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Learning for an unknown future: Complexity, uncertainty, challenge

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Abstract: *In a complex and uncertain world, what is our responsibility in the university to prepare the next generation to meet the challenges of the future? The most compelling reason for us to address these challenges in depth is that there are fundamental changes in goals and expectations for postsecondary learning that were not present or recognized until recently. The need for increased higher order learning or thinking skills on the part of graduates of postsecondary programs is a global phenomenon. This change in expectations for the capabilities of our graduates ricochets into a changed role for us as professors and mentors to help students achieve these goals. But what models or approaches can we envisage that would help us in our task? What guidance can our disciplines and the fields of psychology and education provide? What changes will these challenges necessitate in the way we envisage and realize learning in a scholarly community?*

What makes the future unknown? Are we becoming increasingly more aware of uncontrollable variables or have we less faith in the social structures we have developed over the past several centuries? What is most evident about our world is that it is becoming more complex and uncertain. We can, however, attempt to understand the complexities, and we can live with and investigate varying degrees of uncertainty. We may also want to search for the comfortable words available to us. One documented strategy for dealing with the unknown is to study the past for principles and trends. A retrospective provides opportunity to review and reinterpret what has gone before, but may also increase our realization of how complex our lives and environments have become. In this discussion, I want to explore some of the complexities and uncertainties of university pedagogy by beginning with a few pedagogical challenges I encountered in my formative years.

On complexity and pedagogical principles

Earlier this year I was asked to address the question of 'Why I had made a major investment in university pedagogy in my life?' for the conference of the Association internationale de pédagogie universitaire (AIPU), an organization similar to HERDSA, with the purpose of improving teaching in francophone universities. In my exploration of how university pedagogy became a central responsibility for me, I examined what I learned from the time that I decided to become a psychologist, to the time that I joined McGill University's Centre for Learning and Development. I found 14 pedagogical principles developed in as many years *before* I became a university professor responsible for helping other professors improve their teaching. I wonder how many principles each of us has hidden away? I wonder to what extent they govern our activities or to what extent we test them for their validity and utility?

Let me describe a few of these principles, some approaching the proverbial and some more specifically pedagogical. One basic principle arose from my psychological internship between my first and second degrees: after working with people whose lives were in tatters, I realized that preparing people to cope through education is a more productive endeavor than attempting to assuage the ravages after people have failed to cope. Put another way, early investment in human capital could alleviate much societal non-productivity, pain and suffering at a later date. Another basic principle, learned in the research department of the Toronto Board of Education between my second and third degrees, was that our expectations for students, male or female, limit or extend their frontiers. I had been asked to investigate why the ratio of boys to girls was 6 to 1 in special education classes. I found that there were biological differences in learning rates, but also that different countries, some with the same genetic makeup, had different learning rates. Culture can impose barriers or open new vistas, and we need to be aware of the conditions our cultures impose upon us.

A third realization, more specifically pedagogical, was the extent to which grading is a political issue. In the early 1970s when the college system, two to three years between secondary school and university, was being put into place in the province of Quebec, some of my colleagues took exception to giving their students grades, causing parents, students and college administrators considerable concern. Other colleagues had to pick up the pieces around them. What we did not, at this time, understand in spite of much discussion on the Academic Council, was that grades had to have meaning, and the meaning could only be attached through mutual understanding of what the learning goals and outcomes might be. We are still struggling with the problem of trying to explain to students what constitutes a valid grade and why. Even with carefully criterion referenced evaluation in the course we offer to prepare graduate students to teach, some do not reach any depth of understanding of the importance of alignment between what is taught and what is evaluated.

Teaching psychology at the college level also taught me that students have their own ideas about what a discipline is and what they expect to get from it. Psychology is the discipline most mythologized by the general populace and least understood in its scientific form. I had success with students who intended to pursue science or arts degrees at university, and with students in the nursing program, who were equipped with backgrounds in science and mathematics. There was, however, a fairly large population of students whose interests tended to the paranormal. Their interests were acceded to in their being given a choice of end of term projects that allowed them to investigate LSD complete with Beatles' background music, or to attempt to make contact with persons in other rooms, or to explore sightings of UFOs. I have, ever since, tried to pay careful attention to where students are coming from. Tolerance was a principle learned here: allowing the students to explore these phenomena and come to their own conclusions based on the evidence was an essential pedagogical strategy.

I also learned some basic pedagogical principles from my graduate research. From my masters' research with university students whom I asked to form a concept using either certain or probable information, I found that students tend to use inductive strategies even when they could use deductive strategies and be certain about their answer. The pedagogical point is that students will use learning strategies that are familiar and easier, even though they risk not being certain about the outcome, and even when they could be certain. In my doctoral research, I explored how secondary school students identified concepts depicted verbally by single words or pictorially by simple line drawings. Students gave accurate responses earlier to verbal examples than pictorial, but more significantly, it required several examples of a concept (3) for highly able students to organize their thinking, and twice that (6) for average students. How many of us would or could supply three examples of a concept in our classes?

These few examples from the years before I became a university professor suggest the complexity of our task as instructors. I have yet to examine what I have learned in the 30 years since I joined McGill University, and recognize that the task might be overwhelming. But one of the major questions I think we need to deal with is what principles each of us is operating under. To what extent is it possible to explore these principles and their implications in depth, and put them into practice? How coherent or consistent are our pedagogical principles? Are there some that might work for all of us? Or work better for all of us?

On uncertainty and our responsibility in the university

Uncertainty may pose a greater problem to us as university professors than complexity. Although the connotation of 'unboundedness' inherent in uncertainty may give us freedom of movement, it can deter learning if we cannot enunciate a starting place, goals, or appropriate procedures. We have learned to live with complexity and uncertainty within our disciplines, but it has had unfortunate effects on the ways in which we act within the larger scholarly community. One effect is that our disciplines create boundaries and act as gatekeepers, preventing perspective. For example, we do not tend to read what is written in other disciplines or other cultures. I was reminded of the extent to which this occurs at the AIPU conference. Speakers referred to Piaget and to other noted continental European pedagogical researchers; none to British or North American researchers, even though the topics were about paradigm shifts and competencies, matters that have been discussed in depth in the English-speaking world.

This is not an isolated incident. Some years ago, as part of our research program, we examined the kinds of pedagogical research reported in the indexes of journals of Physicists, Engineers, Psychologists, Educators, etc. In each discipline studied, a body of research had been published on teaching without reference to research on teaching from any other field, including higher education. I was not surprised, therefore, when I wanted to publish an article on professors' and students' conceptualizations of the learning task in physics courses (Donald, 1993), that to reach physicists, I had to join the Society for Research in Science Teaching. We could probably all recall incidents of attempting to communicate with someone from another discipline, and finding that we were using different terms to talk about similar phenomena, or the same terms to talk about rather different occurrences, or that there was a slight twist in meaning beyond immediate grasp.

And yet as a graduate student, when I attended a multidisciplinary seminar on communications, where geneticists, English professors, Canadian Broadcasting Company (CBC) producers and educators discussed the new communications possibilities, I found the learning experience particularly rewarding because of the challenge of multiple perspectives. We teach our graduate course in pedagogy and organize our annual teaching workshop so that people from different disciplines work with each other to discover each other's language and educational proclivities. But we do not appear to readily bridge the frontier existing between our disciplinary areas. If complexity and uncertainty are problems for us within our university environments, to what extent can we be responsible for preparing the next generation to deal with them? The solution may lie in our making examples of ourselves.

If the future is unknown, then we need to teach students to deal with the unknown. How? Increased higher order learning or thinking skills and lifelong learning are major international concerns (Ewell, 2001; Miller, 2001). Whether we call them critical or reflective thinking skills or the ability to make decisions based on evidence, they are now essential learning outcomes (Baxter Magolda & Terenzini, 1999). Important learning outcomes include higher order skills, an ability to apply knowledge to practical problems, an appreciation of human differences, and an integrated identity. But there is relatively little to guide us in understanding what students experience in their programs when they are learning the methods of inquiry of a discipline. In *Learning to think: Disciplinary perspectives* (Donald, 2002), I describe studies we undertook of learning in different disciplines from physics and engineering to law and literature; higher order goals, although expressed in different ways, are essential for learning these disciplines. Broadly based discussion of these goals and their implications for university teaching would be one entry point.

What do the changes in expectations for university graduates mean for us as instructors? In *Teaching alone/teaching together: Transforming the structure of teams for teaching* (Bess, 2000) a group of us attempted to answer this question by examining the different roles expected of teachers. These include classic roles such as lecturing and leading discussions, but also mentoring, integrating, assessing and planning. In my chapter on the pedagogical expert, I suggest four categories of essential characteristics (Donald, 2000a). First is awareness – philosophical breadth, insight, a general interest in the campus as a whole, and in relating campus issues and policies to the program. Second are intellectual characteristics – the abilities of analysis and synthesis, critical interpretation and organization, and a willingness to experiment and to be adaptive in the application of new strategies. Third are characteristics needed to accomplish instructional tasks - goal orientation, dynamism, determination, visual processing and synthesis to bring things together. Finally are interpretive and mediational skills - openness and a willingness to be in contact with and to listen to students, a willingness to collaborate, leadership and persuasion. These characteristics of pedagogical competence provide another entry point for responding to the challenge of providing learning experiences that promote students' thinking skills. To what extent would we be willing to be judged as instructors on the basis of these criteria?

Our role as professors in organizing instruction to ensure higher order learning is far less well understood than our role as researchers in producing knowledge or the traditional role of lecturing. In the evaluation of university teaching over the past 30 years, the focus has been almost exclusively on professors' presentation skills. Course planning, the organization of knowledge into dynamic learning sequences that take into account students' prior knowledge and the evolution of their knowledge and skills is still for the most part a hidden art. With the sophisticated delivery systems that the internet and other forms of technology are now able to supply, the need to understand and develop a working vocabulary of postsecondary pedagogy becomes essential.

Students are also telling us why pedagogical development is important. In our studies of the effect of the classroom climate on student higher order learning, we asked students to compare their learning in a small (maximum 20 student) seminar with that in regular large classes. Students' comments reveal the dilemma.

This course is completely different from others – here, we are taught to understand, argue, and integrate knowledge. In many other courses, we are only taught to memorize and regurgitate facts.

It is quite a unique experience in itself. It is a small group of students (we get to know each other), the professor is close to the students; we can ask questions, give our opinion, etc. It is definitely a course where we can participate vividly, compared to course lectures, where 400 are sleeping almost carelessly.

My other courses are offensively large where the professors at best clarify the obvious, at worst are entirely extraneous.

Our students are saying that a quality postsecondary education cannot take place in a format where students are passive, disengaged and unchallenged. To move from a situation where students are talked at and turn off, to one in which students are thinking and developing their skills requires substantial changes in the organization of instruction. We could further argue that changes of an institutional scope will be necessary to effect the needed evolution.

What models or approaches can we envisage that would help us in the task of helping students learn to think?

We appear to have two sets of models that might be of use in guiding pedagogical practice: the first are models of student learning; the second are models of disciplinary inquiry. Both sets of models are tacit; the influence of learning theories on our classroom practices and our assessment of learning is perhaps more pervasive. A brief review of these models also reveals the effect of complexity and uncertainty on our conception of what learning in the university could be.

Although theories of learning are a product of the enlightenment and the scientific revolution that followed it, they appear to have strings attached to earlier times that render them suspect. Before the enlightenment, scholastics in the middle ages assumed a fixed body of knowledge; they defined that knowledge and were the authorities (Johnston, 1998). The scientific revolution challenged the notion of fixed knowledge; a tenet of the revolution was that knowledge was an expanding and open system. Validity was now based in scientific measurement, and dissent was integral to the process of testing hypotheses. The role of the university changed to that of creator of new knowledge, a major transformation in epistemology that led to an increasingly important role for research in the university. It could be expected that the principle of an expanding universe of knowledge would guide instructional practice. But university pedagogy for the most part appeared to take a different route, with authorities in lecture halls expounding truths and therefore with little opportunity for dissent or the testing of hypotheses. In short, a cultural backwash occurred in the epistemology of postsecondary instruction.

Could greater attention to theories of learning change this epistemological backwash, or are these theories co-conspirators? Learning is defined in psychological dictionaries as *a relatively permanent change in behavior that occurs as a result of practice*. This definition gives us a neutral and measurable phenomenon, but it has certain limitations. The primary limitation is that in order to be measured, the learning task may be construed in an oversimplified or atomistic manner. Early learning theories promoted this atomistic approach. Ebbinghaus in 1885 conceptualized human learning as a process of memorization, especially by repetition, so that one can repeat or reproduce (Woodworth & Schlosberg, 1954). He postulated four stages of memory: impression, retention (persistence of changed performance), recall (reproduction of once learned items) and recognition (awareness of previous experience). We use this model when we give assignments or problem sets for practice, speak of what our students have retained, and set examinations to measure recall and recognition. The problem with the model is that it circumvents the obligation to test our students' understanding of pattern and relationships.

Other atomistic or associationist theories of learning were developed – Thorndike's law of effect (1914) for example, but the first breakthrough in terms of paying attention to higher order processing was Shannon and Weaver's (1949) information theory. This theory drew on communications theory to explain how messages or signals are sent and received and introduced the concepts of complexity and uncertainty as explanatory devices. The prototype of an information channel is a perfect telephone line in which information transmission is complete, but lines or channels do not tend to deliver total output and the receiver is left with some uncertainty (Berlyne, 1965). The receiver may also select information to reduce uncertainty, and complexity of form influences information transmission. Thus information theory recognizes the effects of complexity and uncertainty, defines learning as a process in which information is encoded, transformed and actively retrieved, and has pedagogical implications of active or directed learning. Information theory also updated theories of memory: the concepts of *immediate* or *short term memory* and *long term memory* were introduced to discriminate between the limited capacity of an individual to attend to data – the magical number seven plus or minus two (Miller, 1956), and semantic or mediated memory.

A third model takes a more molar approach and examines what students bring to the learning context. Consonant with Gestalt psychology, it looks for principles of arrangement, synthesis or organization. In this model, one question is how new knowledge is articulated with already existing knowledge. An early answer came in the fit of new knowledge to one's *apperceptive mass* (Bartlett, 1932), interpreted as an individual's cognitive structure or one's own structure of knowledge (Donald, 1987). In this model, learning depends upon discovering relationships between the facts or ideas presented and the learner's previous experience. Prior knowledge may limit or assist the learning of new knowledge. The relationships or logical structures of knowledge are *schemas*, ideas or concepts combined into a coherent plan by a learner interacting with new knowledge or experience. Another question about learners was *why* an individual learns, which led Tolman (1932, 1949), to postulate that an organism responds purposefully and selectively to its environment. Perceiving objects as means toward goals, the organism sets up expectations and is capable of inventive learning. Learning is goal oriented. This more molar approach to learning as exploration was labeled a cognitive theory by Woodworth and Schlosberg (1954). It is the historical basis for *constructivism*, which states that individual learners construct their own understanding of public knowledge.

A fourth model that will be familiar in the southern hemisphere has provided an explanation for why students do not learn. Based on the phenomenological research of Marton and Saljo (1976), and developed by Entwistle and Ramsden (1983) and Biggs (1993), it has provided insight into student orientations to learning, where 'orientation' indicates a combination of an approach to studying, style of learning, and motivation that is relatively stable across different educational tasks. Entwistle and Ramsden (1983) proposed four student orientations: meaning (deep); reproducing (surface); achieving (competitive and grade oriented); and nonacademic (negative attitudes and disorganized study methods) that influence student success in learning. A meaning or deep orientation is consistent with the psychological definition of learning, and with constructivism. In an achieving orientation, learning may be a by-product, and learning is even less probable in a reproducing orientation, since permanent changes in behavior are unlikely to occur.

Models of learning provide us with insights into our instructional habits in higher education. Learning as a process of memorization explains the tendency to give frequent tests, and why students are asked to recall facts or, in the case of multiple choice tests, recognize the best of several alternative answers. The limitation of this model, as in a reproductive orientation, lies in the tendency to promote rote rather than conceptual learning, that is, knowledge is construed as bits of information not necessarily related or contributing to a pattern or theory. The learner therefore adds to a somewhat flimsy storehouse of knowledge without linking it to other knowledge.

If learning is regarded as information processing, then although we as instructors still have the role of providers of information in an instructor-centered classroom, we could be expected to be more aware of our students' role in encoding this knowledge so that it can be retrieved at a later date. Knowledge in this model may be at the most basic level of cognitive objectives - terminology and facts (Bloom, 1956), but may also extend to ways and means of dealing with knowledge. Students in this model of learning are expected to be active learners, even though the focus is still on information rather than relationships or purposeful learning.

When learning is considered to be a process of organization or construction, individual learners are expected to create their own understanding of public knowledge, and our role as instructor changes substantially from subject matter expert to expert pedagogue (Donald, 2000a). The classroom becomes student centered, and our role expands to ensure that students learn rather than that we present information. Constructivist theory suggests that students need to identify themselves as explorers or inventors, and actively select and organize their own knowledge. This theory is more consistent with the methods of inquiry that different disciplines espouse. Discussion, collaborative and project work are the instructional strategies that follow from this theory.

What models of disciplinary inquiry tell us

As I have proposed in *Learning to think*, the primary source of *what* is to be learned is the discipline. Disciplines have been defined as bodies of knowledge, which include specialized vocabularies and accepted bodies of theory, systematic research strategies, and techniques for replication and validation (Dressel & Mayhew, 1974). They are thus a center and a fulcrum for our lives as researchers and teachers. Among disciplines, the most prototypical are the physical sciences, which are described as hard, well structured, or paradigmatic (Frederiksen, 1984; Kuhn, 1970). A paradigm consists of a logical structure and governing truth criteria that provide maximum direction to scholars in the field (Kuhn, 1970). In physics, for example, Newton's laws of classical mechanics form part of the curriculum around the world. The theories that describe physical phenomena, however, are often incongruent with experience, and to be able to problem solve, the main task in the physical sciences, students must radically change their conceptual framework. Articulation between new and existing conceptions becomes a pedagogical target.

In the social sciences, phenomena are examined at a broader or more general level than in the physical sciences, and one of the learning tasks is to choose among various theoretical frameworks that could describe the phenomena. For example, in psychology, we have seen a series of models of learning. In comparison with the physical sciences, where abstract concepts are proven by concrete experiments, in the social sciences multiple variables and their interaction render theories more difficult to test. Methods of analysis therefore assume greater importance in the curriculum, and the student's task is to locate, recognize and relate the varied conceptual frameworks within a discipline. This is a highly abstract process.

The humanities specify different tasks again. Often they are described as training in sensibility, and an aesthetic criterion is applied to learning. Humanistic truth involves authenticity or genuineness rather than logical or scientific validity (Broudy, 1977). There is a technical language to be learned, however; for example, *trope* or *genre* in English literature. The student's task is to learn how to interpret text using the new terminology, and how to present an argument. The learning tasks for students in physical and social sciences and the humanities thus differ considerably, and students must adopt a different approach in order to be successful in each of them. In physics, for example, the student must analyze a problem by breaking it down into its elements, then reconstitute or represent the problem. The student in psychology must wrestle with contrasting perspectives or theoretical frameworks in order to approach intellectual closure, but at the same time, needs to be skeptical and to continually search for consistency to validate findings. In English literature, the processes of argument and judgment provide the structure for learning.

Methods of inquiry often cross disciplinary boundaries, however. The earliest method, *hermeneutics*, or interpretation, was developed in order to analyze biblical text (Table 1). It is the construction of textual meaning which elucidates the connotations that text explicitly or implicitly represents (Hirsch, 1967). The interpreter of the text begins by assuming that the text is coherent, then develops a framework of explanation which is tested by the facts it generates. The method is thus a process of hypothesizing and then searching for corroborating evidence in the text. Although the hermeneutic approach is espoused most frequently in the humanities, discourse analysis as currently utilized in the social sciences owes much to hermeneutics.

A method more generally referred to across disciplines, *critical thinking*, developed out of the Socratic tradition of disciplined inquiry. Defined as a reasoned or questioning approach in which one examines assumptions and seeks evidence (Donald, 1985), researchers suggest that critical thinking includes components of logic, problem solving and Piagetian formal operations (Meyers, 1986; Sternberg, 1985). Different disciplines focus on different aspects of the critical thinking process - inferential processes in physics compared with testing assumptions in English (Donald, 1985; Meyers, 1986).

In comparison to critical thinking, *problem solving* is described more specifically and procedurally, as a set of steps consisting of formulating or representing a problem, selecting the relations pertinent to solving the problem, doing the necessary calculations, and verifying the logic used to see if the final answer makes sense (Reif, Larkin & Brackett, 1976). Thus, problem solving includes critical thinking processes but, in addition, those of implementation or testing; the difference between critical thinking and problem solving is analogous to comprehending versus doing. For example, the critical thinker would examine underlying assumptions and infer their effects; the problem solver would continue from this action to create a strategy for dealing with the problem. Problem solving is most frequently used to describe method in the physical sciences.

A more recent approach to understanding methods of thinking is to examine *expertise*, because the expert is one who has acquired not only a solid base of knowledge but the ability to apply it (Ericksen & Smith, 1991). The expert in a given area has well developed representations of knowledge or schemas in the subject matter and can relate the schemas in order to operate intelligently. Research on the development of expertise provides insight into potential pedagogical practices. For example, studies on expert and novice differences reveal that novices use surface structures while experts use action schemas (Chi, Feltovich & Glaser, 1981); novices represent problems literally while experts use a scientific and mathematical representation (McDermott & Larkin, 1978). Novices become experts by passing through a stage of analysis where problem solving time increases until they develop the representations and strategies characteristic of the expert. Experts recognize patterns and solve problems efficiently and effectively. They have a sense of the context, select appropriate information, recognize organizing principles, and verify their inferences. They are equipped with representations and thinking strategies for applying these representations to problems. What is particularly important about this model is that it describes the relationship between knowledge and thinking processes, and contrasts the thinking strategies of novices and experts, thus opening the way to promoting such strategies.

Table 1. Methods of inquiry in different disciplines

Method	Example
Hermeneutics Interpretation, the construction of textual meaning through a dialectic between understanding and explanation	Biblical text, English literature
Critical thinking A reasoned or questioning approach in which one examines assumptions and seeks evidence	English literature
Problem solving Steps for formulating a problem, calculating and verifying the logic used	Physics, engineering
Expertise Well developed representation of knowledge, action schemas	Physics, education

What changes will the challenges of the future necessitate in the way we envisage and realize learning in a scholarly community?

One goal is axiomatic to our discussion: the ultimate outcome of instructional practice is effective student learning. To measure student learning, however, we require a sense of their starting point, their background and their needs. Only then can we create appropriate learning situations. Professors need to explain educational goals to students, supply an overview of their discipline, and clarify to students that their learning will depend primarily upon the quality of effort they put into their work (Donald, 2000b).

In what ways can we improve the match between student learning and accountability for that learning? My research into the university curriculum (Donald, 1983, 1986, 1987, 1992) has told me that there is a wide difference in what students are expected to learn for the same credit, and that students, although prepared for our programs in terms of subject matter background, lack the strategies to take maximum advantage of the university learning situation. The advent of electronic courses increases the attention needed to delineate what constitutes a course. We need a better understanding of the variety of instructional goals and methods across disciplines and the extent to which they can be transferred. The methods and approaches that best support higher order learning require longer term, focused, student-directed studies and projects, similar to our own programs of research. If seminars and problem-based learning challenge students to think in a manner that lectures do not, and eliminating lectures is not feasible, how do we make lectures more like seminars and problem-based learning?

Do students learn to think in a new way from their experience in their courses? If students are not prepared in terms of learning strategies, how can we provide them with clear expectations about learning outcomes and, more specifically, that they are expected to think? If seminars lead to communities of learning, and large classes lead to anomie, what is our responsibility as professors and faculty developers to our institutions with reference to the differential effects of learning contexts? Providing opportunities for students to extend their learning by means of extracurricular activities or field experiences is a program responsibility and requires extended planning by a curriculum committee. It also requires interaction at the campus level to ensure that these kinds of activities are supported by the campus as a whole. How proactive can we be in establishing a campus environment that supports learning?

The models of learning and disciplinary inquiry provide insight into how we might help students learn to think. A constructivist view of students as explorers coupled with understanding of how students encode knowledge in our disciplines could be viewed as a baseline. Next we might consider which methods of inquiry most readily fit our learning goals and borrow from them to provide students with a model and rationale for thinking. With this nascent search structure in place, complexity and uncertainty can then be seen as invigorating, and we should be able to show our students how to successfully cope with learning for an unknown future by developing their own principles.

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