apparent confusion about payment direction in purchasing and sales was also observed in subcomponent choices.

![Figure 5.6 Purchasing Subprocess Responses – Position 5](image)

Purchasing subprocess choices for position six appear in Figure 5.7. The sixth sequential subprocess in the ERP purchasing assignment was goods receipt (5), but the
most popular response at this position was invoice payment (8), selected by 23 to 28 percent of respondents. There was a drop of about 4 percentage points for invoice payment after the ERP assignments were completed. Invoice payment was the last step of the ERP purchasing process following the match of a received invoice with goods receipt documentation.

Figure 5.7 Purchasing Subprocess Responses – Position 6

Goods receipt (5) accounted for 10 to 15 percent of student selections while matching invoice choices (10) grew about 10 percentage points from time $t_0$ to $t_2$. Up to 10 percent of students were still creating invoices (12—a sales activity) at position six. Invoice creation choices doubled at time $t_2$ after the second ERP exercise. Moving through one purchasing process and one sales process may have been more confusing than enlightening for some students. Driver’s (1983) suspicion that “I do and I am even
more confused” seems to have occurred with at least one student who commented on the ERP assignments: “Having only done each one once it’s hard to process it all and I feel that I got confused the more I did.”

Purchasing subprocess choices for position seven appear in Figure 5.8. The seventh sequential subprocess in the ERP purchasing assignment was matching invoices to receipts (10), but the most popular response at this position was again invoice payment (8). Invoice payment increased 13 to 18 percentage points at position seven after ERP assignments were completed.

![Figure 5.8 Purchasing Subprocess Responses – Position 7](image)

Subprocess response plots indicate that students were consistently aware of typical consumer purchasing activities and a logical order that allows them to be accomplished. Subprocesses associated with business purchases, but not consumer
purchases, like reviewing sales forecasts, checking credit limits, and matching invoices appeared with less regularity than consumer related purchasing subprocesses. The most popular responses for positions one to seven of purchasing subprocesses are shown in Table 5.1.

<table>
<thead>
<tr>
<th>Position</th>
<th>Subprocess</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Select Supplier</td>
</tr>
<tr>
<td>2</td>
<td>Select Supplier</td>
</tr>
<tr>
<td>3</td>
<td>Create Purchase Order</td>
</tr>
<tr>
<td>4</td>
<td>Receive Goods</td>
</tr>
<tr>
<td>5</td>
<td>Receive Goods</td>
</tr>
<tr>
<td>6</td>
<td>Pay Invoice</td>
</tr>
<tr>
<td>7</td>
<td>Pay Invoice</td>
</tr>
</tbody>
</table>

Table 5.1 Most Popular Purchasing Subprocesses by Position

The most popular responses for a business purchasing process focus on finding a vendor, ordering a product, receiving the order, and paying. These are typical consumer purchasing activities.

SALES SUBPROCESSES

Confidence intervals (CI) at $\alpha=0.05$ for mean scores of sales subprocess choices made by research participants are shown in Figure 5.9. Sales subprocess activities (SalAct) and sequences (SalSeq) display similar patterns before the introduction of ERP assignments ($t_0$) after the first assignment ($t_1$) and after the second ($t_2$). There does appear to be upward shift in CI ranges are $t_1$ which return to $t_0$ values at $t_2$. Subprocess activity score means range from 10 to 11.7 out of a possible 15 and sequence means range from 5.2 to 7.5 out of a possible 15. The relatively high scores for sales subprocess activities at $t_0$ suggest that, prior to their experience with EPR software, students have an
established framework for sales activities that match the sales business process reasonably well.

Research study participants chose business subprocesses relevant to sales from the same 15 item list used for purchasing (see pp. 130–131). Like purchasing, relevant sales subprocesses were put in sequential order. The first seven sequence choices are plotted in Figures 5.10 through 5.16. Abscissa and ordinate values again represent the 15 subprocesses of the item list. The subprocess most appropriate to the optimum sequential position as represented in the ERP software is circled. Percentages of subprocess choices for sales position one appear in Figure 5.10. Receiving customer inquiry (11) was the overwhelmingly dominant subprocess of position 1, accounting for 50 to 60 percent of all selections. The closest alternatives, creating sales orders (1) and reviewing sales forecasts (4) barely touched 10 percent. Although sales forecasts are certainly related to sales, they are not involved in processing a sale. The sales forecast process is mentioned in the purchasing rather than the sales ERP assignment. Receiving an inquiry from a customer was the first sales activity in the ERP sales assignment. Surprisingly, the
number of students choosing customer inquiry dropped about 10 percentage points after the ERP exercises were introduced.

Sales subprocess choices for position two appear in Figure 5.11. Checking inventory (13) was the most popular subprocess of position two, accounting for 27 to 36 percent of all selections, and it dropped modestly with time. About 20 to 25 percent of students selected creation of a sales quote (2) second in their sales sequences. Creating a sales order (1) was more popular at \( t_0 \) with about 14 percent of student choices than at \( t_1 \) with 6 percent of choices. This is a desirable trend. The only other subprocess exceeding 10 percent was the credit limit check (7). Checking customer credit limits was the second subprocess activity in the ERP sales order assignment, but checking inventory after receiving the customer inquiry was also marked as a proper order sequence in sales.
subprocess scoring. An inventory check and credit limit check should be done before a
sales quote is created for a potential customer.

Figure 5.11  Sales Subprocess Responses – Position 2

Sales subprocess choices for position three appear in Figure 5.12. Sales position
three was dominated by sales quotes (2) and sales orders (1) with selections ranging from
15 to 27 percent of all subprocesses chosen. Inventory checking (13) grew from 8
percent at \( t_0 \) to 17 percent at \( t_1 \) but dropped to 12 percent at \( t_2 \). Checking inventory was
the third activity in the ERP sales order assignment. About 10 percent of students
selected credit limit checks (9) for this position and about the same amount selected
suppliers (3). Supplier selection is needed in purchasing but not in sales. About 5 to 6
percent consistently selected order fulfillment for position 3. Order fulfillment in the
sales process occurs after the sales order is created. Students selecting the creation of
purchase orders dropped from about 5 percent at \( t_0 \) to 2 percent after the introduction of ERP exercises. This is a desirable decrease since purchase orders are only used in purchasing processes.

Figure 5.12  Sales Subprocess Responses – Position 3

Sales subprocess choices for position four appear in Figure 5.13. Sales orders (1) and sales quotes (2) were also the most popular selections of position four. Sales orders received 18 to 24 percent of subprocess choices while sales quotes ranged from 13 to 18 percent. As many as 6 other subprocesses achieved a level of 10 percent. During \( t_2 \) about 10 - 12 percent of students chose either payment receipt (6) or review of sales forecast (4) at position 4. Receipt of payment is the last step in the sales process, and logistical reasons for reviewing sales forecasts involve purchasing rather than sales. A small but persistent contingent of students selected a review of the sales forecast for the
early sequences of the sales process most likely because it made logical sense to review a sales forecast before making a sale. Fulfillment of the sales order (9) was a popular choice at \( t_0 \) with 12 percent of students, but dropped in half at \( t_1 \) and \( t_2 \). This is a desirable decrease since orders cannot be fulfilled until a sales order is created. Creating a sales quote was the fourth activity in the ERP sales order assignment.

![Sales Subprocess Responses – Position 4](image)

Sales subprocess choices for position five appear in Figure 5.14. Order fulfillment (9) was chosen most often in position five rising from about 23 percent at time \( t_0 \) to about 28 percent at time \( t_2 \). Other popular choices included sales orders (1) with 12 to 16 percent, payment receipt (6) with 5 to 12 percent, and creating an invoice (12) with 12 to 16 percent. Credit limit (7) selections decreased from 10 percent of the students at \( t_0 \) to about 2 percent at \( t_2 \). This decrease is desirable. Sales quote creation
rose from about 4 percent of responses at \( t_0 \) to 8 percent at \( t_1 \). Creating a sales order was the fifth activity in the ERP sales order assignment. It increased five percentage points after students experienced the ERP assignments—a sought-after trend.

![Figure 5.14 Sales Subprocess Responses – Position 5](image)

Sales subprocess choices for position six appear in Figure 5.15. Order Fulfillment (9) was also chosen most often in position six rising from about 23 percent at time \( t_0 \) to about 28 percent at time \( t_1 \) and then falling back to 22 percent at time \( t_2 \). Payment receipt (6) and invoice creation (12) were also chosen by at least 15 percent of students. Payment receipt is the last activity of the sales process and it decreased from about 22 percent of responses at \( t_0 \) to 15 percent of responses at \( t_1 \) and \( t_2 \). Invoice creation dropped about 10 percent from \( t_0 \) to \( t_1 \) and then rose 50 percent at \( t_2 \). About 8 to 10 percent of
students selected creation of sales orders (1) for position 6. Order fulfillment was the sixth activity in the ERP sales order assignment.

Sales subprocess choices for position seven appear in Figure 5.16. Payment receipt (6) was the most popular position seven selection with about 30 percent of all choices. Other subprocesses that received student attention for this position included order fulfillment (9) and invoice creation (12). Invoice creation was the seventh activity in the ERP sales order assignment, and it increased 12 percentage points after the first ERP assignment. It dropped 7 percentage points after the second ERP assignment.
Subprocess response plots indicate that students were consistently aware of typical consumer sales activities, but many of the optimum sequence sales subprocesses were chosen by a higher percentage of students after they completed the ERP assignments. Among them were: (a) credit check, (b) inventory check, (c) sales quote, (d) sales order, (e) order fulfillment, and (f) invoice creation. Order fulfillment was the only subprocess that yielded a significant interaction with ERP assignment order in the subcomponent analysis. After increasing by nine percentage points after the first ERP assignment, the percentage of order fulfillment responses returned to $t_0$ levels after the second ERP assignment. The ERP assignments seemed to help students recognize business sales subprocesses. The most popular responses for positions one to seven of sales subprocesses are shown in Table 5.2.
<table>
<thead>
<tr>
<th>Position</th>
<th>Subprocess</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Receive Customer Inquiry</td>
</tr>
<tr>
<td>2</td>
<td>Check Inventory</td>
</tr>
<tr>
<td>3</td>
<td>Sale Quote</td>
</tr>
<tr>
<td>4</td>
<td>Sales Order</td>
</tr>
<tr>
<td>5</td>
<td>Order Fulfillment</td>
</tr>
<tr>
<td>6</td>
<td>Order Fulfillment</td>
</tr>
<tr>
<td>7</td>
<td>Payment Receipt</td>
</tr>
</tbody>
</table>

**Table 5.2 Most Popular Sales Subprocesses by Position**

The most popular purchasing subprocesses listed four of the seven contained in the ERP assignments. The most popular sales subprocesses listed six of the seven contained in the ERP sales assignment. The six were relatively straightforward activities: (a) receive a request from a potential customer (customer inquiry), (b) make sure the item is in stock (check inventory), (c) provide description and cost details (sales quote and sales order), (d) send product to the customer (order fulfillment), and (f) get paid (payment receipt). ERP assignments seemed to have affected sales concepts more than purchasing but many scoring gains achieved after the first ERP assignment (e.g., inventory check, payment receipt, invoice creation, and order fulfillment) receded after the second ERP assignment.

In science education, retention of naïve concepts is robust (diSessa, 1993, Ben-Ari, 1998, Brown, 2005) even after students are exposed to educational methods specifically designed to teach more scientifically compatible ways of thinking. The ERP software is not designed specifically to teach, but it does present best practice business purchasing and sales processes to students as they complete purchasing or sales transactions. ERP purchasing and sales processes do not appear to change basic buying frameworks rooted in everyday consumer activities. Changes in the percentage of
responses that align with optimum sequences in the ERP sales assignment indicate that ERP may have affected sales frameworks, but there is no measurable difference in subprocess activity or sequence scores resulting from the completion of ERP assignments.

PURCHASING SUBCOMPONENTS

Confidence intervals at $\alpha=0.05$ for mean scores of the following purchasing subcomponent choices made by research participants are shown in Figure 5.17: (a) sales forecast (SalesForc), (b) inventory check (Inventory), (c) supplier selection (SelSupp), (d) purchase order (PO), (e) receive goods (RcvGoods), (f) match invoice to receipts (MatchInv), (g) pay invoice (Pay), and (h) documents needed to pay an invoice (Need2Pay). Most scores ranged between 8.5 and 11 out of a possible 15 with two noted exceptions: inventory and payments. The relatively low scores for payment support the robust retention of established frameworks. Generally, consumers pay for an item either before they receive it or simultaneously with receipt. It is natural to associate payment with product identification, quantity, and perhaps freight. But these items are on invoice documents rather than payment documents in a typical business process. When the invoice that has been received from the vendor is matched with receipt documents and posted, the invoice amount becomes a payable. The only information that a business needs to pay a bill are the vendor, amount, and the payable document for proper account assignments.
Subcomponent questions were all multiple choice allowing students to check as many items as they wished from the following list of 10: (a) storage location (site ID), (b) product (item ID), (c) commission, (d) vendor (vendor ID), (e) document identifier (document ID), (f) customer (customer ID), (g) quantity, (h) account changed (account posting), (i) trade discount, and (j) freight. Multivariate analysis showed statistically different ($\alpha=0.05$) payment subcomponent scores over time. Repeated ANOVA analysis conducted on the same data did not reveal statistically significant differences over time for payments, but did for purchase orders. Figure 5.18 shows student responses to the
subcomponent assessment question inquiring about payment tracking information. Correct choices are circled.

Figure 5.18  Business Activities Involved in Making Payments

Storage location (a) choices climbed above 10 percent at $t_1$ and $t_2$ from under 5 percent at $t_0$ (undesirable). The “customer” choice (f) scored above 50 percent for all three time points indicating that there may have been some confusion between making a payment (purchasing) and getting paid (sales). Slight increases in commission (c) choices supports this confusion since commissions are only paid in sales transactions. There was an increase in vendor (d) at $t_2$ and document identifier (e) at $t_1$ and $t_2$, and both are desirable. There was also a substantial increase in freight (j) choices, almost doubling at $t_1$ compared to $t_0$ and increasing 12 percentage points from $t_0$ to $t_2$. Increases in freight
showed that students recognized from the ERP assignments that they were paying for freight when they paid a vendor invoice, but increased freight choices also demonstrated that they did not recognize that freight was tracked by the purchase order and invoice rather than the payment documents. A similar condition exists for product. Clearly, the payment is made for a product but the product is tracked by the purchase order and invoice documents rather than the payment. There is a desirable increase of almost 18 percent over time with respect to document identification \((t_0 \text{ to } t_2)\).

Business activity choices for purchase orders are shown in Figure 5.19 with correct choices circled. Responses for storage location \((a)\) nearly doubled (desirable) during time period \(t_1\) but dropped 10 percentage points at \(t_2\). There was an increase of about 20 percentage points for document identifiers \((e)\) at \(t_1\) (desirable) but selections returned to \(t_0\) levels at \(t_2\). Students also increased trade discount selections \((i)\) by about 17 percentage points after the first ERP assignment \((t_1)\), but trade discount choices dropped 5 percentage points after the second ERP assignment \((t_2)\). Customers \((f)\) were selected by at least 50 percent of all respondents for all time periods further indicating potential confusion between purchasing and sales processes. A company that issues a purchase order is a customer of the vendor that receives the order, but there is no customer in a purchase business process. ERP assignments only dealt with customers in the context of sales orders rather than purchasing orders. There was a desirable decrease of about 10 percentage points in customer ID choices after the second ERP assignment. During previous time periods, more than 60 percent of respondents chose customer ID for purchase orders.
Business activity choices for inventory are shown in Figure 5.20 with correct choices circled. High scores for the inventory subcomponent resulted from associations that students made between inventory, items, item locations, and quantity. That association is illustrated in Figure 5.20. Nearly 100 percent of all respondents correctly associated product id (b) and quantity (g) with inventory, and the high percentages at time $t_0$ indicated those associations were part of their pre-ERP inventory frameworks. There is a 33 percent drop in vendor (d-desirable) and a ten percent decrease in site location (a-undesirable). Even with site location down about 10 percent, more than 80 percent of students correctly stated that inventory involves site location.
Scores for the analysis question asking what documents were needed for a business to make a payment were nearly identical for the three assessment time periods. This was a multiple choice question that required students to consider the entire purchasing process and pick relevant items (purchase order, goods receipt, and invoice) from the following list: (a) sales order, (b) payment receipt, (c) purchase order, (d) customer address, (e) goods receipt, (f) invoice, and (g) inventory item number. The ERP assignments made no apparent changes in the way students viewed supporting documents necessary for businesses to pay their bills.
SALES SUBCOMPONENTS

Confidence intervals at $\alpha=0.05$ for mean scores of the following sales subcomponent choices made by research participants are shown in Figure 5.21: (a) inventory check (Inventory), (b) sales quote (SalesQuot), (c) sales order (SalesOrder), (d) order fulfillment (OrderFull), (e) create invoice (Invoice), (f) receive payment (RcvPay), and (g) documents needed to close a sale (CloseSale).

Scores ranged between 7.3 and 10.6 out of a possible 15 with the exception: of inventory noted in the previous discussion about purchasing subcomponents. Confidence interval plots show the consistent upward movement from $t_0$ to $t_1$ and downward movement from $t_1$ to $t_2$ revealed by the repeated measures ANOVA analysis for sales.
subcomponent composite scores. High inventory scores were addressed in the previous purchasing subcomponent discussion. Sales orders and sales quotes showed statistically significant differences in repeated measures ANOVA, and the highest Hotelling’s Trace values for subcomponents, but multiple choice selections displayed in Figure 5.22 for sales quotes and 5.23 for sales orders show similar patterns through the 3 time periods. Correct choices are circled as they were for purchasing subcomponent plots.

![Business Activities Involved in Sales Quotes](image)

Customer choices (f) increased 10 to 15 percentage points for sales quotes (desirable) but dropped about the same amount between $t_0$ and $t_2$ for sales orders (undesirable). About 45 to 50 percent of students selected vendor (d) for sales quotes and more than 60 percent chose vendor for sales orders. Sales quotes and sales orders are created for customers, not vendors. A similar customer/vendor anomaly occurred in
payments made for purchases. There may be some general confusion about distinctions between customers and vendors. Document identifiers (e) increased about 10 to 15 percentage points for both sales quote and sales order (desirable). Trade discounts (i) and freight choices (j) also increased through the $t_0$ to $t_2$ time periods, changing by 10 to 20 percentage points. This is a desirable trend.

![Figure 5.23 Business Activities Involved in Sales Orders](image)

**Figure 5.23** Business Activities Involved in Sales Orders

**DOCUMENT IDENTIFIERS, TRADE DISCOUNTS, FREIGHT, AND ACCOUNT POSTING**

Through virtually all of the subcomponent multiple choice questions, there was a consistent recognition that document identifiers tracked all phases of the purchasing and sales processes. Working with the ERP systems seems to have embedded that subcomponent in the minds of the students. The ERP system also seems to have
provided an awareness of trade discounts and freight charges connected with business purchases or sales. ERP assignments did not seem to change student awareness of which tracking documents required account posting. Account posting choices (h) for sales invoicing are illustrated in Figure 5.24. Even though students posted invoices during the ERP sales assignment and saw the posting documents appear, posting choices declined 10 to 20 percent during each time period for sales invoices.

![Figure 5.24 Sales Invoice Business Activities](image)

After working with the ERP system, document identifier choices (e) rose about 12 percent points over $t_0$ selections. The number of students that chose Vendor ID (d) for the sales invoice was substantial (above 60%) and percentages did not change significantly during the time periods studied. The ERP assignments had students enter
vendor IDs for purchasing but only customer IDs were used for sales. It seems that students did not separate the sales tracking mechanism of customer IDs with the purchasing tracking mechanism of vendor IDs. The fact that both vendors and customers were needed for sales or purchasing transactions superseded the tracking distinctions for each type of business process.

Account posting choices (h) for matching invoices to goods received are illustrated in Figure 5.25. During the purchasing ERP assignment, students posted the invoice received after matching it against goods received. About 40 to 50 percent of students recognized the posting requirements when they took the assessment instrument. There were no differences between \( t_0 \) and \( t_1 \) responses, and about a 5 percentage point decline at \( t_2 \). There is no evidence that the ERP assignments increased awareness of account posting requirements of business processes.

**KOLB LEARNING STYLES**

Significant paired \( t \) test results are shown for subprocesses and subcomponents segmented by Kolb (1984) learning style in Figure 5.26. All significant changes in score differences occurred in either the accommodative or assimilative styles. Purchasing subprocesses produced no statistically significant differences. Only the sales subprocesses showed statistically significant changes in assessment scores with assimilative learners producing higher scores for both sales subprocess activities and sequences in \( t_1 \) compared with \( t_0 \). This time period corresponds to the completion of the first ERP assignment. Accommodative learners produced lower scores for sales subprocess activities in \( t_2 \) compared with \( t_1 \), and higher sales subcomponent composite
scores in both $t_1$ and $t_2$ compared with $t_0$. One-way ANOVA analysis showed no statistically significant mean differences at $t_0$ for the four learning styles in sales subprocess or subcomponent composite scores.

Although Kolb (1984) and Posner et al. (1982) both use the terms “assimilation” and “accommodation” they are not used in identical ways. Posner et al. consider assimilation as the process of adding to existing mental frameworks. Accommodation implies restructuring of existing frameworks. Accommodation imposes greater conceptual differences for Posner than assimilation. Kolb does not consider mental frameworks in his descriptions of learning styles. He is more concerned with preferred methods of learning than mental models or conceptual scaffolds. In Kolb’s view, assimilating learners assemble a wide range of concepts into concise, logical structures.
They tend to be less focused on people and more interested in ideas and abstract concepts. They are often attracted to information and science careers. People with assimilating learning styles prefer learning situations in which they have access to readings, lectures, analytical models. They want time to think things through. Philbin, Huffman, & Boverie (1995) suggest that assimilative learners are more likely to pursue academic careers.

Figure 5.26  Significant Subprocess and Subcomponent Score Differences by Learning Style
Accommodative learners want “hands-on” experiences. They like to carry out well defined plans, but often prefer not to create them. Accommodative learners prefer to collaborate and trust group decisions even at the expense of their own analysis. They are more prone than other styles to act on “gut” feelings rather than logical and reasonable analysis (Kolb & Kolb, 2005, p.12). Numerous research studies have not found definitive differences in learning results from the Kolb learning style classifications (Freedman, 1978; Winant, 1990; Carlson, 1991; Sacks, 1992; Stout & Ruble; 1994, Hart, 1995; Noguera, 2000; Reed et al., 2000; Young, Klemz, & Murphy, 2003). Lynch (1998) found higher scores on multiple choice examinations for medical students with abstract orientations (convergent and assimilative) compared with concrete orientations (accommodative and divergent). Dunn (1984) reported improved reading scores for K-12 students if instruction is matched to learning style. Simon (2002) also found that U. S. Navy trainees achieved higher training scores if training was matched to learning style. Buch and Bartley (2002) found that convergers had stronger preferences for computer delivery of corporate training courses than assimilators who preferred printed materials. Bostrom, Olfman, and Sein (1990) reported that abstract learners produced higher comprehension and accuracy measurements than concrete learners when learning software. Terrell and Dringus (2000) reported that abstract learners may have better chances of completing graduate studies than concrete learners. Thomas et al. (2002) observed that more reflective learning styles scored higher on exams and more experimental styles scored better on coursework.

With respect to learning styles, results of business process assessment measurements produced three distinct outcomes:
1. differences in subprocess mean scores occurred only in sales, not in purchasing;
2. only accommodative and assimilative learning styles demonstrated statistically significant differences in mean scores; and
3. differences in subprocess mean scores were exhibited by assimilative learners and differences in subcomponents were shown by accommodative learners.

One sales subprocess activity mean difference was observed for accommodative learners but it occurred only between \( t_1 \) and \( t_2 \) resulting in a lower assessment score after the second ERP assignment than after the first.

The tendency of assimilative learners to play with ideas and concepts, establish logical structures, and think things through seemed to allow them to reorganize their pre-established patterns of sales subprocesses after experiencing ERP software. Differences in sales subprocess scores were not seen with convergent learners even though they also tend to establish logical structures when they learn. Lack of differences on the part of convergent learners may be related to their interest in problem solving. The step-by-step instructions of the ERP assignments had no problem solving components in their designs. Although Buch and Barley (2002) found that convergent learners preferred computer delivery of corporate training courses, the corporate convergent learners likely had a stronger interest in the corporate training than students had in the ERP assignments. The preference of accommodative learners for “hands-on” activities may have contributed to their paying more attention to the ERP assignment instructions and hence improve sales subcomponent scores. The fact that accommodative learners also tend to trust analyses of others more than their own may have reduced the chances of them creating more robust subprocess structures even though they added to their sales subcomponent
knowledge. Divergent learners had little to attract them to the ERP assignments. There was no discussion, no requirement for sifting through diverse viewpoints, and no encouragement for imagination.

Sales Changes Vs. Purchasing Changes

Measurements of statistically significant changes only in sales processes were consistent throughout the study. Only sales activity subprocesses produced significant changes with time when analyzed with repeated measures ANOVA and paired $t$ tests. Only the sales segment of subcomponent composite scores yielded significant changes with time. Only changes in sales matter choices between $t_1$ and $t_2$ were significant.

The fact that only sales subprocesses showed significant differences in mean scores after exposure to business processes through ERP software may involve a long-held familiarity of research participants with the purchasing process. Every consumer makes many purchases, and a normal purchasing framework can be assumed to exist in the minds of all students in the study. Vosniadou (1994) argues that the human mind operates on the basis of domain-specific constraints that affect the acquisition of knowledge. These constraints are organized in a framework theory analogous to disciplinary matrices and paradigms described by Kuhn (1996) that constrain the development of scientific theories. Conceptual change is particularly difficult with constraint frameworks. Vosniadou (1994, p. 49) writes

The change of a framework theory is difficult because the presuppositions of the framework theory represent relatively coherent systems of explanation, based on everyday experience and tied to years of confirmation.
Although Vosniadou is addressing descriptions of the physical world in her writings, living in market economies would undoubtedly put frameworks of buying and selling processes in the minds of students long before they enrolled in college. The more deeply rooted framework would involve purchasing because the purchasing process is practiced far more often than the sales process. Purchasing frameworks would more likely have “years of confirmation” and offer greater resistance to alteration than sales frameworks by an experience with ERP software.

Accommodative and Assimilative Learning Styles

Only accommodative and assimilative learning styles exhibited differences in subprocess or subcomponent mean assessment scores, and subprocess differences were largely in the domain of assimilative learners while subcomponent differences were in the domain of accommodative learners. Accommodative learners favor “hands-on” instructions and assimilative learners like to observe demonstrations and have time to think things through. Convergent learners are problem solvers and divergent learners like brainstorming, group feedback, and thinking “out of the box”. The ERP software experience had no problem solving or brainstorming components, and there were no group dynamics in the software exercise. In addition, the assessment instruments focused on components and sequences associated with business purchasing and sales processes rather than problem solving. The most definitive aspect of the ERP software exercise was its “hands-on” nature. Students followed a purchasing or sales cycle exactly as they would if they were processing transactions in a business. The “hands-on” nature of the ERP assignments provided an obvious connection with accommodative learners.
Assimilative learners may have benefited from the step-by-step descriptions and screen shots that accompanied the ERP assignments. The assessment score differences emerging only for assimilators may have stemmed from the ordered structure of components and sequences and the preference of assimilative learners to think things through. Accommodators may have recognized subcomponents from their hands-on encounters with ERP exercises which seemed to have produced a “gut feel” sense of connection rather than an analytical problem solving process. The fact that accommodative learners scored lower in sales activity subprocesses at $t_2$ compared with $t_1$, but showed no significant differences between $t_0$ and either $t_1$ or $t_2$ supports a less structured and organized orientation of the business sales process. Only Accommodative learners exhibited changes in subcomponent scores, and only for the aggregate of sales subcomponents. The absence of purchasing differences is consistent with well established purchasing frameworks that are unlikely to change as a result of two encounters with business process software. Significant changes in sales subcomponent scores only for accommodative learners are consistent with “hands-on” ERP exercises providing a “feel” for constituent parts of business sales processes. In addition, the significant interaction effect of the concrete experience learning style factor with time shown by repeated measures ANOVA, comparing aggregate subcomponent scores with assessment times, reinforces the connection between process components and experiential activity.

The absence of problem solving attributes attractive to convergent learners in ERP assignments and assessments is supported by the amount of time students from each learning style spent in the assessment instruments that produced subprocess and
subcomponent scores. Mean times spent in assessment instruments, segmented by learning style, appear in Table 5.3. Research participants spending under 1 minute in any of the instruments were eliminated from the analysis resulting in the removal of one convergent and one divergent learner. Convergent learners, the people most likely to employ analytical problem solving, spent the least amount of time with the assessment instruments.

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Time $t0$</th>
<th>Time $t1$</th>
<th>Time $t2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N  Mean  Std Dev</td>
<td>N  Mean  Std Dev</td>
<td>N  Mean  Std Dev</td>
</tr>
<tr>
<td>AS</td>
<td>17  28.09   13.8007</td>
<td>18  19.80   5.894</td>
<td>18  24.26   17.066</td>
</tr>
<tr>
<td>CO</td>
<td>18  20.25   10.5629</td>
<td>16  14.56   6.540</td>
<td>18  15.41   9.165</td>
</tr>
</tbody>
</table>

Table 5.3 Time in Assessment Instruments by Learning Style

Table 5.4 shows one-way ANOVA results for time spent in assessment instruments by learning style groups. Differences of time spent in the assessments was statistically significant only at $t_1$, $F (3, 80) = 3.273, p = 0.025$. Games-Howell post hoc tests indicated significant mean differences between convergent learners and accommodative learners ($p = 0.025, d=0.803$), and also between convergent and divergent learners ($p = 0.018, d=0.786$). In each case, convergent learners spent less time in the assessment that either accommodative or divergent learners. Using Cohen’s (as cited in Leech et al., 2005) guidelines, these are large differences.
<table>
<thead>
<tr>
<th></th>
<th>Sum of Sqs</th>
<th>df</th>
<th>Mean Sq</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time $t_0$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>658.37</td>
<td>3</td>
<td>219.46</td>
<td>1.996</td>
<td>0.121</td>
</tr>
<tr>
<td>Within Groups</td>
<td>8685.58</td>
<td>79</td>
<td>109.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>9343.96</td>
<td>82</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time $t_1$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>935.31</td>
<td>3</td>
<td>311.77</td>
<td>3.273</td>
<td>0.025</td>
</tr>
<tr>
<td>Within Groups</td>
<td>7620.48</td>
<td>80</td>
<td>95.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8555.80</td>
<td>83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time $t_2$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between Groups</td>
<td>781.03</td>
<td>3</td>
<td>260.34</td>
<td>1.19</td>
<td>0.319</td>
</tr>
<tr>
<td>Within Groups</td>
<td>16630.41</td>
<td>76</td>
<td>218.82</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17411.44</td>
<td>79</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.4  One-way ANOVA Comparing Learning Styles on Time Spent in Assessment Instruments

Learning Styles and Self-assessment Scores

Statistically significant differences were only seen in accommodative and assimilative learning styles. Accommodative learners produced statistically higher sales subcomponent scores after completing ERP assignments and assimilative learners produced statistically higher sales activity and sequence scores after completing ERP assignments. Improved scores correspond with student self-assessment measurements, plotted according to learning style in Figure 5.27. The self-assessment measurements resulted from surveys administered after the ERP assignments were completed. Surveys requested that students rank how beneficial their ERP software experience was to improving their understanding of purchasing and sales business processes. Although one-way ANOVA analysis produced results that were not statistically significant (p = 0.12), mean values for accommodative and assimilative learners appear at the top of the chart for both purchasing and sales. Considering both purchasing and sales self-assessment of ERP benefit in business process understanding, learning style order appear as follows:

$AC \simeq AS > CO > DI$
where
AC is Accommodative
AS is Assimilative
CO is Convergent
DI is Divergent

Figure 5.27 Self-assessment Scores by Learning Style

STUDENT SELF-ASSESSMENT

The Technology Acceptance Model has been used in industrial settings to predict adoption of technology by measuring two constructs of adoption: ease of use and usefulness (Venkatesh & Davis, 2000). Adoption of ERP software was not an issue in this study but since TAM has been used to predict adoption of technology, its constructs might influence the degree to which students believed their ERP software experience helped their understanding of business purchasing and sales processes. Regression of the two TAM usefulness factors, social influence and future job performance, against Likert
scale measurements of self-assessed understanding of business purchasing and sales processes showed that usefulness factors significantly predicted both sales and purchasing self-assessment scores with the model accounting for 30 percent of the variation in self-assessment scores. Adding ease of use to the regression analysis did not alter the statistical significance and slightly reduced correlation coefficients. Students who considered the ERP software useful for their future careers were more likely to strongly agree that ERP software had increased their understanding of business purchasing and sales processes. Outcomes were analogous to those of Szajna (1996) who reported usefulness, but not ease of use, as a predictor for intentions to utilize software.

Analyses of scores for all students in the study revealed no statistically significant differences in purchasing or sales subprocess activity or sequences. There were statistically significant differences in four of twelve subcomponent scores as well as the composite average of all sales related subcomponents. Improvements observed after the first ERP assignment were not sustained through the second ERP assignment. In fact, there was a consistent trend towards lower scores after the second ERP assignment compared with scores after the first. The only significant sales subprocess differences observed in the entire study occurred with a subgroup of assimilative learners.

The modest changes in assessment scores belie the self-assessment responses, particularly those given by accommodative and assimilative learners. Accommodative and assimilative learners averaged 2 out of a maximum possible 3 points when responding to survey questions asking how strongly they agreed with the statement that their ERP experience increased their understanding of purchasing and sales processes. Convergent learners averaged 1.7 and divergent learners averaged 1.2.
Assessment instruments evaluated 4 subprocesses and 12 subcomponents at three time periods: (a) before ERP software activity, (b) after the first ERP assignment (purchasing or sales), and (c) after the second ERP assignment (purchasing or sales). Only one subprocess, sales activity, showed statistically significant differences over the three time periods and score trends moved up after the first ERP assignment and down after the second. The effect size was small. The within subjects time factor calculated by repeated measures ANOVA accounted for no more than about 5 percent of the variation of sales activity scores. The general trend up for all significantly different assessment scores from time $t_0$ to time $t_1$ followed by a return down towards $t_0$ scores at time $t_2$ was consistent throughout the study. Four of the 12 subcomponents generated statistically significant changes in scores with time and all followed the parabolic trend just mentioned. Three were related to sales subprocesses and one was related to purchase subprocesses. Activity choices accounting for the difference in scores included site location, trade discounts, freight, commissions, and document identifiers.

Subprocess assessment instruments required students to both list relevant activities of purchasing or sales and put them in sequential order. The subcomponent assessment instruments required students to associate a list of subcomponents with specific purchasing or sales activities. Both focused on details exhibited by step by step assignments with ERP software demonstrating how purchasing and sales are accomplished in business settings. Windschitl and Andre (1998) argue that computer step by step science instruction is less likely to promote conceptual change in students than computer simulation environments that allow students to freely create, test, and
evaluate their own hypotheses in a richly contextualized environment. Cobern (1994) suggests that without academic pressures like exams students have little incentive to alter perspectives or frameworks that fit their everyday lives and/or natural way of thinking. Scores for most assessments over time show no statistical differences, indicating interaction with ERP software does not result in radical restructuring of frameworks students have created for purchasing and sales. Only one subcomponent, order fulfillment, demonstrated a statistically significant interaction effect of exercise order with time and the effect was small. There were no significant interaction effects of gender, course grade, or intended undergraduate major with assessment differences measured before and after ERP software assignments. The Windschill and Andre (1998) concerns about the unlikely prospects of step by step exercises inducing conceptual change seem to have been reinforced in this study. The insight of Cobern (1994) is also relevant. Students had no incentive to alter, in any substantive way, purchasing or sales frameworks that worked perfectly well for them whenever they had to buy or sell. Students’ experience with enterprise software did not induce what Posner et al. (1982) would consider accommodative conceptual change. Herbert Simon proposed the principle of “satisficing” – good enough solutions to meet goals (Dasgupta, 2003). Students’ original ways of thinking prior to completing ERP assignments were quite sufficient to meet their personal purchasing and sales goals. There was no reason to move away from “good enough” solutions. In the Posner et al. (1982) characterization of conceptual change, there was no dissatisfaction with existing conceptions. In the terminology of Kuhn (1999) the background (frameworks) students created as a result of their purchasing and sales experiences established expectations that resisted change.
Perhaps a more stimulating exercise could reorient student thinking about purchasing and sales processes and provide more engagement for students, particularly convergent and divergent learners.

BUSINESS PURCHASING AND SALES FRAMEWORK MODEL

While there is no evidence of accommodative conceptual change involving business purchasing and sales processes as a result of experiencing ERP software there is evidence in the study that students assimilated some of the added complexity that businesses require for their purchasing and sales processes compared with consumer purchasing and sales activities. A post-ERP conceptual model of purchasing and sales is presented in Figure 5.28. The conceptual frameworks that students bring with them before encountering ERP software create the core processes of the model. These are either familiar or logical activities needed to buy or sell. While not as primitive as the p-prims of diSessa (1993) they are the elementary structures, or rule sets, of buying and selling. For purchasing they include: (a) needs or desires result in requests or orders, (b) orders result in goods received, and (c) goods received require payments to supplier. For sales they include (a) needs or desires result in requests or orders, (b) orders result in goods sent, and (c) goods sent require payments from customers.
The business ring adds a degree of complexity to the core processes, and working with ERP software brings an awareness of document identification, commissions, discounts, and freight that exist in that ring. Students attach these “business” additions to the core processes. The sales segment of the core processes seems more permeable to business additions than the purchasing segment. The outer ring of business architecture is much less defined but the ERP system helps students recognize that businesses take considerable effort in sequencing, tracking, controlling, and optimizing their processes,
even processes which are as basic as buying and selling. Even if students are unable to describe the specifics of the control and optimization system, they know that it exists, and that it is important to business operations. The ERP system provides an appreciation of business process architecture even if specific components and relationships of that architecture are not apparent. The overall sense of organization and coordination imposed by the business architecture ring was expressed by one student explaining the learning benefits of ERP assignments:

I never knew how much there was to a simple purchase or shipment of goods. It keeps things very organized for the company to go through their records and see what they shipped, for how much, where it came from, and where it went.

The ERP software experience is analogous to working with a typical furniture kit purchased from a home improvement store. The furniture can be assembled from the step by step instructions without any expertise in furniture building on the part of the assembler. The assembler is concentrating on following the instructions, inserting peg (A) of board (C) into hole (G) of mount (F) rather than attempting to understand the theory and practice of furniture building. Completing the piece does not mean that the assembler can build a similar structure without the step by step instructions but the assembly process, by itself, adds an holistic appreciation of furniture making to the assembler.
T SHAPED PEOPLE

Higher education is a unique business. Students are both customers in the sense that they purchase course instruction and the credential of a degree, and products in the sense that they will be marketed to either employers or other higher education institutions upon graduation. The educational intent of ERP software is the broadening of student knowledge to improve product quality. The goal is development of T shaped people (Kono, 2004), people with both specialized depth of knowledge and the ability to situate that expertise in a broad business framework. A model for T-shaped knowledge is shown in Figure 5.29. Traditional instruction has concentrated on the vertical leg of the “T”, which remains an important segment to modern businesses. But the horizontal cross piece is increasingly emphasized\(^2\), and it is much less straightforward than the vertical leg. Knowledge integrated across domains is much more context dependent than domain specific knowledge. It is more complex to define, and more complex to measure. This study demonstrated the that measurement of integrated knowledge is a complex process. Much work will have to be done to appropriately define integration and develop assessment instruments to measure it.

\(^2\) Dr. Andrew Targowski of Western Michigan University reports that IBM Corporation expressed its desire to hire T shaped people at its “Services Sciences, Management and Engineering, Education for the 21st Century” conference held October 5-7, 2006 at its Palisades, NY conference center.
The introduction of experiential learning with ERP in business schools is analogous to laboratory teaching in science education. The laboratory is an important vehicle for the teaching and understanding of scientific processes. Through the laboratory students are exposed to the way scientists work and think. Introduction of ERP software in business curricula is intended to show students how business processes work and interact. Many research studies conducted during the 1970s and 1980s showed no differences in standardized test scores between students who received laboratory instruction and those who did not, particularly when laboratory instructions were step by step recipes (Hofstein & Lunetta, 1982). Attempts to assess the real benefits of science laboratories have moved beyond standard scientific knowledge content to include process
knowledge and attitude. Improved attitude toward science is one benefit of science laboratories touted by its proponents (Hofstein & Lunetta, 1982). Student self-assessment convincingly showed that students considered the ERP helpful in their comprehension of business processes even if the modest transfer of knowledge and comprehension did not signal accommodative conceptual change. Student judgments that ERP was beneficial to their comprehension have appeared regularly in the literature (Wagner et al., 2000; Nelson & Millet, 2001; Davis & Comeau, 2004). Some attempts have been made to design assessment instruments that are specific to science laboratories (Hofstein & Lunetta, 1982). Assessments specific to ERP process comprehension would be helpful to this type of research.

Although considerable progress has been made in effective teaching and understanding how people learn (Bransford et al., 2000), many students in science laboratories today are still following recipes and gathering data without a clear sense of purpose, procedure, and interconnections; and although tests specific to laboratory learning have been developed and tested, they are not widely used (Hofstein & Lunetta, 2004). There is some concern that science teachers lack the experience and expertise to evaluate learning in science laboratories in a meaningful way (Hofstein & Lunetta, 2004). The experience of science educators attempting to re-engineer both exercises and assessments involved in science laboratories suggests that the development of effective ERP instruction that demonstrably provides integrated process understanding will take considerable time.
INSTRUCTIONAL IMPLICATIONS

Results of the study have the following implications for ERP instruction:

- Experiencing purchasing and sales transactions in ERP systems did not substantively change the purchasing and sales conceptual frameworks of students in the sample and did not transfer detailed component relationships of business transactions to the sample of students. The ERP exercises did help students recognize the importance that businesses place upon tracking and control of their transactions. Since purchasing frameworks appear to be more rigid than sales frameworks extra care should be taken in pointing out the differences between a business purchasing process and a consumer purchasing process.

- Learning styles were not a major factor among students in the sample for recognition of subprocess or subcomponent details; however, learning styles may influence performance on assessment instruments. Step-by-step exercises in the business sales process affected students with accommodative and assimilative learning styles more than convergent and divergent learners. Convergent learners spent the least amount of time in the assessment instrument employed in the study, even before the ERP assignments were conducted. Perhaps assessment questions that directly address the problem solving preferences of convergent learners would make ERP instruction more relevant to convergent learners. Dunn (1984) and Simon (2002) found that performance was improved when training was matched to learning style. Consideration should be given to matching assessment instruments to learning style.
• Relevance is an important factor in learning. With particular reference to ERP, students who experienced the belief that the knowledge gained from working with the software would be useful in their future careers were more likely to judge that their experience with the software helps them understand business processes. Relevance has been an important factor in student achievement in all coursework (Feldman, 1989), and it was shown to be significant in student self-assessment in this study. Addressing the benefits of ERP knowledge to business careers may provide an environment in which ERP software exercises can be used as an effective tool to teach integrated business processes.

In consideration of the first point, a step by step introduction to ERP software can be an effective beginning to business process understanding but it clearly not sufficient. At some point, there must be more engaging uses of the software than step by step transactions, perhaps through market simulations or real-time business games in which the ERP system provides the data to make business decisions. Greater engagement can address different learning styles (more problem solving for convergent learners) and relevance to future careers. Attempts to provide greater engagement have already begun. HEC Montreal has created a simulation game to teach ERP concepts and they are actively promoting it to universities throughout North America (Leger, 2006).

LIMITATIONS

Although ERP software is becoming more prominent in business school curricula, there are no standards for instruction methods or assessment instruments. There are no guidelines for integrated systems instruction similar to the National Science Education
Standards. All evaluations of ERP systems have been done with customized assessment instruments based on the ERP software itself. Some have focused more on software navigation than on the processes that the software enables, and many have measured only self-assessment of increased knowledge with no attempt at “objective” measurements. Fortunately, purchasing and sales business processes have been well established in commercial businesses for many years and sequence and tracking methods are well established. But there are still no standards that insure optimized measurements. This study attempted to focus on purchasing and sales transaction processes utilizing an ERP system to model those processes. Assignments were created to highlight the interconnections of business transaction activities. Student process choices were examined in a more thorough and detailed way than previous ERP studies; however, without standards and validated ERP assessment instruments, there are no uniform methods of assessing student process knowledge of business purchasing and sales processes. As additional attempts are made to measure understanding of processes compared with understanding of software commands, researchers will continue to require better evaluation tools.

The number of students participating in the study was also a limitation. Administration of five assessment instruments and logistical challenges emerging from providing the same instruction, grading, and delivery for ERP assignments makes data collection a formidable task. The complexity of gathering the data resulted in shrinkage rates of 16 percent of original research participants to obtain usable data, and 45 percent for complete data packages for all instruments. The five research instruments include subprocess and subcomponent assessments at three time periods, a learning styles survey,
and a technology assessment survey. There was no way to insure that all instruments were completed by all research participants. Additional data would be required in order to determine if the patterns exhibited by participants in this study are maintained for larger populations, particularly the trend toward higher scores after the first ERP exercise followed by lower scores after the second, and the nearly but not quite significant self-assessment trends for learning styles.

Every assessment instrument except the learning style survey was administered on-line. There was no way to insure that data entered was based solely on the judgments of individuals submitting the assessment instruments. Two techniques were employed to maximize the probability that students answered assessment instruments independently: (a) specific assessment responses were not linked to course grades, and (b) students were asked if their responses were their own. Self-reporting done by students indicated that their responses represented their own thinking.

RECOMMENDATIONS FOR FUTURE RESEARCH

Research often generates more questions than answers and this study is no exception. The lack of standardized ERP process lessons and assessments makes it challenging to validate that assessment scores accurately measure process understanding. Research instruments for process understanding that were validated would benefit all future research involving enterprise software.

If the trend of purchasing and sales assessment scores rising from $t_0$ to $t_1$ and falling from $t_1$ to $t_2$ is typical for broad populations, what is really causing the regression of score values after the second ERP exercise? I have suggested that pre-established frameworks for purchasing and sales are robust, particularly purchasing frameworks, and
there is no incentive for students to expend energy attempting to modify those frameworks in any substantive way since they serve well enough to negotiate any transactional environments students encounter. This is an area well suited to qualitative research. In addition to the apparent parabolic trends, qualitative research could address whether purchasing conceptual frameworks really are more rigid than sales frameworks as they appeared to be in this study. The study measured systemic understanding of holistic purchasing and sales processes with two questions asking which tracking documents were needed to pay for a purchased item or complete a sale. Student responses to these questions were clear: the step by step ERP assignments did not provide a conceptual framework that gave students insight into these transaction requirements. Additional research is needed in two areas to measure integrated thinking: (a) validated question sets demonstrating integrative thinking, and (b) qualitative research examining the way students view purchasing and sales cycles in business transactions.

Despite generally small differences in process assessment scores after the ERP assignments and assessments, students reported that the software helped them better comprehend business purchasing and sales processes more clearly. I argued that this sense of comprehension resulted from the general architecture of purchasing and sales business processes provided by the ERP software, but this is an area that could also benefit from additional quantitative and qualitative research. What is it about the ERP software that is helpful to students in believing that they are more process knowledgeable?

Evaluation of learning styles with respect to subprocess and subcomponent scores produced few results with statistical significance at the critical level set in the study (α=
Additional research can confirm or negate the apparent result that step by step assignments are most attractive to assimilative and accommodative learners. If these two learning styles are more likely to benefit from step by step examples, then what aspects of the step by step presentation have the observed effects? Qualitative research can be beneficial here. Can assignments be created with problem solving components to make them more attractive to convergent learners? What about utilizing gaming technology to provide a more engaging and interactive experience with the software system? There are no current ERP gaming systems, but some are in development (Leger, 2006). Research into effective computer gaming pedagogy is needed to avoid the Driver (1983) concern of experience without adequate guidance: “I do and I am even more confused”. There was clear evidence of confusion. Invoice creation choices doubled at time t2 after the second ERP exercise but the change occurred for the question asking about purchasing. Creating an invoice is a sales function. Paying an invoice is a purchasing function. There was also confusion about paying in the purchasing cycle and receiving payment in the sales business cycle. Finally, qualitative research can determine if the apparent confusion in distinguishing making payments for a purchase vs. getting paid for a sale really exists.
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APPENDIX A: ERP ASSIGNMENTS

ERP Purchasing Assignment

Learning Objective:
Enterprise Resource Planning software connects a variety of business disciplines as it optimizes and controls business processes. This purchasing exercise will be completed through Microsoft Great Plains, and involves the Porter value chain activities of inbound logistics, procurement, human resources, technology, and infrastructure. At the conclusion of this exercise you should

- Understand the different business activities needed for purchasing and their place in the Porter business value chain
- Be able to navigate through Great Plains ERP software
- Recognize the component parts of a purchase order form and their importance
- Export data from Great Plains to Microsoft Excel for personal analysis

Some questions in the exercise may require team consultation since they involve business concepts covered in other courses.

Microsoft Great Plains is one of three Enterprise Resources Planning software solutions offered by Microsoft Business Solutions. It contains the “back-office” data of procurement, inventory, operations, sales, human resources, accounting, and finance. The ERP system distributes real-time data throughout the enterprise so all people working with the business system are working with accurate, updated data from the same source. Accurate real-time data can be a potent competitive advantage for a company, but inaccurate real-time data, or inaccessible data can cause tremendous problems. ERP requires significant corporate attention and resources.

Scenario:
The sales department is forecasting an order for green phones (Item 100XLG) which will have to be shipped from the SOUTH warehousing site in two weeks. You are responsible for insuring that the phones are ready for shipment. Green phones are a re-sale item for your company. If you do not have enough in inventory, you will have to order more to arrive within a week.

Step 1: Check Inventory
How much inventory do we have?
Item information in Great Plains can be found under the Cards Menu

Cards > Inventory > Item brings up the Item Maintenance Window.

1.1 Search for Item No. 100XLG by clicking the magnifying glass next to the Item Number field.
1.2 Choose 100XLG. You can scroll through the list or enter part or all of the Item No. in the search field and then press Enter. The binoculars can be used for advanced searching. Item cost, quantity on-hand and quantity available are shown here.

Inventory may vary. How much do you see?

When you are in a window in Great Plains you can receive help specific to that window by pressing the F1 key. Clicking on “Field” in the context help window
gives you explanations for the fields in the window. Experiment with Help if you wish but it is not necessary to complete the assignment. Close the Item Maintenance window when you have entered the inventory.

Where is the inventory?
1.3 Inventory locations can be found through the Cards Menu as well. Cards > Inventory > Quantities/Sites brings up the Items Quantity Maintenance Window. Quantities/Sites can be seen in the first graphic of this step. It is located below Site.

1.4 Search for 100XLG in the Item Number field as before. Click the Site ID and Assigned radio buttons. Then click the magnifying glass in the Sites section. After viewing inventory, close all windows.

There is another way to view inventory and send it to other programs easily. Let’s look at SMARTLIST. The SMARTLIST icon is on the top toolbar and is shown in the graphic on the next page. Click the icon and scroll down to Item Quantities. Click on Item Quantities. You will see all inventory items and amounts. Now filter the list so only the 100XLG items are listed. Click the Search button. Click the magnifying glass near Column Name and choose Item Number from the list. Leave the “is equal to” string in the Filter field and type 100XLG in the Value field. Click OK and the list should only show 100XLG items. Now send the filtered list to Excel by clicking the Excel icon.
Step 2: Select a Vendor

We will have to choose a vendor. We will find vendors of Item 100XLG from SMARTLIST.

2.1 Scroll down to Vendor Items and select it.

2.2 Now filter the list to see only the 100XLG item numbers. Click the Search button and after the Search Vendor Items window appears, click the
magnifying glass in the Column Name field and choose Item Number. Leave the
default filter choice is equal to and enter 100XLG in the Value field. Click the
OK button on the lower right of the Search Vendor Items window to filter the
SMARTLIST so only Item Number 100XLG is displayed. Choose any one of the
vendors offering Green Phones 100XLG. Write the Vendor ID below

**Turn In**

Enter your Vendor ID in the GP Assignment Excel document in the Vendor ID section.

Choose Cards > Purchasing > Vendor Enter the Vendor ID by using the
magnifying glass near the Vendor ID window. After the vendor window appears,
click the Options button.

With respect to this vendor, do what is our
- Trade discount? ___________
- Credit Limit? ___________
- Minimum Order? ___________
- Payment Terms? ___________

Note: Answers may be none (zero or blanks).

Step 3: Create and Release Purchase Order

NOTE: When you save a purchase order in Microsoft Great Plains the order disappears
and the system offers you a blank form for another order. You can retrieve your order in
a variety of ways, but the easiest is to know your PO number and use the lookup
magnifying glass to get it to return to the screen. Please make sure that you are
working on your own order. You should see your PO number and your buyer id.

Create a Purchase Order through the
Transactions Menu

Transactions > Purchasing >
Purchase Order Entry brings up
the Purchase Order Entry
Window.

3.1 Refer to the next graphic for locations for the following instructions. Click in the
PO Number field to obtain a self-generated PO number. Write down your PO
Number below:

3.2 After you see the PO number, press the tab key to leave the field. Enter a Buyer
ID in the Buyer Id window. Use you bronco Net id and click Enter. The system
will ask if you want to add this buyer. Click the Add button. Enter a description in the Description window and click the New buyer button in the next screen. The description can be anything but the software will require one. Save the buyer when prompted. You will need your Buyer ID later so be sure to put it in. Then click on the magnifying glass near the Vendor ID and choose the Vendor ID of your selected vendor.

<table>
<thead>
<tr>
<th>Location of fields described below can be confusing. Pay attention to the points of the arrows. If you get a message about not completing all fields you have probably not clicked the proper Site ID field – the white box at the point of arrow 4</th>
</tr>
</thead>
</table>

3.3 Click in the Vendor Item field (arrow 3, next page). The location of the item fields can be a little confusing when you see them for the first time. The point of arrow 3 is in the Vendor Item field. It is a white box. The box below is the Vendor description field and it will be automatically filled in after the vendor item is selected.

3.4 After clicking in the Vendor Item field (remember, the white box with the point of arrow 3) click the magnifying glass near the blue underlined Vendor Item label. Choose the 100XLG item from the list and click the Select button. The units of measure field should now automatically fill in.

3.5 Click in the Site ID field (white box at the tip of arrow 4) and then click the magnifying glass near the blue underlined Site ID label. Select the SOUTH storage location. Then enter the quantity (arrow 5). Order 10 phones The field below the quantity ordered is a quantity cancelled field which can be used at a later date for any cancellations.

3.6 If this were a taxable item, we would use the magnifying glass near the blue underlined tax schedule label to select the appropriate tax. We will assume we are buying a non-taxable item. Finally we will enter a freight charge (arrow 6) of $20.00.
3.7 We have almost completed the Purchase Order. There is an expansion arrow near the date field that opens the *Purchasing Date Entry* window. It is hidden by arrow 1 above but is shown in the graphic below. Click on the expansion arrow to bring up the *Purchase Date Entry* window and enter a required date two weeks from the current date.

Promised dates can be entered after communicating with the vendor. Click the **OK** button in the Purchase Date Entry window. Costs should be automatically calculated and there should be a total calculation.
3.8 If it was active the Hold box to the left of the Vendor ID could be clicked to prevent the release of the purchase order until it is approved by company management. Great Plains can be configured to allow certain levels of management authority to release holds.

3.9 Save the purchase order by clicking the **Save button** in the upper left of the Purchase Order Entry window. After saving, a blank Purchase Order Entry window appears ready for another PO. We will not be creating another PO at this time but we want to release the PO we just created. A company releases a purchase order when it makes it available to the vendor. The process of releasing an order in Great Plains is accomplished by printing the purchase order.

3.10 Bring the PO you just created back by clicking the magnifying glass near the PO Number and select your PO Number from the list. With the Purchase Order open, click the Printer icon located at the upper right of the Purchase Order Entry window.

3.10 Accept the default for the Purchase Order Print Options by clicking the **Print button** to obtain the Report Destination screen. and check the **Screen** box (uncheck the Printer box) and the **File** checkbox for Report Destination. Click on the **Folder icon** to save the file in a place that you can retrieve it (like the desktop). Save the file as po_nohold. Choose the **tab delimited** file type in the **Save as type** window. Click the **OK button**.
The Purchase Order will print to the screen and to the file. Close the window containing the printed purchase order and look at the PO Status in the Purchase Order Entry window. It should show “Released.”

3.11 With the PO released, the vendor has been contacted and agreed to ship within a week. Enter the promised ship date (one week from today) in the Purchasing Date Entry window. The window is opened by clicking the expansion arrow after the date field on the Purchase Order Entry window. See the previous page for its location. Save the PO. Once again the PO disappears upon saving.

<table>
<thead>
<tr>
<th>Turn In</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Excel, open the tab delimited po_nohold file. The tab delimited file type should be the default. After the file is imported into Excel copy the PO to the GP Excel document and put a double lined border around it.</td>
</tr>
</tbody>
</table>

**Step 4: Receive Goods**

One week later several boxes from your selected vendor appear at the SOUTH storage area. Items are received into Great Plains from the **Transactions Menu**

**Transactions > Purchasing > Receiving Transaction Entry** brings up the **Receiving Transaction Entry Window**.

4.1 The **Receiving Transaction Entry** window is designed to be similar to the **Purchase Order Entry** window. Refer to the next graphic for locations for the following instructions. Figure 16 on page 24 of the coursepack can also help with locations. Click in the **Receipt No.** field to obtain a self-generated Receipt number. Write the receipt number here _______________________.

4.2 After you see the Receipt number, press the tab key to leave the field. Also **fill in the date field with a date a week from the PO date.**

4.3 Then click on the magnifying glass near the **Vendor ID** and choose the Vendor ID of your selected vendor.

4.4 The **Vendor Doc. Number** (arrow 3) is the Vendor document identifier that will appear on the invoice. Enter **Fabri-XXX** for this one where XXX is your login number. For example if you login as BUS2700H-20, use Fabri-H20.

4.5 Then click in the **PO Number** field (arrow 4). After clicking in the PO Number field (remember, the white box with the point of arrow 4) click the magnifying glass near the blue underlined **PO Number** label. Choose the PO Number you generated from the list and click the Select button. **Make sure it is YOUR PO number.**

4.6 Receiving documents should describe the Vendor, PO Number, and line items delivered so all of this information should be readily available for the person
receiving the shipment. The cursor should automatically move to the **Vendor Item** field (arrow 5). Click the magnifying glass near the blue underlined **Vendor Item** label. Select the 100XLG item. Other information from the purchase order should now automatically fill in. The system assumes all quantities ordered are received but the receiving area could change the quantity shipped to indicate a partial shipment.

4.7 Click the **Distributions** button on the bottom right to see the accounts that will be affected by the receipt of goods. Click in a window with an account number and view the account description by clicking the blue account expansion arrow. Write down the accounts numbers and descriptions below:

**NOTE**: If you get an error message when attempting to see the accounts you will have to auto-generate serial numbers. Click OK to the error message. If it brings you to the Purchasing Serial Number Entry Screen, click the **Auto-Generate** button. If it does not, bring up the Purchasing Serial Number Entry Screen by clicking the blue arrow near the **Qty Shipped** (see graphic below).
4.7 Post the Receiving Transaction Entry by clicking on the button. If you don’t get any error message then you have successfully posted the transaction. Then close the Receivings Transaction Entry window. Before the window closes, you will be asked to select destinations for the posting reports. Send all outputs to the screen.

A Note on Posting:
Posting produces a similar effect in Great Plains as saving. When a document is posted, it disappears and you see a blank form available for a different transaction. Do not start over if you need a document that disappeared. You can always find it again through SMARTLIST. Also posting usually produces multiple documents. For this exercise just send them to the screen (uncheck Printer and check Screen)

Step 5: Re-check Inventory after Receiving Goods
5.1 Click the SMARTLIST icon and scroll down to the Item Quantities folder. Search for Item 100XLG and filter the list so it only contains item 100XLG. Export the Item Quantities columns to Excel by clicking the Excel button at the top of the SMARTLIST.

You should see 10 more phones in the SOUTH site than when you started. You may see even more if other orders are involved.

Step 6: Enter Invoice into Great Plains
When the invoice is received from the vendor, it must be matched with goods received. The invoice document will certainly identify the vendor and it will show the Purchase Order number and purchase order line items billed. The invoice could be entered into the Great Plains system if it accompanies the shipment of goods but simultaneous receipt of goods and invoice does not often occur. Invoices are matched to receipts through the Transactions menu.

Select Transactions > Purchasing > Enter/Match Invoices
The Purchasing Invoice Entry window appears. It is similar in appearance to the Purchase Order Entry and Receivings Transaction Entry windows. You can see a depiction of the window on the next page.

6.1 A Receipt Number for the Invoice Entry will be automatically generated. Write the receipt number here ____________.

6.2 Enter the Vendor ID in the usual way with the magnifying glass near the Vendor ID field (arrow 1). The Vendor Doc. Number (arrow 2) is the Vendor invoice identifier that appears on the invoice. Enter Fabri-XXX for this one where XXX is your login number. For example if you login as BUS2700-H20, use Fabri-H20.

6.3 Change the Invoice Date (arrow 3) to the day you received the goods (a week after the PO).

6.4 Click in the PO Number field (arrow 4) and pick the Purchase Order number you created in Step 3 by clicking the magnifying glass. You can view the Purchase Order itself after your selection by clicking on the blue underlined PO Number link after the vendor item is entered. The vendor invoice will always include the customer Purchase Order number. Make sure it is YOUR PO number. After selecting the PO Number, the cursor should be in the Vendor Item (arrow 5) field. Click in the field if it isn’t. Choose item 100XSL from the list after clicking the magnifying glass.

6.5 Click in the Freight field (white box, arrow 7) and enter the $20.00 freight. Click on the Matched to Shipment expansion arrow (see arrow 6) near the blue underlined Matched to Shipment link. Click on the Match button, and then the OK button after confirming the correct receipt number.
6.6 Back in the Purchasing Invoice Entry window, the total amount of the invoice will appear in the lower right. Write down the amount of the total invoice below. You will need this amount for payment.

6.7 Click the **Distributions** button (lower right) to view the accounts that will be affected by the invoice. It is likely that you will see one account missing at the top. The software cannot process a document if it does not know the proper accounts to charge. We have to add an account. Since we are debiting PPV *unrealized*, we’ll credit PPV *realized*. Click in the account field and then click the magnifying glass near the blue **Account** label. Either scroll or use the binoculars to find the PPV realized account (000-2950-00). The accounts are in numeric order. You can also just filter the display with the search skills you have already learned. Try filtering with the Account description field containing PPV. After you select account 000-2950-00 it will appear in the first line. Then click the **OK** button.
If you run into a problem with Invoice Matching
If you encounter unexpected problems, delete the Purchase Invoice Entry document and start the match again. The system may not let you delete the Purchasing Invoice Distribution Document. If you want to delete it, and the software will not allow it, save with errors. Then click the Distribution button again and correct the accounts. **If you do not see any debit or credit dollar amounts for a blank account do not be concerned. You do not have to add an account if there is no money involved.**

**Step 7: Post Invoice for Payment**
The posting process officially records transactions in ledger accounts. When the invoice is posted, it can be paid.

7.1 Post the invoice by clicking the Post button. **Remember, when the posting occurs the document disappears and you see a new document that you can use for other transactions. When you close the window, you will be asked about posting document destinations. Send all outputs to the screen. You can view the accounting information in the posting screens if you wish but close all windows, including the Purchasing Series Posting window when you are finished.**

**Step 8: Status of Payables Transaction**
Select Inquiry > Purchasing > Transaction by Document
The **Payables Transaction Inquiry – Document** window appears. Leave the default **Documents view by Document Number**, click the **From** radio button and enter $E$ and enter $G$ for **To**. Click **Redisplay**. All the Fabri documents should appear. Fabri-XXX is Open. It will be archived when the invoice is paid. Close all windows.

**Step 8: Pay the Invoice**

In order to maintain control of the company checkbook, access to the payment window can be restricted in software configuration.

8.1 Select **Transaction > Purchasing > Manual Payments** which brings up the **Payables Manual Payment Entry** window. Enter the date (two weeks after receiving the shipment). Select the Vendor ID in the usual way. Also click on the **Checkbook ID** magnifying glass and choose any bank.

8.2 Enter the total amount of the invoice in the amount field. Then click the **Apply** button and put a check in the box to the left of Fabri-XXX in the next screen. Click **OK**.

8.3 Click the distribution button and write the account numbers and their descriptions here. You can find full account descriptions by clicking in the account number field and then clicking the blue underlined **Account** link.
Step 10: Post the Payment

Click the `Post` button. Remember, posting causes the document you are working on to disappear. You will be asked about destinations for the posting documents after you close the window. Send all outputs to the screen.

Step 11: Status of Payables Transaction

Select Inquiry > Purchasing > Transaction by Document

The Payables Transaction Inquiry – Document window appears. Leave the default Documents view by Document Number, click the From radio button and enter E and enter G for To. Click Redisplay. All the Fabri documents should appear. Fabri-XXX is now archived in history.

Step 12: Assignment Submission

Print the final Payables Transaction Inquiry – Document with Fabri-XXX shown as History to a file (tab delimited like po_nohold) in a location where you can retrieve it.

Click the Printer icon in Payables Transaction Inquiry – Document

Select file and click the folder icon. Use the tab delimited Save as Type. Remember to save it in a location where you can retrieve it.

Name the file `history`. 
In Excel, open the tab delimited history file. The tab delimited file type should be the default. After the file is imported into Excel copy the history list to the GP Excel document in the Archive Purchase Order section. Highlight your Fabri-XXX with the PO in history.

Upload your complete Excel sheet in WebCT assignments.

ERP Sales Assignment

Learning Objective:
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- Understand the different business activities needed for fulfilling a sales order and their place in the Porter business value chain
- Be able to navigate through Great Plains ERP software
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Scenario:
An inquiry has been received about green phones from a customer. You must quote the product, and later turn the quote into a sales order. Use the customer assigned to you.

Step 1: Check Customer
In the Great Plains menu, select Cards > Sales > Customer
The Customer Maintenance window appears.
Click in the magnifying glass next to the Customer ID field
Choose the customer you were assigned and click the Select button. Find the trade discount in the lower right side of the wind. Write it here ________________.

Then click on the Options button. Find the credit limit for the customer in the upper left portion of the wind. Write it here ________________

Step 2: Check Inventory

Start with a Smartlist Search:

Click the Smartlist icon on the Great Plains toolbar to open the Smartlist window.

Scroll to the Item Quantities folder and click on the words Item Quantities next to the folder. It may take a few seconds for the list to populate.

Filter the list so it shows only 100XLG green phones by clicking the Search button. In the Search window, click the magnifying glass next to the Column Name field for Search Definition 1. Choose Item Number from the list and click OK. Leave the default Filter “is equal to” and use the dropdown arrow in the Value field type 100XLG. Click OK. The Smartlist now displays only 100XLG items.
Export the FILTERED list to Excel by clicking the Excel button. Copy and paste the results to the gp_sales.xls file.

Leave the SMARTLIST screen open. We’ll return to it later.

**Step 3: Create a Sales Quote**

Select Transactions > Sales > Sales Transaction Entry

Leave the Type/Type ID at the default Quote. Click on the Document No field to automatically generate a document number. Write the Document Number below.

Select YOUR customer by clicking the magnifying glass next to the Customer ID field. Click the magnifying glass next to the Batch ID field and select Sales Quotes. Today’s date is automatically generated in the Date field. Click the arrow next to the Date field to enter the quote expiration date (one month from today’s date) and Requested Ship Date (two weeks from today). We are shipping the phones from the SOUTH store so the Default Site ID should be changed to SOUTH. Click the magnifying glass next to the Default Site ID field to bring up the Sites window. Type SOUTH in the Find by Site ID field and press Enter. Click SOUTH and then press the Select button. Click in the Customer PO Number field and type your Great

![The blue arrow above is an expansion arrow]
Plains login ID (BUS2700XXX where XXX is the number/letter you use to log into Great Plains. For example if you are BUS2700H-20, use BUS2700H20). The Customer PO field can be changed later when a real purchase order number is available. Click in the Currency ID field. It should enter automatically.

Click in the Item Number field (the white box below the blue underlined Item Number) and select 100XLG by clicking on the magnifying glass next to the blue underlined Item Number label. Choose 100XLG from the list and click Select. If the customer is not in the United States, Great Plains may warn you about currency. If that happens, click the magnifying glass near currency ID and choose US Dollars. Enter a number between 2 and 5 for Quantity Ordered.

In the Comment ID window (the white box to the right of the blue underlined Comment ID) enter your initials. Add a comment by clicking on the expansion arrow near the Comment ID field, but when you click, the software will ask you if you want to add the Comment ID. Click Add. In the Sales Comment Entry window, type “This quote prepared by [your name]”. Put your actual name in the bracketed area. Click Save, then to close the Sales Comment Entry window.

NOTE: When you save in Microsoft Great Plains the document disappears and the system offers you a blank form. The document is not lost. Do not be concerned that the comment has disappeared.

Click on the button to open the Sales Commissions Entry window to see who will get a commission from the sale (if it occurs) and the commission percent. Write the Sales person and commission percent below.

Close the Sales Commission Entry window.
Click on the blue arrow to the right of the tax field window. Then click on the blue underlined Account to see the tax account that will be affected if the quote becomes a sale. Write the account description below.

Close the Account Maintenance and Sales Tax Summary windows. Click OK to close the Sales Commission Entry Window.

Close all windows but the Sales Transaction Entry window (but you can leave SMARTLIST open).

Enter a freight charge of $5.00.

Save the quote. Remember, the document will disappear. Close the Sales Transaction Entry window.
Step 4: Retrieve the Quote from the System
Several days have passed and your customer calls to place an order based on the quote. Find the quote through the Sales Transaction Entry window. Select Transactions > Sales > Sales Transaction Entry. Click the magnifying glass to the right of Document No. and find your quote in the list through the document number. Make sure it is yours. Double click on it and it will appear in the Sales Transaction Entry window. If it is your quote you should see YOUR CUSTOMER PO NUMBER AND YOUR COMMENT ID. If you do not, it is not your quote, so close the window and start again. Get YOUR quote.

Step 5: Create an Order from the Quote
With the Sales Transaction Entry window showing, click on the Transfer button to transfer the quote to an order.

The Sales Transfer Documents window appears. In the Quotes quadrant, check the Transfer to Order and Include Totals checkboxes. Click the Preview button to view quantities that will transfer. Click OK to close the Preview window. Then click the Transfer button at the bottom of the Sales Transfer Documents window (see graphic).
After a short processing time, Great Plains presents the **Report Destination** window. Check the **Screen** checkbox. Then click the **OK** button. The screen output shows you the transfer log. Close that screen.

You should now see your order in Sales Transaction Entry Window. Write your order number below

With the order displayed, click on the **expansion arrow** next to the **Document No.** field. The **Sales Document Detail Entry** window appears which includes the quote from which the order was generated.

Great Plains provides a document trail linking related documents. The Sales Document Detail Entry window adds additional rows as the sales order process progresses.

View the Quote by clicking anywhere in the quote line (highlighting the entire line) and then click the blue underlined **Document Number** column header. You can close the Quote and the Sales Document Detail Entry window. You should be back in the **Sales Transaction Entry** window looking at the order.

**Step 6: Complete Order Fulfillment**

The order fulfillment process requires picking the phones from inventory, packing them, and shipping them to the customer. Fulfillment verifies that the correct number of items is taken out of inventory to fill item requests on an order.

The documentation of the fulfillment process in Great Plains starts with printing the order.

With the order showing in the **Sales Transaction Entry** window click the printer icon on the upper right to bring up the Sales Document Print Options window.

In the **Include** quadrant, check the **Orders, Picking Tickets, and Packing Slips checkboxes**. Uncheck boxes in all other quadrants.
Click the Print button in the upper left of the window and select screen (not printer) as the report destination. All three documents will print to screen. The order will disappear from the Sales Transaction Entry Window. We’ll get it back soon. Close the Sales Transaction Entry window.

Verify order fulfillment through
Transactions > Sales > Order Fulfillment

The Sales Order Fulfillment window appears. Use the magnifying glass near the Doc. Number field to find your order number and select it. Remember the type of document you are seeking is an order. If the list is long, click on the binoculars icon in the Sales Order Fulfillment window and choose Customer PO Number for the Column Name, leave the filter “is equal to” and enter your Customer PO Number (GP login ID) in the Value area. Click OK and the list should be filtered to only your order. Make sure that it is your order number and double click on it in the list. Check the Customer ID to be sure this is your order. Verify that the correct number of items was fulfilled, click Fulfill All and Save the document. Remember, once you Save it, your document disappears. Verification of Order Fulfillment would normally occur when the ordered items were picked, packed, and shipped to the customer. Close the Sales Order Fulfillment window.

Step 7: Inventory Check
With the order fulfilled, re-check item inventory thorough the Item Quantities Smartlist. Remember to refresh the screen. If SMARTLIST was closed, access the
list by clicking the Smartlist icon on the Great Plains toolbar and scroll down to the Item Quantities folder. Filter the list to just the 100XLG phones as you did before. You should see a change in inventory but other orders may mean the change does not match your order quantity exactly. Leave SMARTLIST open. Like Arnold, we’ll be back.

Export the FILTERED list to Excel by clicking the Excel button. Copy and paste the results to the gp_sales.xls file.

Step 8: Create an Invoice from the Order

Bring back the Sales Transaction Entry window in any of the ways previously described with your order on display. Make sure that it is YOUR order. You should see the correct customer, customer order number, and your Comment ID. Click on the Transfer button at the top of the window.

In the Orders quadrant, check the Transfer to Invoice and Include Total and Deposits checkboxes. Click on the Transfer button on the lower right of the Sales Transfer Documents window.

Send all the SOP transfer log reports to the screen. Close the report screen. You should see your invoice. Great Plains assigns an invoice number. Write it down.

Check Sales Document Detail:
The invoice document now appears on the screen. Click on the expansion arrow next to the Document No. field. The Sales Document Detail Entry window appears which includes the quote and the order from which the invoice was generated. All documents can be viewed by highlighting the appropriate row and clicking the blue underlined Document Number column header. Close this window.
Click on the Distributions button which shows the accounts affected by the invoice. You will likely see accounts missing! This is a problem. Businesses cannot function without knowing how to allocate economic value. We have to fill in the missing accounts.

You do not have to fix an account if it has no money associated with it. If debits and credits are both zero, do not be concerned.

One at a time, click in the empty account fields and then click the magnifying glass near the blue underlined Account. Choose accounts to replace the blanks. Double click to have them appear in the Sales Distribution Entry window. You can use the binoculars to search, just scroll to get account numbers, or type the numbers in yourself. If you type, do it carefully.

300-5130-00 for COMMEXP (account description Commission Sales)
000-2120-00 for COMMPAY (account description Commissions Payable)
000-2410-00 for FREIGHT (account description Freight Payable)
A correctly completed account table appears below. You may or may not have the taxes, depending upon your customer.

Click the OK button to save the Sales Distribution Entry. If you make a mistake and Great Plains will not let you correct it. Close the window (Save with errors) re-open and correct the accounts again.

Erase the Batch ID (highlight SALES QUOTES and hit the backspace or delete key) and type your bronco net id in its place. We need a unique Batch ID for everyone. Click off the field elsewhere in the screen and you will be asked if you want to add the new Batch ID. Click the Add button. When the Sales Batch Entry window appears, click Save. The new batch ID disappears. Then close the Sales Batch Entry window. In the Sales Transaction Entry window, Save the Invoice. It disappears. Close the Sales Transaction Entry window.

Step 9: Posting the Invoice
Select Transactions > Sales > Series Post
Check the batch name you just created. Make sure that it is the only one checked. There will be many batch names so choose carefully.
Then click the **Post** button at the top of the screen. There are numerous posting documents. Send the first report to the **screen** and **cancel** the remaining choices.

![Sales Series Posting](image)

Close all windows except SMARTLIST.

Re-check item inventory for the last time thorough the **Item Quantities** SMARTLIST. If you left SMARTLIST open just return to the window but make sure that you **REFRESH** the **screen** by clicking the **REFRESH icon** near the COLUMNS button. If SMARTLIST was closed, access the list by clicking the SMARTLIST icon on the Great Plains toolbar and scroll down to the **Item Quantities** folder. You should see a change in inventory.

![Export FILTERED list to Excel](image)

You can now close the SMARTLIST.

**Step 10: Check Receivables**

When Great Plains posts an invoice, it designates it as a receivable. Inventory assets move up the liquidity ladder to receivables.

Check receivables through the Inquiry menu.

Choose **Inquiry > Sales > Transaction by Customer**

The Receivables Transaction Inquiry window appears. Choose your customer by clicking the magnifying glass in the Customer ID field. Once the customer data populates the table, your invoice should be in one of the table rows. Isolate it by entering the invoice number in the **From** and **To** fields and click the **Redisplay** button (see graphic)

Write down the amount owed by the customer below
Step 11: Get Paid

Payment is the last step in the sales transaction process. Posting a payment ends the order to payment business process. There will be one more housekeeping task in Great Plains that involves archiving the electronic transaction, but all financial and tracking information is completed with payment. When a company receives payment the documentation always identifies the paying company and the invoice paid.

Select Transactions > Sales > Cash Receipts.

The Cash Receipts Entry window appears (graphic next page). A receipt number will be automatically generated. Select your customer in the usual way. Enter the exact invoice payment amount in the Amount field. Leave the default Check radio button.
Click on the Distribution button to see the accounts affected by this payment. Then close the Distribution Entry window.

If the currency of the payment matches the currency of the invoice, the Apply button will be active. If it is dimmed, you will have to change the currency to match the currency of the invoice. If you have to switch currencies, click the magnifying glass near the currency field. Click the Apply button and the Apply Sales Documents window appears. **Find the invoice that is being paid from the list. Check its checkbox** and click the OK button.

Click the Post button on the Cash Receipts Entry window. As usual, the document disappears. The posting document dialogue box comes up when you close the window. As usual, there are numerous posting documents. Send them to the screen, not the printer.

**Step 12: Archive the Invoice**

Archive the invoice by selecting Tools > Routines > Sales > Paid Transaction Removal.

The Paid Sales Transaction Removal window appears. Leave the Customers field at the default by Customer ID. Change the radio button from All to From and click the magnifying glass to the right of the From field. Select your customer. Do the same thing for the To field. The same customer number should show in both the From and To fields. Then click the Process button. Choose the screen as the report destination (uncheck printer). Click the Yes response to the question about removing transactions. The report will print to the screen.

**Step 13: Final Check of Document Flow**
Choose **Inquiry > Sales > Transaction by Customer**

The Receivables Transaction Inquiry window appears. Choose your customer by clicking the magnifying glass in the Customer ID field. Once the customer data populates the table, your invoice should be in one of the table rows. Isolate it by entering the invoice number in the From and To fields and click the Redisplay button.

Click once on the invoice row to highlight it, then click on the blue underlined **Document Number** link. The Invoice document appears. Antecedent documents (quote and order) can be seen by clicking the expansion arrow near the document number field (shown below). After viewing the document flow, close all windows except the Receivables Transaction Inquiry-Customer window.

Payments made for the invoice can be seen by highlighting the invoice and clicking the blue underlined **Amount Remaining** header.

From the **Receivables Transaction Inquiry-Customer** window, click the Printer icon in the upper right. Uncheck printer, check file and click on the folder icon.

Save the file in a location where you can retrieve it (Desktop or your portable media), name the file *history* and save as a tab delimited file (see below). Click OK and the file will be created in the space you specified (see graphic).
In Excel, open the tab delimited history file. The tab delimited file type should be the default. After the file is imported into Excel copy the history list to the gp_sales.xls file.

Upload your complete Excel sheet in WebCT assignments.
Appendix B: Assessment Instruments

Business Process Research

Question 1
*Check Inventory Tracking Characteristics*
Check all tracking characteristics below involved in a checking inventory.
   a. Storage Location (Site ID)
   b. Product (Item ID)
   c. Commission
   d. Vendor (Vendor ID)
   e. Document Identifier (Document ID)
   f. Customer (Customer ID)
   g. Quantity
   h. Account Changed (Account Posting)
   i. Trade Discount
   j. Freight

Question 2
*Invoice Tracking Characteristics*
Check all tracking characteristics below involved in a sales invoice.
   a. Storage Location (Site ID)
   b. Product (Item ID)
   c. Commission
   d. Vendor (Vendor ID)
   e. Document Identifier (Document ID)
   f. Customer (Customer ID)
   g. Quantity
   h. Account Changed (Account Posting)
   i. Trade Discount
   j. Freight

Question 3
*Match Invoice/Receipts Tracking Characteristics*
Check all tracking characteristics below involved in matching an invoice with receipts.
   a. Storage Location (Site ID)
   b. Product (Item ID)
   c. Commission
   d. Vendor (Vendor ID)
   e. Document Identifier (Document ID)
   f. Customer (Customer ID)
   g. Quantity
   h. Account Changed (Account Posting)
   i. Trade Discount
   j. Freight

Question 4
*Order Fulfillment Tracking Characteristics*
Check all tracking characteristics below involved in order fulfillment.
Question 5

Receive Goods Tracking Characteristics
Check all tracking characteristics below involved in receiving goods.

a. Storage Location (Site ID)
b. Product (Item ID)
c. Commission
d. Vendor (Vendor ID)
e. Document Identifier (Document ID)
f. Customer (Customer ID)
g. Quantity
h. Account Changed (Account Posting)
i. Trade Discount
j. Freight

Question 6

Receive Payment Tracking Characteristics
Check all tracking characteristics below involved in receiving payment.

a. Storage Location (Site ID)
b. Product (Item ID)
c. Commission
d. Vendor (Vendor ID)
e. Document Identifier (Document ID)
f. Customer (Customer ID)
g. Quantity
h. Account Changed (Account Posting)
i. Trade Discount
j. Freight
**Question 7**

*Sales Forecast Tracking Characteristics*

Check all tracking characteristics below involved in a sales forecast.

a. Storage Location (Site ID)
b. Product (Item ID)
c. Commission
d. Vendor (Vendor ID)
e. Document Identifier (Document ID)
f. Customer (Customer ID)
g. Quantity
h. Account Changed (Account Posting)
i. Trade Discount
j. Freight

**Question 8**

*Sales Order Tracking Characteristics*

Check all tracking characteristics below involved in a sales order.

a. Storage Location (Site ID)
b. Product (Item ID)
c. Commission
d. Vendor (Vendor ID)
e. Document Identifier (Document ID)
f. Customer (Customer ID)
g. Quantity
h. Account Changed (Account Posting)
i. Trade Discount
j. Freight

**Question 9**

*Sales Quote Tracking Characteristics*

Check all tracking characteristics below involved in a sales quote.

a. Storage Location (Site ID)
b. Product (Item ID)
c. Commission
d. Vendor (Vendor ID)
e. Document Identifier (Document ID)
f. Customer (Customer ID)
g. Quantity
h. Account Changed (Account Posting)
i. Trade Discount
j. Freight
Question 10  
**Selecting Supplier Tracking Characteristics**  
Check all tracking characteristics below involved in selecting a supplier.  
- a. Storage Location (Site ID)  
- b. Product (Item ID)  
- c. Commission  
- d. Vendor (Vendor ID)  
- e. Document Identifier (Document ID)  
- f. Customer (Customer ID)  
- g. Quantity  
- h. Account Changed (Account Posting)  
- i. Trade Discount  
- j. Freight

Question 11  
**Payment Tracking Characteristics**  
Check all tracking characteristics below involved in making a payment.  
- a. Storage Location (Site ID)  
- b. Product (Item ID)  
- c. Commission  
- d. Vendor (Vendor ID)  
- e. Document Identifier (Document ID)  
- f. Customer (Customer ID)  
- g. Quantity  
- h. Account Changed (Account Posting)  
- i. Trade Discount  
- j. Freight

Question 12  
**Purchase Order Tracking Characteristics**  
Check all tracking characteristics below involved in a purchase order.  
- a. Storage Location (Site ID)  
- b. Product (Item ID)  
- c. Commission  
- d. Vendor (Vendor ID)  
- e. Document Identifier (Document ID)  
- f. Customer (Customer ID)  
- g. Quantity  
- h. Account Changed (Account Posting)  
- i. Trade Discount  
- j. Freight
Question 13
Needed to pay
Which transaction documents are needed for a business to pay for an item?
- a. sales order
- b. payment receipt
- c. purchase order
- d. customer address
- e. goods receipt
- f. invoice
- g. inventory item number

Question 14
Complete a Sale
Which transaction documents are needed for a business to complete a sale?
- a. sales order
- b. payment receipt
- c. purchase order
- d. customer address
- e. goods receipt
- f. invoice
- g. inventory item number

Question 15
Purchasing components and sequence
Arrange the business activities listed below in the proper sequence for a business purchase process. Use as many as you think are appropriate to complete the purchase process. You may not need all of the activities. Place the number of the activity in the answer boxes. The first answer box should receive the first activity in the sequence.

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Create Sales Quote</td>
<td>2.</td>
</tr>
<tr>
<td>3. Select Supplier</td>
<td>3.</td>
</tr>
<tr>
<td>5. Receive Goods</td>
<td>5.</td>
</tr>
<tr>
<td>7. Check Credit Limit</td>
<td>7.</td>
</tr>
<tr>
<td>12. Create Invoice</td>
<td>12.</td>
</tr>
<tr>
<td>13. Check Inventory Quantity</td>
<td>13.</td>
</tr>
<tr>
<td>15. Create Purchase Order</td>
<td>15.</td>
</tr>
</tbody>
</table>

For example if you thought that a purchase process consisted of creating an invoice, checking inventory, and updating employee benefits in that order, you would list number 12 in the first box, 13 in the second, and 14 in the third.
Remember, choose activities associated with business purchase and enter numbers in proper sequence.

**Question 16**

*Sales components and sequence*

Arrange the business activities listed below in the proper sequence for a business sales process. Use as many as you think are appropriate to complete the sales process. You may not need all of the activities. Place the number of the activity in the answer boxes. The first answer box should receive the first activity in the sequence.

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Create Sales Quote</td>
<td>2.</td>
</tr>
<tr>
<td>3. Select Supplier</td>
<td>3.</td>
</tr>
<tr>
<td>5. Receive Goods</td>
<td>5.</td>
</tr>
<tr>
<td>7. Check Credit Limit</td>
<td>7.</td>
</tr>
<tr>
<td>12. Create Invoice</td>
<td>12.</td>
</tr>
<tr>
<td>13. Check Inventory Quantity</td>
<td>13.</td>
</tr>
<tr>
<td>15. Create Purchase Order</td>
<td>15.</td>
</tr>
</tbody>
</table>

For example if you thought that a sales process consisted of creating an invoice, checking inventory, and updating employee benefits in that order, you would list number 12 in the first box, 13 in the second, and 14 in the third.

Remember, choose activities associated with business sales and enter numbers in proper sequence.

**Question 17**

*Important Purchase Order Processing Activities*

From the list below, select the ten most important activities of a business purchasing process. We are interested in your impression of a purchasing process rather than an objective answer that could be considered to be right or wrong.

*Note that not all activities in the list apply to a purchasing process.* Of the 21 choices, choose the ten you think are most important for purchases and enter numbers associated with those activities in the boxes.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. specify a product</td>
<td></td>
</tr>
<tr>
<td>2. specify a color</td>
<td></td>
</tr>
<tr>
<td>3. specify a storage location</td>
<td></td>
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<tr>
<td>4. specify an individual buyer</td>
<td></td>
</tr>
<tr>
<td>5. create a document tracking number</td>
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</tr>
<tr>
<td>6. specify a vendor</td>
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</tr>
<tr>
<td>7. check inventory</td>
<td></td>
</tr>
<tr>
<td>8. specify a customer</td>
<td></td>
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<tr>
<td>9. check vendor performance</td>
<td></td>
</tr>
<tr>
<td>10. specify a quantity</td>
<td></td>
</tr>
<tr>
<td>11. change financial accounts</td>
<td></td>
</tr>
<tr>
<td>12. specify a price</td>
<td></td>
</tr>
<tr>
<td>13. specify a sales agent</td>
<td></td>
</tr>
<tr>
<td>14. specify physical dimensions</td>
<td></td>
</tr>
<tr>
<td>15. check trade discount</td>
<td></td>
</tr>
<tr>
<td>16. check credit limit</td>
<td></td>
</tr>
<tr>
<td>17. create an invoice</td>
<td></td>
</tr>
<tr>
<td>18. pay an invoice</td>
<td></td>
</tr>
<tr>
<td>19. receive goods</td>
<td></td>
</tr>
<tr>
<td>20. send goods</td>
<td></td>
</tr>
<tr>
<td>21. create a quote</td>
<td></td>
</tr>
</tbody>
</table>
**Question 18**

*Important Sales Order Processing Activities*

From the list below, select the **ten most important activities of a business sales process**. We are interested in your *impression* of a sales process rather than an objective answer that could be considered to be right or wrong.

*Note that not all activities in the list apply to a sales process* Of the 21 choices, choose the ten you think are most important for sales and enter numbers associated with those activities in the boxes.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. specify a product</td>
<td>1</td>
<td></td>
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<tr>
<td>2. specify a color</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3. specify a storage location</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4. specify an individual buyer</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5. create a document tracking number</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>6. specify a vendor</td>
<td>6</td>
<td></td>
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<tr>
<td>7. check inventory</td>
<td>7</td>
<td></td>
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<tr>
<td>8. specify a customer</td>
<td>8</td>
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<tr>
<td>9. check vendor performance</td>
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<tr>
<td>10. specify a quantity</td>
<td>10</td>
<td></td>
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<tr>
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<tr>
<td>12. specify a price</td>
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<tr>
<td>13. specify a sales agent</td>
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<tr>
<td>14. specify physical dimensions</td>
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<tr>
<td>16. check credit limit</td>
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</tr>
<tr>
<td>17. create an invoice</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>18. pay an invoice</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>19. receive goods</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>20. send goods</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>21. create a quote</td>
<td>21</td>
<td></td>
</tr>
</tbody>
</table>
Technology Attitude

Question 1
I am comfortable using technology in my normal school and work activities
a. strongly agree
b. moderately agree
c. somewhat agree
d. neutral (neither agree nor disagree)
e. somewhat disagree
f. moderately disagree
g. strongly disagree

Question 2
Given an opportunity to use enterprise software, I predict that I would use it.
a. strongly agree
b. moderately agree
c. somewhat agree
d. neutral (neither agree nor disagree)
e. somewhat disagree
f. moderately disagree
g. strongly disagree

Question 3
People who influence my behavior think that I should use enterprise software to prepare for a future career.
a. strongly agree
b. moderately agree
c. somewhat agree
d. neutral (neither agree nor disagree)
e. somewhat disagree
f. moderately disagree
g. strongly disagree

Question 4
People who are important to me think that I should use enterprise software to prepare for a future career.
a. strongly agree
b. moderately agree
c. somewhat agree
d. neutral (neither agree nor disagree)
e. somewhat disagree
f. moderately disagree
g. strongly disagree
Question 5
My interaction with the enterprise software system is clear and understandable.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 6
My interaction with the enterprise software system does not require a lot of my mental effort.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 7
I find the enterprise software system easy to use.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 8
I find the enterprise software system easy to get to do what I want it to do.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 9
I believe using enterprise software would improve my performance in my future job.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree
Question 10
I believe using enterprise software would increase my productivity in my future job.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 11
I believe using enterprise software would enhance my effectiveness in my future job.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 12
I believe using enterprise software would be useful in my future job.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 13
I have no difficulty telling others about the results of using enterprise software.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 14
I believe that I could communicate to others the consequences of using enterprise software.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree
Question 15
The results of using enterprise software are apparent to me.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 16
My experience with enterprise software has increased my understanding of a business sales process.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 17
My experience with enterprise software has increased my understanding of a business purchasing process.
   a. strongly agree
   b. moderately agree
   c. somewhat agree
   d. neutral (neither agree nor disagree)
   e. somewhat disagree
   f. moderately disagree
   g. strongly disagree

Question 18
If your ERP experience increased your understanding of purchasing or sales business processes please describe how the experience improved your understanding.
### Right Side Subprocess Sequence Scoring – Spreadsheet Formula

```excel
=IF(ISERROR(MATCH(E143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(E143,ra1_p,0),pointchk,2,FALSE))+IF(ISERROR(MATCH(F143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(F143,ra1_p,0),pointchk,2,FALSE))+IF(ISERROR(MATCH(G143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(G143,ra1_p,0),pointchk,2,FALSE))+IF(ISERROR(MATCH(H143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(H143,ra1_p,0),pointchk,2,FALSE))+IF(ISERROR(MATCH(I143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(I143,ra1_p,0),pointchk,2,FALSE))+IF(ISERROR(MATCH(J143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(J143,ra1_p,0),pointchk,2,FALSE))+IF(ISERROR(MATCH(K143,INDEX(ra1_p,MATCH(D143,ra1_p,0)):INDEX(ra1_p,pend),0)),0,VLOOKUP(MATCH(K143,ra1_p,0),pointchk,2,FALSE))
```

### Pointcheck

<table>
<thead>
<tr>
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<th>Points</th>
</tr>
</thead>
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<tr>
<td>1</td>
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<tr>
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<td>7</td>
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<td>1</td>
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<tr>
<td>pend</td>
<td>8</td>
</tr>
<tr>
<td>send</td>
<td>8</td>
</tr>
</tbody>
</table>
Sequence Scoring Flow Diagram

**Left Side Scoring**

Score array $N_i; N_j$

$i = 7$

$j = 7$

$i = 1$? Yes: Stop

No: Select $N_j$

Score $N_j = 0$

$N_{j+1}$ contained in CA segment $C_j : N_{j+1}$?

Yes: Assign PP based on position of $N_{j+1}$ in CA

Score $N_j = ScoreN_j + PP$

$j = j - 1$

$j = 1$? Yes: $i = i - 1$

No: Continue

**Right Side Scoring**

Score array $N_i; N_j$

$i = 1$

$j = 1$

$i = 7$? Yes: Stop

No: Select $N_j$

Score $N_j = 0$

$N_{j+1}$ contained in CA segment $N_j : C_j$?

Yes: Assign PP based on position of $N_{j+1}$ in CA

Score $N_j = ScoreN_j + PP$

$j = j + 1$

$j = 7$? Yes: $i = i + 1$

No: Continue
Appendix D: HSIRB Approval Letter and Consent Form

Approval Letter

Date: March 6, 2006

To: William Cobern, Principal Investigator
   Thomas Rienzo, Student Investigator for dissertation

From: Mary Lagerwey, Ph.D., Chair

Re: HSIRB Project Number: 06-02-30

This letter will serve as confirmation that your research project entitled “Conceptual Change and Experiential Learning with Business Enterprise Software” has been approved under the exempt category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note that you may only conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the HSIRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: March 6, 2007
Consent Form

You have been invited to participate in a research project entitled “Conceptual Change and Experiential Learning with Business Enterprise Software”. This research is intended to study how technology affects learner understanding of systems, processes, and relationships. You will describe your understanding of business purchasing and sales processes, and answer questions relating to their components and relationships. You will be expected to provide general information about yourself, such as age, level of education, and familiarity with technology.

One possible benefit of this activity is a better understanding of the interdependencies of business processes through software actually used in the business world to support commercial business processes. Experience with real-world business software can help students market their skills to potential employers.

All of the information collected is confidential. Data will be aggregated and not be traceable to any individual. Data will be retained in a locked file in Thomas Rienzo’s office for a minimum of three years.

You may refuse to participate but that refusal does not change the requirements to complete class assignments which include descriptions of your understanding of business systems as a result of your interaction with the enterprise business software. Data will be collected as part of normal class assignments regardless of your decision to participate in this research. Your decision to participate or not will have no effect on the amount of work required for the course, and no effect upon your grade in the course. If you elect to participate, you will be agreeing to have your data aggregated and analyzed for business process understanding. You can withdraw permission to use data for publication at any time during the study without prejudice or penalty. If you have any questions or concerns about this study, you can contact either Thomas Rienzo at 387-5511 or William Cobern at 387-5409. You may also contact the Chair, Human Subjects Institutional Review Board (387-8293) if questions or problems arise during the course of the study.

Consent documents will be collected during the class period, sealed in an envelope by a student designated by the class instructor, and taken to the office of the chair of the BIS department. The envelope will not be opened until after grades have been submitted to the registrar. This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right hand corner. Do not participate in this study if the stamped date is older than one year.

Your signature below indicates that you have read and/or had explained to you the purpose and requirements of the study and that you agree to participate.

______________________________
Signature

______________________________
Date