

Student Understandings of Information Systems Design, Learning and Teaching: A Phenomenography Approach

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ABSTRACT

Phenomenographic studies have shown clear links between the approach students take to learning and the achievement of deep versus surface learning outcomes in higher education. The context in which learning takes place is a key factor in these studies. The purpose of this research is to discover the conceptions of learning, teaching and information systems design held by a diverse group of 60 second-year university students and to determine whether there are differences between field-dependent and field-independent students. Our context-dependent findings on student conceptions of teaching and learning are descriptive in nature. These findings were integrated into an outcome space of student conceptions of information systems design, which is interpreted with respect to existing theory on differences between field-dependent and field-independent students and the cognitive demands of learning information systems design. The results have implications for teaching practice and further research on the effects of qualitative variations in student conceptions on the achievement of deep versus surface levels of learning about information systems design.

Keywords: Information Systems Design, Learning Approaches, Learning Outcomes, Phenomenography, Cognitive Demands of Design, Field-Dependent Learners, Field-Independent Learners

1. INTRODUCTION

"When you have a diverse group of people from different cultures, you get not just different beliefs about the world, but different ways of perceiving it and reasoning about it, each with its own strengths and weaknesses." ... J. Nisbett, Senior Research Scientist, Institute for Social Research

What do our students think information systems (IS) design is? How do they approach learning? What are their expectations about university teaching? How do student conceptions relate to our expectations about the depth of learning that should take place in introductory courses on IS design? This phenomenographic study aims to discover the conceptions of learning, teaching and IS design held by a diverse group of 60 second-year university students and to determine whether there are differences between field-dependent (FD) and field-independent (FI) students that might impact learning outcomes in IS design courses. The term field-independent refers to the extent to which one perceives information analytically (Witkin, Moore, Goodenough and Cox, 1977), that is the extent to which one is able to discern elemental parts or basic principles as discrete entities, independent of the field (e.g. learning context or environment) in which they are perceived. The

term field-dependent refers to the extent to which the field, including emotionality and social cues, dominates perception, resulting in a more global or holistic way of perceiving that does not distinguish between the field as a whole and elements within it that are critical versus non-critical to the task at hand. The FD/FI dimension of cognitive style has been explored in a number of other areas of education to examine how students learn, how teachers teach, how matching versus mismatching styles influences student-teacher interaction and how students make educational choices and perform in their area of choice (Hayes and Allison, 1996; Lieberman, 1998; Pithers, 2002; Witkin, 1973; Witkin et al., 1977). FI learners have been shown to be attracted to subjects that require significant analytical skill (such as IS design) and to have a performance advantage over FD learners in such subjects (McKenna, 1990; Pithers, 2002). This advantage may be due to the primarily FI way in which subjects with a large analytical component are taught and assessed (Pithers, 2002). The motivation for this study is to facilitate the development of teaching strategies for IS design courses that make use of phenomenographic pedagogy (Bowden, Dall'Alba, Martin, Masters, Laurillard, Marton, Ramsden and A., 1992) to facilitate deep learning for both FD and FI learners. The context for this study is an introductory, second-year course on object-oriented IS design, taught within the Information

Systems curriculum in a New Zealand University with a primarily FI culture. The majority of students, however, are non-native English speakers from a diverse group of primarily FD cultures. Conceptions about teaching and learning in general attributed in the literature to FD versus FI students (Lieberman, 1998; Pithers, 2002; Witkin et al., 1977) are summarized and used as a theoretical basis for comparison and for interpreting our results. Current findings in the literature on the cognitive abilities specific to IS design and the cognitive abilities needed to master IS design (Detienne, 2002; Turley and Bieman, 1995) are discussed in relationship to our expectations for IS design students in terms of what they should focus on and what constitutes deep learning.

The next section further explains the motivation for this study and breaks our aim into research questions. Section three places our study in the context of existing work on the cognitive demands of IS design and relates these demands to theoretical differences in the ways FD and FI learners approach learning tasks. Section four explains the rationale behind choosing a phenomenographic approach and the analysis procedures used. The results of our analysis are presented in section five. Section six interprets our results with respect to the theory discussed in section three yielding implications for the use of phenomenographic pedagogy in teaching IS design and suggestions for future research based on the findings and limitations of this study.

2. RESEARCH QUESTIONS AND MOTIVATION

Phenomenography is a qualitative, learner-centered approach to understanding how variations in "ways of experiencing" a phenomenon influence learning outcomes (Fransson, 1977; Marton and Säljö, 1976a, 1976b; Svensson, 1977). As such, it provides a suitable approach to addressing our primary research question: *Are the conceptions of learning, teaching and IS design held by our IS design students primarily field-dependent or field-independent and how are these conceptions related to deep and surface learning outcomes with respect to IS design?* This larger question is subdivided into the following more specific research questions:

- 1) What are the qualitative variations in conceptions of teaching, learning and IS design held by the participants? Are there qualitative differences in these conceptions with respect to FD and FI students?
- 2) How (structural aspects as internal foci and external boundaries) do the participants approach learning and what (referential aspects, deep/surface level) do they learn about IS design? Are there qualitative differences for FD and FI students?
- 3) How are student conceptions of teaching, learning and IS design related to surface and deep understandings of IS design relative to our expectations as teachers of IS design? Are there qualitative differences for FD and FI students?

Evidence in the literature of student difficulty in dealing with the cognitive demands of IS design (Budgen, 1995; Detienne, 2002; Glass, 1992; Northrop, 1993; Tegarden and

Sheetz, 2001), evidence of student difficulties with the "design" aspects of learning to program (Booth, 1997; Bruce, McMahon, Buckingham, Hynd and Roggenkamp, 2004; Hohmann, 1996; Rosson and Carroll, 1996), personal experience with the challenges of dealing with large introductory classes of diverse students, along with evidence of the relationship between field-dependence/ independence and learning outcomes in analytical subjects such as IS design (McKenna, 1990) were strong motivators for this study. Information Systems courses take a broad view of software development, covering both large and small system development issues, contextual issues such as working in teams and communicating with clients, and modeling the problem and solution spaces. Students intending to pursue a career, as software developers need to acquire this diverse set of skills but anecdotal evidence from industry suggests that not all students may be learning at the desired level.

Most of the work relating cognitive style to software design has been done in the area of human computer interaction. The influence of cognitive style on learning strategies has not been as thoroughly explored. (Watkins and Biggs, 1999) studied the rote memorization strategies employed in Chinese teaching and learning, finding unexpectedly that such strategies can lead to successful outcomes. Students from different backgrounds, who begin a design course with different cognitive styles may approach the learning and conceptualization of IS design differently. Phenomenographic studies including (Cope, 2002; Lucas, 2001; Marton and Säljö, 1976a, 1976b; Prosser and Trigwell, 1999) find that learning outcomes are related to learning approach and that learning approach often differs across disciplines. Using Phenomenography in this study to understand FD and FI conceptions of teaching, learning and IS design appears to be new.

3. LITERATURE REVIEW

In this section, relevant findings from the Computer Science, Information Systems and Educational Psychology literature on the cognitive abilities of software designers, FD/FI cognitive style differences, and the relationship between cognitive style and learning IS design are reviewed. This section provides the theory used in interpreting our results.

3.1 Effective IS Designers

Designing software is a complex, socio-technical, cognitive process that requires a combination of technical, social, analytic and creative abilities (Cougar, 1986a, 1986b; Cougar, Higgins and McIntyre, 1993; Wynekoop and Waltz, 1998, 2000). IS designers must create alternative solutions, evaluate trade-offs and recognize that most problems have many possible solutions. Good designers can abstract out the important aspects of a problem, and can communicate with both non-technical business analysts as well as programmers. Few studies, however, have specifically looked at the cognitive abilities of IS designers, as distinct from programmers and analysts (Wynekoop and Waltz, 1998, 2000).

Top IS designers creatively visualize the system as a whole and also have the analytical ability to view its parts at varying levels of abstraction (Glass, 1992; Stolterman, 1991; Turley and Bieman, 1995; Wynekoop and Waltz, 2000). This entails switching between left- and right-hemispheric thinking. Top designers have a deep understanding of design principles and strategies allowing them to produce more effective solutions (Turley and Bieman, 1995). These abilities have a skill and knowledge component which can be taught (Kelley and Kaplan, 1993; Wynekoop and Waltz, 2000). An important question is whether or not what we intend to teach is learned at a deep level and whether we can alter teaching practice to encourage deeper learning as well as style switching.

3.2 Learning IS Design

(Tegarden and Sheetz, 2001) related the cognitive skills required for object-oriented design to software development activities which students perceived as being the most difficult. They found that logical design was seen to be more difficult than either programming or analysis. Other studies on learning outcomes in introductory object-oriented programming courses found that many students learn how to *implement* software, but whether or not most learned *how to design* was unclear (Mercer, Biddle, Duvall, Clancy and Cockburn, 1997; Reil, 1996; Rosson and Carroll, 1996). Since the importance of "good" design increases with system size and complexity, this deficiency creates a significant problem for industry.

In a recent phenomenographic study, (Booth, 2001) found that students who approached learning to program as learning to code in a language or as passing the course, exhibited a surface approach to learning. In contrast, students who focused on creating the design of a program in terms of understanding/integrating, as problem-solving, as producing a product to be used by people or as becoming a programming professional, exhibited deeper learning. These deeper aspects reflect the design component of programming and primarily involve the ability to learn, create and use effective design strategies. This result also supports the claim that expert designers are not necessarily expert coders (Curtis, Krasner and Iscoe, 1988). This relationship implies that our findings on conceptions held by IS design students may vary but overlap with those of recent phenomenographic studies (Booth, 1997, 2001; Bruce et al., 2004) on learning to program. In a comprehensive review of research on learning to program, (Robins, Rountree and Rountree, 2003) concluded that differences in pre-existing strategies that learning were a significant predictor of differences between effective and less effective student programmers.

3.3 The FD/FI Dimension of Cognitive Style

Cognitive style refers to how people think, solve problems, learn and relate to others. People are conditioned to use the teaching, learning and/or problem-solving approaches that predominate in their culture (Kleinfeld, 1994; Lieberman, 1998). Most people use both sides of the brain when learning but often show a tendency to favor one way of thinking over another. According to (Lieberman, 1998; Tsunoda, 1979) this tendency is related to the way a person's

first language is sequenced and ordered. (Springer and Deutsch, 1985) also claim that different languages have either a more concrete or a more abstract orientation, which is responsible for differential hemispheric involvement in cognitive activities. The particular form that a culture's writing system takes may also play a crucial role (McLuhan and Logan, 1977). With respect to the FD/FI dimension of cognitive style, field-independence has been positively related to left-hemispheric reasoning and field-dependence has been positively related to right-hemispheric reasoning (Lieberman, 1998). The main characteristics of FD and FI learners and the relationship to right and left hemispheric reasoning are summarized in Figure 1. FD and FI are treated as the end points of a continuum, rather than as either-or classifications.

These cognitive style differences may influence student conceptions of teaching, learning and IS design as well as their ability to master IS design. A recent review (Pithers, 2002) of existing work on the impact of FD/FI styles on learning concludes that matching teacher and learner styles may only have short-term benefits in the form of student satisfaction and that it is more important in the long run for learners to be encouraged to apply style flexibility based on the nature of the task or problem.

3.4 Cognitive Style, Learning and Problem-Solving Approach

Studies of the relationship between Graduate Record Examination (GRE) scores and FD versus FI approaches to problem-solving show that switching learning styles can improve performance. Monaghan (1998) found that style switching was a significant predictor of successful outcomes to complex problem-solving tasks. He found that FD problem-solving strategy started with translating words into images to generate an external structure as a way of setting boundaries. FD learners looked for connections between multiple aspects of the problem simultaneously and made use of nested assumptions. In contrast, FI problem solvers isolated parts of the problem, then formed connections between them, using little or no nesting of assumptions (Monaghan, 1998). The nature of IS design, as an ill-structured problem-solving task (Budgen, 1995), requires both left-hemispheric (FI) and right-hemispheric (FD) reasoning.

4. RESEARCH METHOD

This study uses a phenomenographic research design. Phenomenography has been used to study variations in problem-solving approach (Laurillard, 1984) and to find educationally critical differences in understandings of course content (Renström, Andersson and Marton, 1990) in a broad range of subject areas (Booth, 2001; Bruce and McMahon, 2002; Bruce et al., 2004; Marton, 1994), including student conceptions of an Information System (Cope, 1997, 2002, 2003; Cope, Horan and Garner, 1997).

4.1 Phenomenography as a Theoretical Framework

Phenomenography aims to "describe" qualitative variation, not to "explain" why the variation exists. Detailed

Figure 1. Cognitive Style Continuum

←	→
<p>Field-Independent Learners (analytical/impersonal/abstract)</p> <p>Prefer to use left-hemispheric reasoning which is serialist/logical/inductive (specific to general).</p> <p>Perceive analytically by isolating out the relevant facts, like to self-structure situations and prefer problems that allow multiple solutions. Have self-defined goals and reinforcements.</p> <p>Prefer to answer questions quickly and are less comfortable with long pauses. Think teachers who pause may not know the answer.</p> <p>Problem-solving approach is practice until you get it right, seek guidance only if needed and learn from your mistakes.</p> <p>Prefer to work independently and get individual recognition for achievement. Less affected by criticism. May need training in social skills.</p> <p>Focus on nouns over verbs and use distinct concept categories (individual detail). Meaning comes directly from the verbal message independent of context. Prefer open discussion.</p>	<p>Field-Dependent Learners (holistic/social/concrete)</p> <p>Prefer to use right-hemispheric reasoning which is holistic/analogical/deductive (general to specific).</p> <p>Perceive in a global fashion, adhering to externally provided structure and prefer problems with one correct answer. Require externally defined goals and reinforcements.</p> <p>Prefer to think longer before answering questions. Think teachers who do not pause have not considered their question carefully.</p> <p>Problem-solving approach is observe with lots of guidance and examples from the expert to set boundaries to avoid making mistakes before attempting a task.</p> <p>Prefer to work in groups and be rewarded for effort. More affected by criticism. Like material with social content or that is perceived as relevant to their own experience.</p> <p>Focus on verbs (interactions) over nouns and use less distinct concept categories (big picture). Meaning is influenced by non-verbal behavior. Prefer to listen with less talking.</p>

knowledge of the *ways in which learners* come to grips with the concepts and principles of a domain are critical for developing an understanding and eventual mastery of a subject (Bowden et al., 1992). The underlying premise is that awareness of differences can lead to conceptual change in both teaching and learning. The goal is to improve outcomes in the form of deep learning (Prosser, 1993). In this study, descriptions collected from participants are interpreted using phenomenographic techniques to discover avenues for further research, to make recommendations for teaching practice and to discuss implications for the proficiency levels of design students entering a global software industry.

4.2 Data Collection and Context for the Study

A request for participation was made in 2003 to all students taking a second-year IS design course at a New Zealand university. Participants were required to read an information sheet and to sign a consent form. All participants had taken an object-oriented systems analysis course the previous semester that ended with an introduction to object-oriented design. The lectures and tutorials in the early part of the object-oriented design course covered product and process aspects of design, design principles, the goals of design, the relevance of design in systems development and in becoming a systems development professional. Characteristics of the 60 participants are summarized in Table 1. The sample demographics are representative of the class population.

This data gathering effort was part of a larger study, however, only the results of 3 open-ended questions on teaching, learning and IS design and 11 binary-choice questions on FD/FI were relevant to this paper. The open-ended questions asked for a brief written statement of the student's understanding of teaching, learning and IS design. The 11 questions (see the appendix) on FD/FI were not previously validated, they were developed for this exploratory study from the findings in the literature on the preferences of FD and FI learners summarized in Figure 1. The information in Figure 1 was also used in interpreting our results with respect to findings in the existing literature on FD and FI learners.

4.3 Data Analysis

Phenomenographic analysis produces a descriptive model of qualitative variation in the ways a group of individuals experience a phenomenon (Marton, 1986; Marton and Booth, 1997), by identifying common themes. "Ways of experiencing" are categorized, into "conceptions" that emerge from the data analysis as commonality is identified across responses. Each conception says something unique about the phenomena of study and stands in logical relationship with the other conceptions (Marton and Booth, 1997).

Table 1. Participant Characteristics

Sex		Age Group			IS Work Experience			Field-Dependent (FD) / Field-Independent (FI)			Native English Speaker?	
F	M	<26 yrs	26-30yrs	>30 yrs	< 2 yrs	2-5 yrs	>5 yrs	FD	FD/FI	FI	Yes	No
28%	72%	68%	19%	13%	86%	14%	0%	46%	37%	17%	37%	63%

In this study, “ways of experiencing” IS design, teaching and learning were first considered separately, following the analysis procedures of (Bradbeer, Healey and Kneale, 2004). To derive conceptions of *IS design*, all responses were read several times on three days. After the third reading, initial conceptions were noted. At the next, more thorough reading, responses were allocated to conceptions. At subsequent readings, responses were evaluated in detail for fit within each conception, reducing the number of conceptions and moving some responses. Two conceptions from Bradbeer et al. (2004) were used to categorize responses on *teaching*. Six well-established conceptions of learning and three conceptions on how learning is achieved from (Marton, Dall’Alba and Beaty, 1993; Marton and Säljö, 1976a) were used to categorize *learning* approaches here as in (Bradbeer et al., 2004).

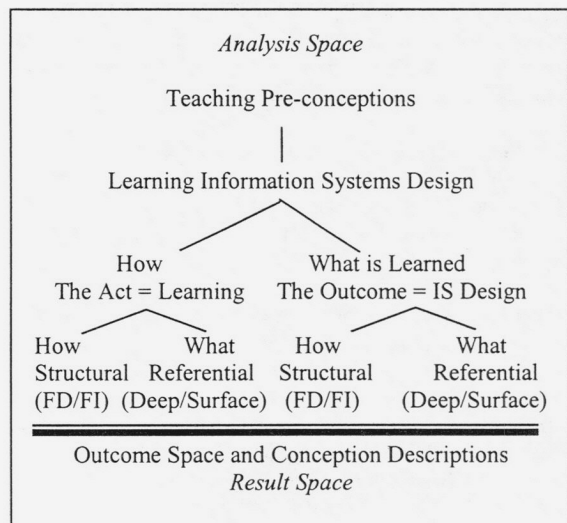
Identification of the “what” and “how” dimensions (see Figure 2) is common practice in Phenomenography. Deep and surface intention are distinguished in terms of “what” a participant refers to in their responses (Marton and Säljö, 1976a). The “how” dimension deals with structural aspects of how explanations are given in terms of the perceived external boundary of the experience and the internal foci of the experience. A common practice is to model the structural aspects as an outcome space. It describes logical relationships between conceptions and visually integrates the separate ways in which the phenomenon was understood, subject to the researchers’ interpretation. In our study, the external boundary of each IS design conception represents the widest context in which participants experienced IS design. The internal foci refer to what participants focused on in their responses. The outcome space shows - in qualitative terms - how well learners succeed with their learning task relative to our teaching goals.

The depth of the “what” aspect was examined using the Structure of Observed Learning Outcomes (SOLO) taxonomy, developed by (Biggs and Collis, 1982, 1989) as it has been widely used in research in higher education (Cope, 1997). SOLO categories reflect surface to deep levels of understanding as: uni-structural (one relevant known aspect), multi-structural (several relevant independent aspects), relational (integrate aspects of knowledge into a structure) and extended abstract (generalize knowledge to a new domain). The “how” aspect of learning represents participants’ understandings in terms of their own actions. A response may focus on relational or on independent aspects of learning (Marton, 1994).

4.4 Validity, Reliability and Qualitative Studies (Erlandson, Harris, Skipper and Allen, 1993) recommend using the criteria of credibility, transferability, confirmability

and dependability for qualitative studies. Credibility was addressed by collecting data from participants engaged in the phenomena of interest, by verification of interpretations by all three researchers and by reviewing findings of similar phenomenographic studies on learning to program and learning about Information Systems. Transferability was addressed by the use of thick descriptions of the context of the study and of the conceptions held by the researchers. Confirmability was strengthened by keeping a data file of student responses, which included notes on differences in interpretations, and the results of discussions that led to changes in categorizing responses. Dependability was addressed by managing researcher subjectivity through bracketing (Sandberg, 1997). Interpretation is bracketed by examining participant responses for similarities and differences without judging the extent to which the responses reflect the researcher’s own understanding (Marton, 1994). This practice was followed, but as in

Figure 2. Visual Representation of the Analysis and Result Spaces for this Study



any interpretive study, it is likely that our interpretations were partly influenced by our own pre-conceptions. Two of the researchers are primarily FI and have English as their first language. The third researcher is primarily FD but received some of her recent education from a western university. All three are involved in the teaching, preparation, assessment and delivery of the IS Design course which represents the field or context in which learning takes place in this study. All three interact with the participants in small, group tutorials and have object-oriented programming experience.

5. CONCEPTIONS AND OUTCOME SPACE

Student responses on teaching, learning and IS design were generalized into conceptions of teaching, learning and IS design. These results relate to the first research question and the “what” aspect of the second research question:

- 1) What are the qualitative variations in conceptions of teaching, learning and IS design held by the participants? Are there qualitative differences in these conceptions for FD and FI students?
- 2) How (structural aspects as internal foci and external boundaries) do the participants approach learning and what (referential aspects, deep/surface level) do they learn about IS design? Are there qualitative differences for FD and FI students?

The descriptions that follow provided data for constructing the outcome space to address the “how” aspect of the second question above. A few participants gave no response to one or more of the open-ended questions and some provided responses that were either tautological or indicated insufficient understanding. Not providing a response when the respondent is either unsure of the “correct” answer or has not had time to prepare an answer in advance, could be interpreted as a FD characteristic (Lieberman, 1998; Pithers, 2002). However, these responses were excluded from the results and analysis that follow.

5.1 Conceptions of Teaching

Only 46 of 60 respondents gave interpretable explanations of teaching. These responses were categorized as: “teaching as information transfer” and “teaching as helping learning”, as documented in previous research (Bradbeer et al., 2004).

Conception 1: Teaching as Information Transfer

About two-thirds of the students held this FD view of teaching, seeing the expert as responsible for transferring knowledge to a passive student observer. Many of these responses used analogy, a FD form of reasoning. About half of these responses indicated a FD need for extensive direction, personal relevance and extensive use of examples as illustrated by the following responses.

Response 9: “Process of explaining the material through personal experience or understanding with modified language suitable for the audience.”

Response 46: “Teaching should involve explaining concepts, if possible demonstrating how to apply them and describing ways it can be used in real world/industry (showing the importance and relevance of the material).”

Conception 2: Teaching as Helping Learning

About one-third of the respondents (primarily non-native English speakers) held this relational, FI view of the expert as a facilitator and students as active participants, seeking guidance only as needed. As with conception 1, some responses indicated a greater need for direction and greater dependence on the teacher but still focused on the interaction between the teacher and student participant.

Response 35: “Teaching is demonstrating something, then getting the student to help you as you demonstrate it again, then watching as the student does it, the getting the student to do it themselves without supervision.”

5.2 Conceptions of Learning

With respect to the six conceptions of learning cited in (Bradbeer et al., 2004), 49 of the 60 participants provided interpretable responses. The conception “learning as memorization for reproduction”, assuming short-term reproduction for tests, was not found. However, we did find a variant, conception 2, which implied rote learning with a long-term focus. This result is in agreement with previous findings on the successful use of rote learning by Chinese students (Watkins and Biggs, 1999). Five conceptions of *what* learning is and three conceptions of *how* it takes place were found in this study with conceptions 1 and 2, being the most common as in (Bradbeer et al., 2004). Conceptions 1 and 2 suggest a surface understanding of learning as fact accumulation. The remaining three conceptions, held by only one-quarter of the students, indicated deeper, relational understandings of learning.

Conception 1: Learning as an Increase in Knowledge

These responses had a FD focus on adhering to external structure and preferring social interaction.

Response 8: “to understand the tasks, to plan your schedule and talk with others for advices.”

Conception 2: Learning as an Increase in Information or Memorization for Later Application

These responses described a FD approach of focusing on the current context (e.g. university studies) and seeking personal relevance as in the following response.

Response 47: “In terms of university studies I perceive 'learning' as gaining a new knowledge towards becoming a specialist in chosen field”

Conception 3: Learning as Constructing Personal Understanding

The few responses in this category dealt with mastering concepts or ideas and understanding not just ‘what’ but ‘why’. These responses reflected a FI preference of using self-defined goals, self-structuring and self-reinforcement as in the following example.

Response 42: “Learning is a process from knowing, understand it through thinking, asking questions, analysis etc, then apply the knowledge to the real life situation; finally it becomes your personal asset.”

Conception 4: Learning as Changing Personal Understanding

The few responses under this conception reflected a FI belief that there is not always “one” answer and that the viewpoints of others may or may not influence one’s own understanding.

Response 11: "Learning is taking something that has been discussed and looking at what you think about the idea and how it fits into your way of thinking. It's also about being open minded and learning that there are more than one way of looking at and/or working though an issue or idea."

Conception 5: Learning as Changing a Person

The response below shows a FD use of analogy to describe learning as an enabler of personal change and growth.

Response 40: "When you reach high, but find yourself short. So you are going to find something to prop yourself up. That is learning."

Some responses also indicated *how* learning was attained and could be placed under the following three conceptions cited in the (Bradbeer et al., 2004) study:

Conception A: Learning is Attained by Being Taught by a Teacher or an Expert

Conception B: Learning is Attained Through Self-Teaching and Study

Conception C: Learning Comes Through Experience (Own or Other's)

Conception A appeared about twice as frequently as B and almost three times as frequently as C. Conception A's greater frequency, supports previous findings (Bradbeer et al., 2004) and is consistent with a FD need for externally defined structure, goals and reinforcement. Conception B reflects a more FI approach to self-structuring the learning situation (e.g. self-study), learning from mistakes, and working independently. Some of those holding conception C focused primarily on their own experience (FI) while others focused on social interaction and learning from the experience of others (FD).

5.3 Conceptions of Information Systems Design

Only 43 of the 60 responses about IS design indicated some level of understanding and hence were considered here for further analysis. About two-thirds of these respondents described IS design in a FI way as a distinct part of a larger process by elaborating on its distinguishing characteristics. Others described IS design in a FD way, as indistinct from either the course, programming or analysis. No examples of the deepest level of understanding (extended abstract) from the SOLO taxonomy (Biggs and Collis, 1982, 1989) discussed in section 4 were found. Of the 43 responses, 25 were classified as uni-structural, 13 as multi-structural and 5 as relational, implying that many students had only a surface understanding of IS design.

Conception 1: IS Design as a Course

A few respondents described IS design in a FD manner, as indistinct from the course or context in which it was experienced. The external boundary of IS design is passing a course in order to complete a university degree. This conception reflects a uni-structural, surface understanding of

IS design and a FD focus on personal relevance, as a key issue.

Response 23: "A paper i think where i add some skills in my c.v. for future requirements."

Response 31: "It's a hard paper because we've got lots of practical designing to do, but once you get used to it, i think it is alright."

Conception 2: IS Design as Building an IS

These FD responses made no distinction between modeling/planning an IS and constructing an IS. Our interpretation was that "build/create" referred to construction using a programming language and programming tools. The meaning of this conception is that the "code is the design" and the two are inseparable. This observation supports the current move towards agile methods such as extreme programming (XP) where the test code represents design decisions. This FD view may have resulted from the fact that the participants had taken a programming course before taking IS design. This conception was seen to represent a uni-structural, surface understanding of IS design. Examples include:

Response 15: "To understand the user requirements and create a tool or an environment to satisfy the user's needs."

Response 19: " create systems of information by using some methods and tools"

The remaining four conceptions expand the external boundary of IS design, viewing it as a method (product or process dimension) for guiding the development of IS or as a way of meeting long-term goals of either the student or others.

Conception 3: IS Design as a Method of Planning an IS (Process Dimension)

This was the most commonly held conception of IS Design. IS design was seen as a distinct process of modeling and planning how a system will work, with relevance beyond the context of the learning environment, a FI characteristic. This conception also has FD aspects such as the focus on the social context of IS design (e.g. Response 10) and a global focus on naming major phases (i.e. big picture) versus giving more descriptive detail. Most responses were uni-structural (e.g. Responses 10 and 47) but others (e.g. Responses 2 and 26) show a relational understanding of IS design as a distinct part of the larger process of system development or in relation to other phases within the larger process.

Response 10: "Sorting out the layout of an Information System so that everyone can agree on how it would be built."

Response 47: "Logical creation and planning a computer-based system."

Response 2: "Information Systems Design is the phase between analysis and actual coding (physical). It can affect the use of the information system greatly."

Response 26: "The process of taking analysis models and making them into diagrammatic plans and functions for the system."

Variations of this conception focus on aspects of Architectural Design (AD) and Detailed Design (DD) or mention activities within these stages of IS design. These variants were about equally split between uni-structural (e.g. Response 36), multi-structural (e.g. Responses 12 and 39), and relational (e.g. Response 35) understandings.

Response 36: "the planning and layout of a relational database."

Response 12: "Information Systems Design involves working out how to get a system to work. It is split further into architectural design that focuses on the overall project and detailed design that is concerned more with implementation."

Response 39: "It tries to transfer the business rules of an organisation to computer language and assign the language to some hardware (PCs, nodes) and combine the hardwares into a whole via communication (network, TCP/IP)."

Response 35: "Information Systems Design is taking the theory requirements (analysis) for a new Information System and finding and documenting practical solutions of how to apply the theory so that someone can construct it."

Conception 4: IS Design as Models for Planning an IS (Product Dimension)

A small number of respondents described IS design in either a FI way by focusing on isolated artifacts (e.g. devices on a deployment diagram), related to a future use or context (e.g. Response 8). Others gave a FD high-level description focusing on the big picture (e.g. Response 40), describing IS design as an intermediate result between two activities. Most responses were uni-structural (e.g. Response 8) while a minority of responses (e.g. Response 40) indicated a relational understanding.

Response 8: "Something that helps use, to give a bit of "colour" to the architecture of the information systems devices. Ways of making the customer feel better and secure when he is searching for something on a web-site."

Response 40: "It is something between what you decided to build and what you have built."

Conception 5: IS Design as Providing IS Skills for the Student

This small group of respondents described IS design in a FI way, in terms of a self-defined, long-term goal of working as a professional or in terms of skills needed to work in a future context as a professional. Some of these responses have FD aspects in their focus on personal relevance of skills and social interaction (e.g. working on a team). IS design is understood here at a higher level of abstraction in terms of developing creative and analytical abilities that could be applied in new contexts. These responses are multi-structural and imply degrees of both FD and FI.

Response 29: "Information Systems Design is a process of inspiration and logical thinking."

Response 33: "Is complex but possible task to achieve. Key to success is understand client requirement and good relation with various staff members."

Response 46: "Information Systems design presents a basic foundation about the architecture of modern information systems, the way we are supposed to approach design, things we should consider while making decisions, patterns recommended to follow or consider when it comes to design".

Conception 6: IS Design as Meeting Future Goals of Clients

In this conception, IS design is about meeting a client's goals with respect to functional requirements, non-functional requirements or both. This is a FI view when it reflects IS design in a new context and a FD view when the focus is primarily on externally defined goals. Responses were split between uni-structural (e.g. 11 and 41) and multi-structural (e.g. 9 and 42).

Response 11: "Information Systems Design is looking at ways to design an efficient system that will do what its users need to do. Also to enable the system to change easily with the changing requirements of the organisation."

Response 41: "To design a computer system that support business process to be more effective and efficient."

Response 9: "The process of evaluating the client's requirements, logically connect them, and try to put them in a system that would satisfy all users of that system".

Response 42: "According to the business requirement to design the whole information systems from logic to detail. Also aims to maximize the best results, including functional and non-functional aspects."

5.4 The Outcome Space

The outcome space in Figure 3 summarizes the structural aspects of "how" the six conceptions of IS design found in this study were given (i.e. the internal foci and external boundary) and indicates the dominant conceptions of teaching and learning associated with each IS design conception. The boundaries of the four nested rectangles represent the perceived field or context in which student participants situated their understanding of IS design (i.e. as a course in a university degree, as indistinct from programming, as planning an IS solution or as meeting future goals of working as an IS professional). Each context rectangle contains a summary of the internal foci of each IS design conception, the associated conception(s) of learning and teaching and the level(s) of understanding of IS design. The outer two rectangles are sub-divided due to having a common boundary but different internal foci. As one moves to the right beyond the first two conceptions, towards conception 6, the boundary of awareness of IS design expands beyond the current learning environment and the responses begin to include both FD and FI aspects, moving towards the expectations we have for our students. Teaching conceptions expand from "teaching as information transfer"

towards “teaching as helping learning”. Learning conceptions expand from “learning as increasing knowledge” towards deeper, relational views of learning as incorporating new knowledge with previous knowledge and experience, changing a person’s understanding.

A few responses within conceptions 3 and 5 indicated deeper understandings of IS design but were not associated with correspondingly deep understandings of learning and teaching. The majority held conception 3 and expressed a surface understanding of IS design, teaching and learning. Only the few students holding conception 5 expressed multi-structural or relational understandings of teaching, learning and IS design. Respondents’ seeing IS design as meeting client goals (conception 6) were split between uni-structural and multi-structural understandings of IS design but mostly held surface understandings of teaching and learning.

6. DISCUSSION

These findings are further interpreted with respect to existing theory on FD/FI learning preferences, previous findings on the cognitive demands of IS design summarized in section three and the results of previous phenomenographic studies on learning to program leading to implications for practice and further work.

6.1 Implications for Teaching and Learning IS Design

The outcome space and conception descriptions (see section five) provide information to answer the third research question:

How are student conceptions of teaching, learning and IS design related to surface and deep understandings of IS design relative to our expectations as teachers of IS Design? Are there qualitative differences for FD and FI students?

The predominance of surface understandings of teaching and learning are likely to be influenced by students’ prior learning experiences in large first year courses as well as previous secondary school experiences. When student expectations and teacher expectations diverge, as in this study, confusion and dissatisfaction can result in the short-term. Students expressing conception 5 of IS design held the deepest understandings of teaching and learning, and held conceptions most representative of the expectations of the teaching staff involved in this study. These expectations are based on the cognitive demands of IS design discussed in section three and reflect the need for both FD and FI design strategies. Our goal is to provide a learning environment that encourages students to learn to style switch based on task requirements.

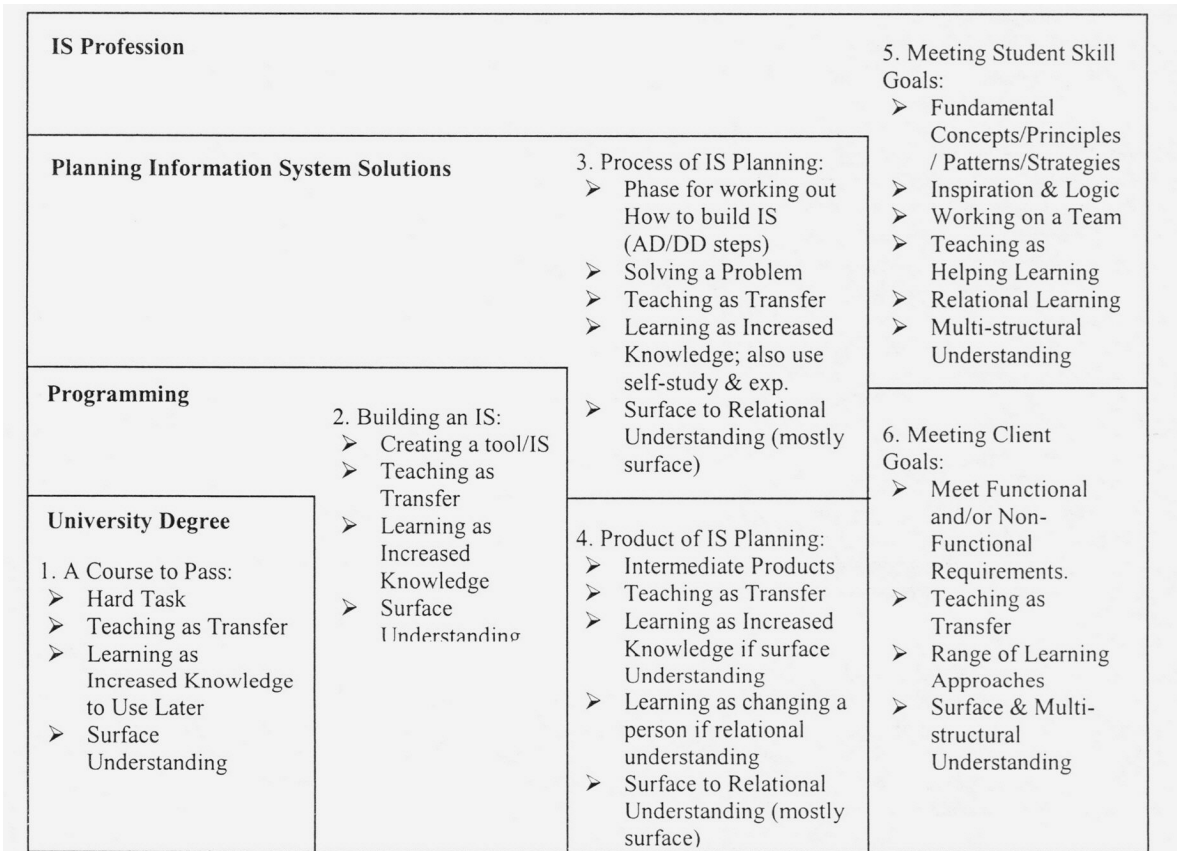


Figure 3. Outcome Space

The majority of students held conception 3 of IS design and gave evidence of taking both FD and FI viewpoints of IS design in their responses, while holding more FD views of teaching and learning. Our current teaching style is primarily FI focusing on encouraging students to work through ideas in teacher-organized learning situations, encouraging students to think and to apply IS design principles through practical exercises, and giving corrective feedback. We also make use of FD teaching techniques such as running small tutorial groups that use questions to check on student learning, provide positive feedback and facilitate participation from less verbal, FD learners. Lectures also include discussion of examples of good designs in the form of design patterns which are then discussed in tutorials and applied in both exercises and tests.

Our findings, however, indicate that the majority of students have a *surface understanding* of teaching and hold FD views of teaching. Most students considered themselves to be FD based on their responses to the survey questions posed in this study and expressed a FD view of teaching as information transfer with only about one third viewing teaching in a FI way, as a relationship between teachers and students where both are meant to be active participants. Interestingly, the small number of students that saw IS design as an aspect of becoming an IS professional, considered themselves to be FD but all gave FI views of teaching. This provides evidence of style-switching where FD learners, who tend to be more sensitive to the social context of the learning situation, are giving FI responses to please FI teachers.

About three quarters of the students had a *surface understanding* of learning as increasing knowledge, either for immediate or later application. Only one quarter of the respondents expressed a *deeper relational* understanding of learning as constructing a personal understanding, changing a personal understanding or changing a person. FD learners prefer externally defined goals and reinforcements, follow course structure, need the teacher to provide an organized learning environment, learn best from observing examples explained by an expert and are more affected by criticism. Given the large number of FD and borderline FD/FI participants, a surface understanding of both learning and teaching is not surprising. Furthermore, students tend to start university with FD learning preferences but to end it with more FI preferences if they are involved in subjects such as IS design with a large analytical component. This later aspect is evidenced in the presence of mixed FD and FI descriptions of IS design as one moves to the right through the outcome space.

The majority of students had a *surface understanding* of IS design as planning IS solutions and expressed their views in a primarily FD way by referring to a few "big picture" aspects of the design process. FD learners often ask teachers to pre-mark assignments, ask few if any questions in lecture, want one-on-one guidance through exercises, and fear making mistakes by working independently. This learning approach is problematic for instructors of large IS design classes of 100-200 students such as the one that served as the context for this study. Students who view IS design solely in

FD terms, only as part of the original context of first exposure (conceptions 1 and 2) have little understanding of IS design and its broader relevance. These students may have difficulty in advanced courses for which this course is a prerequisite unless they can be encouraged to engage in style switching. Making the importance of style switching explicit to students may help them to think about altering their approach to learning to suit the task at hand. FI learners may also benefit from learning to see the big picture during architectural design and not getting bogged down in the detail too soon, thereby restricting the set of alternative designs.

Only about one third of the 60 respondents expressed a *multi-structural or relational understanding* of IS design. Most students expressing this deeper understanding viewed it in one of two ways of working as an IS professional. A FI view of IS design was expressed as meeting the student's self-determined goal of working as an IS professional, but was expressed by students who saw themselves as being more FD. The second view of IS design, as a way of meeting client needs when working as an IS professional, shows a FI view of IS design as being useful in a context other than the one in which it was learned. However, it also implies a FD view of meeting externally defined client goals and the use of general terms rather than details.

Findings in the literature indicate that "good" IS design requires communication skills (FD), creating and examining multiple potential solutions (FI), evaluating these solutions against conflicting requirements and making a choice based on a deep understanding of IS design principles (FI), the ability to use abstraction to identify critical aspects of design problems (FI), and being aware of the organizational context (FD) in which systems are designed and used. There is evidence in the literature that style-switching, that is using the form of reasoning most suited to the task at hand, is beneficial (Monaghan, 1998) in tasks such as IS design that involve teamwork, complex analytical reasoning and creative problem solving. Our findings indicate that the bulk of students (those holding conceptions 3 to 6 of IS design) were beginning to style switch in terms of viewing the external boundary of IS design as being beyond the original learning context. Our findings suggest that pedagogy for teaching IS design should include recognition of both FD and FI learning preferences and the means for encouraging style-switching to improve learning outcomes for all students. For example, students who are primarily FD may benefit by being asked to work through problems with less prescriptive guidance in order to encourage them act more independently and to develop the creative problem-solving strategies needed by IS design professionals. In addition, requiring students to work in teams on practical design projects could be used to encourage FI learners to develop the communication skills and attention to social context they will need as IS professionals. At the same time, it would encourage FD learners to practice applying design principles in a group situation to reduce their fear of individual criticism and tendency to avoid trying to put principles into practice without extensive guidance.

6.2 Implications for Future Research

The findings of this study can be used as a point of comparison for future phenomenographic studies on IS design. However, specific learning environments differ on many factors, so the context in which the phenomenon (e.g. IS design) is studied must be kept in mind when attempting to generalize. Our findings are likely to represent a subset of the possible ways students view teaching, approach learning and experience IS design in an academic context. Further work is needed to identify other student conceptions of IS design, teaching and learning based on contexts other than the one studied here where the majority of students were from primarily FD cultures. Conceptions may also differ in universities with stricter entrance requirements, smaller class sizes and less diversity in terms of student backgrounds. While all participants satisfied the minimum English requirement for entrance at our university, language difficulties (not explicitly measured here) may be a mediating factor in our results. This issue could be dealt with in future studies by allowing students to answer the open-ended questions in a language of their choice, provided interpreters are available.

Our findings do not reflect archetypes or expressions of individual differences (Booth, 2001). What they do reflect are educationally critical differences (Cope, 2002, 2003) in depth of understanding of *what* students think teaching, learning and IS design refer to, *how* a student's understanding might be structured and the implications for learning outcomes based on teachers' expectations. These findings are influenced by when the data was collected. Therefore, future phenomenographic studies could reveal additional conceptions of IS design, teaching and learning by examining whether or not and to what degree students' conceptions evolve over time by collecting student responses over the duration of a course or over a period of years.

Conceptions identified in this study could provide a basis for creating scales for a survey instrument to gather student perceptions from a larger sample about learning and teaching introductory IS design. Further work is also needed to develop and validate questions for each scale. Other conceptions of learning and teaching that are specific to IS design, but which were not uncovered here, may also be found by doing further studies.

Our study supports previous findings in the Phenomenography literature (Bradbeer et al., 2004; Bruce et al., 2004; Cope, 2003; Lucas, 2001) of the predominance of surface understandings of teaching and learning held by students in introductory courses on subjects with a strong analytical component. We did not find other phenomenographic studies on IS design but compare our findings with a related study on how students learn to program (Bruce et al., 2004). Both studies identified conceptions indicating no significant understanding of the subject matter (e.g. conceptions 1 and 2 in this study) and both found conceptions relating the subject matter to future career aspirations. Our study differs in its focus on IS design as opposed to programming and its use of theory on FD/FI learners. The conceptions of IS design that emerged from our

study, along with those of future studies of IS design, may help create a basis for making changes in pedagogy that encourage style switching in order to improve learning outcomes for both FD and FI students.

7. CONCLUSIONS

Phenomenographic pedagogy is about teaching for change, making learners' conceptions explicit to them, and broadening student horizons. This study makes a contribution to enabling the use of phenomenographic pedagogy to teach IS design by identifying a variety of student conceptions of IS design as well as the relationship to teacher expectations. These conceptions express varying degrees of FD and FI understandings of IS design. Successful IS designers must engage in both styles of thinking implying a need to use teaching practice that encourages style switching. Helping students who are inflexible in their learning approach to determine when switching styles is called for can be beneficial. For example, we found that using marks to encourage FD students to ask and answer questions in small tutorials raised test grades by an average of 10%. Encouraging a FD approach in architectural design and a FI approach in detailed design also facilitates switching styles based on task. Further work is needed to determine the relationships between the nature of different IS design tasks and the use of FD and FI teaching and learning strategies to facilitate and encourage appropriate style switching. Providing learning experiences that encourage style switching stretches students' abilities and deepens their learning experience. Deeper approaches to learning, lead to deeper understanding, a worthwhile goal for all students.

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