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Learning Different Types of Knowledge: An Integrated Framework of Constructivist-based Curricula Design

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Abstract

In attempting a paradigm shift away from traditional didactic teacher-centered learning environments, many reform-minded schools and academic institutions have designed curricula based upon constructivist principles of learning. However some educators with unfounded zest have interpreted this to literally mean that no prerequisite knowledge needs to be disseminated to learners at the onset of a lesson unit. Rather learners are left to construct, through their own independent endeavours, all forms of knowledge without giving due consideration to learners' foundation knowledge bases and prior learning experiences. This has resulted in much confusion with many learners feeling frustrated in the course of learning and terminal learning objectives not being fully realized. In this paper, I have articulated a constructivist-powered framework that illuminates on the curricula design of teaching different types of knowledge within any scientific discipline and the instructional sequencing necessary for facilitating the construction of these categories of knowledge.

Introduction

Knowledge is a personal, inner state of abstraction that is drawn directly through meaning-making of our experiences in real-life situations. Personal interactions with objects of knowledge lead the knowledge seeker to become acquainted or connected with the understanding of facts, concepts, methods, rules and principles through a range of actions such as interpretation, rumination, analytical reasoning and observation. Knowledge is amenable to being gathered and analysed both through individual endeavours as well as socially co-constructed efforts based upon collaboration and negotiated dialogues.

Though the terms 'data', 'information' and 'knowledge' are used synonymously in everyday usage, Ackaff (1989) has highlighted some key differences between these three terms with the following definitions:

Data... data is raw. It simply exists and has no significance beyond its existence (in and of itself). It can exist in any form, usable or not. It does not have meaning of itself.

Information... information is data that has been given meaning by way of relational connection. This "meaning" can be useful, but does not have to be.

Knowledge... knowledge is the appropriate collection of information, such that its intent is to be useful. Knowledge is a deterministic process.

Devlin (1999) gives due importance to the understanding of the above mentioned subtle distinctions between the three concepts of data, information and knowledge to improve the quality of their application and utility. Davenport and Prusak (1998) argue that knowledge is "broader, deeper and richer than data or information." They proffer the following explanation of what constitutes knowledge:

> *"Knowledge is a fluid mix of framed experience, values, contextual information and expert insight that provides framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of the knowers. In organizations, it often becomes embedded not*

only in documents or repositories but also in organizational routines, processes, practices and norms." (p.5)

The broad phenomena of knowledge when understood from a learning context can be classified into two main categories: declarative knowledge and procedural knowledge.

Declarative knowledge

Ontologically declarative knowledge relates to the 'who', 'what', 'where' and 'when' aspects of temporal and strategic knowledge domains. It is a static description which captures an insight of the physical world through the medium of words, images, sounds and emotions. For all practical purposes declarative knowledge can be identified with explicit knowledge or knowledge that can be coded and clearly articulated in textual, graphical or verbal structures of representations (Nickols, 2000). Since declarative knowledge deals with the exposition of facts, methods, techniques and practices, it can easily be expressed, recorded and disseminated in the form of artifacts, written norms and verbal communications to become explicit knowledge assets.

Procedural knowledge

Procedural knowledge is related to the procedure to carry an action out. Knowledge about "how" to do something is procedural knowledge. Procedural knowledge is instruction-oriented. It focuses on how to obtain a result (Turban & Aronson, 1988).

Problem Statement

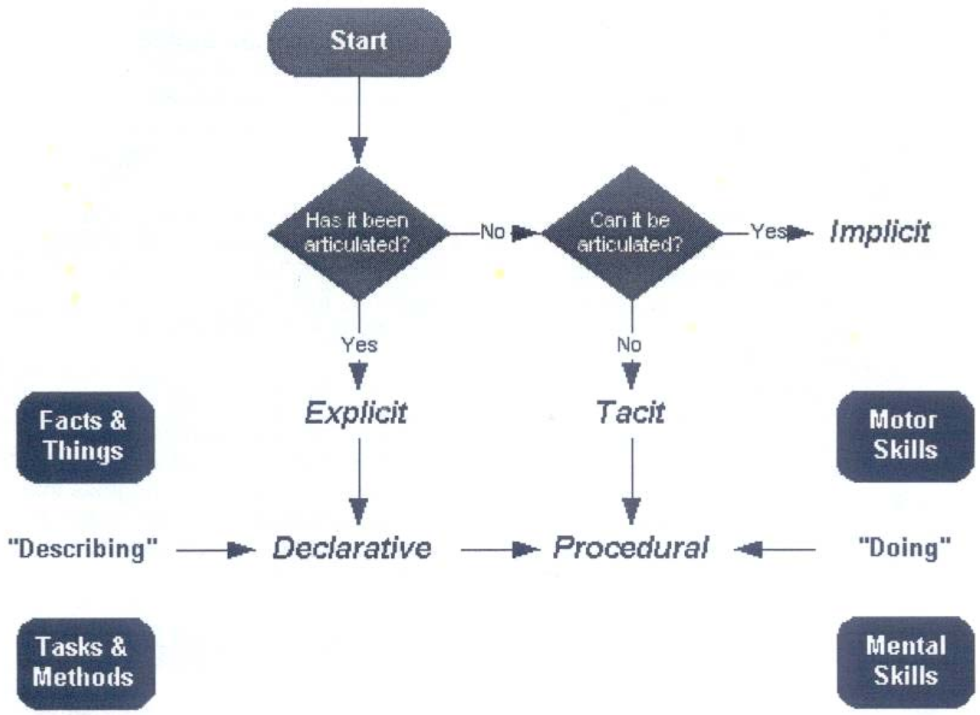
The overview of the key concepts of the two types of knowledge presented in the earlier section could potentially yield the next question of how these two categories of knowledge could tie in together organically as the integral components of a coherent learning system? I have previously worked in reform-minded educational institutions and schools of higher learning that have attempted to design their curriculum and frame their teaching practices with constructivism as the underpinning epistemology. In the course of my teaching experiences, I have heard questions such as the following making their frequent rounds amongst the teaching staff: "How much of content information should I deliver to the students?", "What types of knowledge should I allow students to actively construct on their own through exploration and experimentation?", "Did I give away too much of information in the course of conducting today's class without encouraging learner inquiry and higher order thinking?", "When and how much should I make use of didactic and dialogic instructional strategies in facilitating constructivist-based teaching approaches to foster authentic learning environments in my classes?"

An Integrated Framework of Constructivist-based Curricula Design

Rationale of framework

I hope to outline a theoretical framework in the following sections that holistically brings together the afore discussed two classes of knowledge within the framework of a constructivist-based learning design focused upon situated learning. I wish to highlight that this proposed framework is not a rigid, fine-grained structure that needs to be adhered to and applied in all instructional contexts. Rather it is a flexible, generic model that I hope could inform and guide educational practitioners in their attempts at developing, organizing and implementing the various elements of a disciplinary curricula anchored upon constructivism. This framework has as its undergirding epistemology elements drawn from the ideas formulated by Nickols (2000) in his heuristics for thinking about knowledge. Nickols has organized his framework from a knowledge management perspective. I will be critically analyzing in the following sections the inherent strengths and drawbacks of his framework from the viewpoint of constructivist pedagogical representations of knowledge building. The following flowchart encapsulates the key principles put forth by Nickols:

Figure 1: Nickols (2000) framework for thinking about knowledge



Nickols explicates in the following paragraph his views on how knowledge can be classified as either declarative or procedural. He equates them respectively with explicit and tacit knowledge forms depending upon the context, purpose, orientation and scope of the subject matter under scrutiny. I am in agreement with his opinions in this regards.

> *"I choose to classify all descriptions of knowledge as declarative and reserve procedural for application to situations in which the knowing maybe said to be in the doing…declarative knowledge ties to 'describing' and procedural knowledge ties to 'doing'. Thus for my purposes, I am able to comfortably view all procedural knowledge as tacit just as all declarative knowledge is explicit."* (p.4)

Further deliberating on the texture of procedural, tacit knowledge, Nickols cites the example Nonaka (1991) presented in his widely acclaimed article of how a product developer, Ikuro Tanaka apprenticed herself to a hotel chef famous for the quality of his bread. She learnt how to make bread in the expert's way including an unusual kneading technique.

> *"Tacit knowledge cannot be articulated. Thus, although Nonaka's product developer was clearly able to devise a set of product specifications based on what she learned while apprenticed to the chef in question, it seems doubtful that she articulated the chef's tacit knowledge or her own. It seems more likely that she articulated some rules or principles or descriptions of procedures, that is, she created some declarative knowledge that subsequently proved useful in the design and development of the bread making machine."* (p.6)

Again, I concur with Nickols's arguments on the inherently tacit nature of procedural knowledge structures. However his repeated references to knowledge representations, both procedural and declarative being acquired through various modes is an idea that is rather disconcerting and does not sit comfortably well with me. One good example of this line of thinking is his following statement "……the systematic or facilitated acquisition of knowledge, not simply learning from experience." Such a viewpoint though well-intentioned from a knowledge management perspective seems to be largely ignorant of key learning theories and recent educational research developments. It appears to be premised on an information delivery theory of instruction. The information delivery theory of instruction argues that teaching predominantly consists of disseminating loads of information with learning essentially constituting mechanically acquiring such information through memorization and recalling. Pedagogically how viable and justified is such an assertion? Clark and Mayer (2003) counter that the information delivery theory is based on an incorrect conception of how learning occurs. It erroneously assumes that the minds of learners are empty vessels which can be filled with unlimited amounts of information mimicking the modes of operational functioning of computers. Such a hypothesis fails to take into account the scientific processes of active meaning-making, cognitive modeling and construction of mental schemas embodied in intentional learning. The use of the word acquisition connotes a passive style of learning disposition where the learner absorbs huge chunks of information and participates in an educational initiative in which the instructor predefines and drives the attainment of instructional objectives. More often than not these objectives are usually divorced from the realities of learners' previous experiences.

However constructivist experts such as Dewey (1997) have criticized such constrained notions of learning as being fallacious, resulting in mis-educative experiences. According to Dewey, a positive educative experience "arouses curiosity, strengthens initiatives, sets up desires and purposes that are sufficiently intense to carry a person over a dead place in the future" (p38). Dewey's principle of continuity of experience calls for learning to be a continuous process of reconstructing experiences. On the other hand a mis-educative experience "has the effect of arresting or distorting the growth of further experience" (p25). The principle of continuity posits that "every experience both takes up something from those which have gone before and modifies in some way the quality of those which come after " (p35). The prior experiences of learners need to be the starting point in organizing an instructional curriculum that is both robust and engaging. This ensures that with the progression of instruction the current scope of these experiences coalesce into fuller, richer and thicker forms of knowledge. Such an instructional design allows the learning trajectory of the immature learner to be systematically guided through an instructional sequence that is built upon a continuum of meaningful educative experiences. Consequently this enriches learners' conceptual understandings and facilitates sustained intellectual growth. Otherwise, failure to make connections between what the learner already knows and what needs to be taught could result with the teacher facing the "problem of discovering ways and means of bringing them within experience." (p73)

Thus in defining the subject matter for a curriculum, careful focus needs to be placed on incorporating learners' prior knowledge to allow for learners' psychological, cognitive and affective development within a continuum of formation of progressive experiences. But what should be the epistemological order of declarative and procedural knowledge representations within such a curriculum design? Most existing models of skill learning are "top-down" (Sun & Peterson, 1997, 1998) with the underlying assumption being that individuals learn generic, verbal, declarative knowledge first and then through practice, turn such knowledge into specific, usable procedural skill (Anderson, 1983, 1993; Ackerman, 1988). Some experts (Anderson & Fincham,1994) believe otherwise in that some procedural skills develop prior to the learning of declarative knowledge, with explicit, declarative knowledge being constructed only after the skill is at least partially developed.

I personally am of the opinion that some low-level skills domains permit the "bottom-up" approach to learning where procedural knowledge is learnt and then declarative knowledge expressed. On the other hand, development of most other skills especially those that are cognitively complex and structurally interdisciplinary such as in the physical sciences and computer programming requires the learning of declarative knowledge prior to the construction of procedural knowledge. This then enables one to ultimately perform the complicated task with no access to the declarative knowledge and without conscious awareness of the specific details and intricacies involved. The logic underlying this argument is that the initial groundwork of declarative knowledge facilitates the transfer of skills, speeds up the learning process in new settings and enables the communication of knowledge and skills to others (Willingham, Nissen, Bullemer, 1989; Sun & Peterson, 1998). Declarative knowledge lays the knowledge foundation in place which when acted-upon in a contiguous manner through practice becomes proceduralized and converted to a tacit, procedural form (Anderson, 1982). This transition happens in gradual, concurrent ways through continuous experiential learning. When actualized and internalized, the learner is able to thereafter competently and automatically perform the actions of the task though he or she is unable to analytically and heuristically express or communicate the "whys" and "hows" of carrying out the procedures within the task. Such preliminary, prerequisite declarative knowledge could be activated within learners if they have the prior knowledge or otherwise it needs to be communicated to them before they attempt to learn new procedural knowledge.

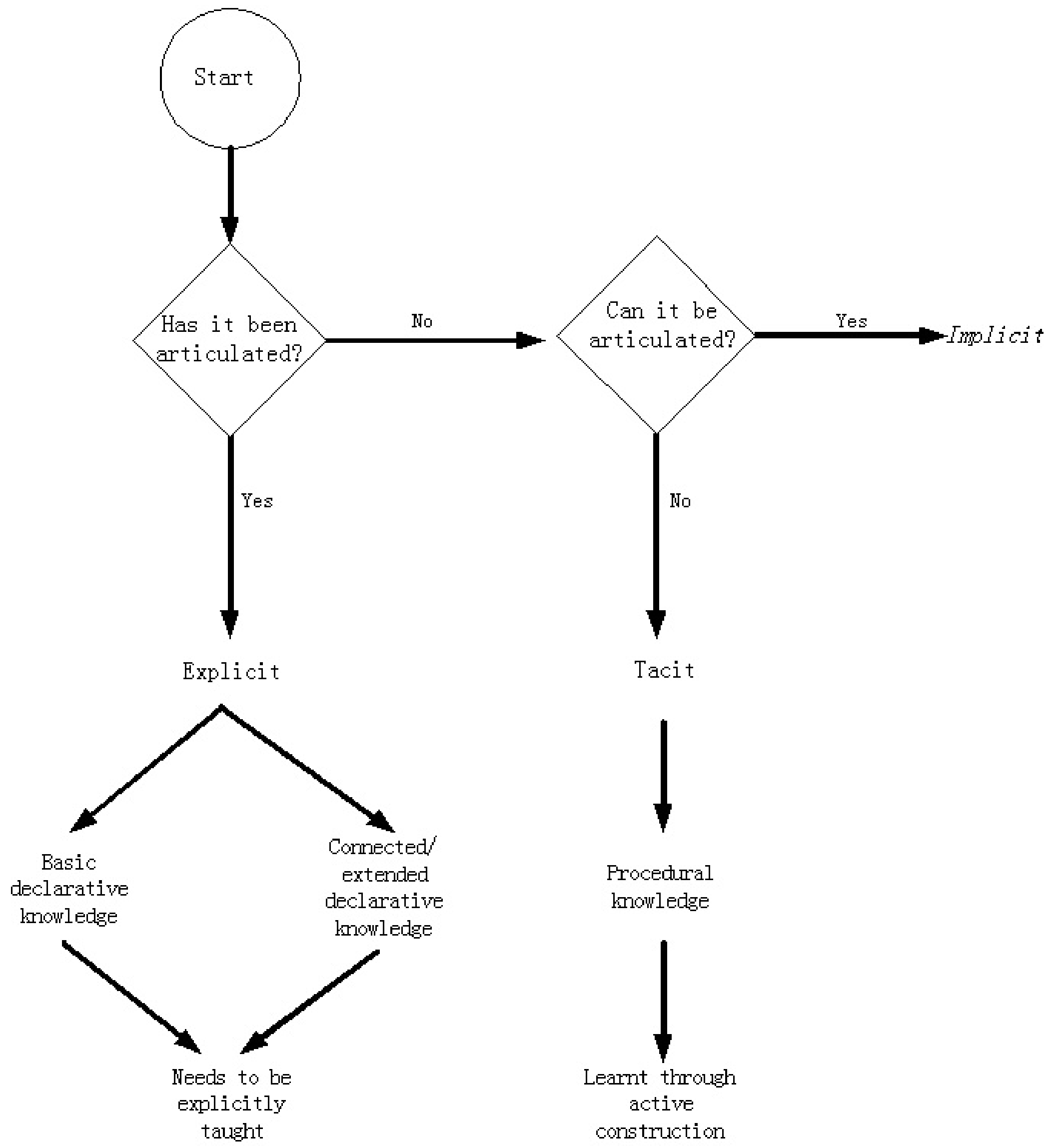
In support of my above mentioned views, I have produced the following few quotes by the polytechnic students whom I interviewed in the course of facilitating their class for the module of problem solving and cognitive thinking. The polytechnic that these students are enrolled with is an academic institution that is highly reform-minded. It has implemented a number of constructivist-based reform measures in its curriculum design to improve the quality of the education that it delivers to its students. One such innovation is the use of problem-based learning methodology that is rigorously used for the teaching of all disciplinary subject domains and at all academic levels of training. Students are trained to independently access and assess given resources to build up their own base of pre-requisite, foundational declarative knowledge to tackle problem-solving.

> *"As for me, problem-based learning should not be applied to all modules. Modules such as programming, I guess, would be better if there is someone who first teaches us the codes and how to go about writing the program. It is very difficult for us when in the first place we have no knowledge about programming and are expected to come up with the codes by ourselves. Sometimes, at the end of the lesson, I am still left wondering how to solve the problem and am not sure about the coding."*
>
> *"I feel that not all modules can be done using PBL, especially modules such as programming and sciences. In programming, we need to understand the commands and we need a teacher to teach us and help us understand these concepts. Science is a module which we can't do using PBL, since sometimes we read the information but can't understand the concepts and we need a person to explain to us or even use a better and a more simpler way to let us understand these concepts."*
>
> *"Lack of basic knowledge. Take for example, Basic Science. Everyday, there are different problems to be solved and for every problem, there will be a different topic. As for some topics, we do not even have the basic knowledge for them and yet we have to solve the problems. Learning the basic knowledge at the very last minute is difficult for us, first timers and we understand only the surface."*

Description of components of framework

In the knowledge taxonomy of my framework, I have chosen to classify declarative knowledge into two broad, functional forms i.e. basic and connected/extended factual knowledge. When verbal information which is originally in an abstract form gains a meaningful representation as organized bodies of knowledge it becomes transformed into usable, declarative knowledge. At this juncture, I would like to recall the distinctions between the concepts of information and knowledge discussed in the preceding sections. Knowledge is an expansion of information. Unlike information, knowledge is a dynamic mix of information embedded in context, experience, insight and values (Brooks, 2000). Such knowledge could be characterized as being either specialized or generalized (Gagne, Wager, Golas & Keller, 2003). Specialized knowledge is possessed by individuals within their own fields of expertise or work whereas generalized knowledge is a body of cultural and historical knowledge that has a societal imprint in it being well acknowledged by all citizenry as being desirable for the 'educated class' to be learnt. Such generalized knowledge serves as the foundation for creative, reflective thinking and critical reasoning.

Figure 2: Integrated Framework of Constructivist-based Curricula Design



In my taxonomy of knowledge structures, for most working purposes the order of instructional sequencing is organized such that declarative knowledge in its basic form is acquired first by learners followed by learning of connected/extended declarative knowledge. Both of these categories of knowledge lay the epistemological groundwork for learners to interact with the objects of declarative knowledge through a range of learning activities. Then they are encouraged to learn the intrinsic, procedural knowledge of processes and skills involved in automatically performing the series of steps required of instructional tasks. In my model, procedural knowledge also subsumes systemic knowledge where the learner is aware of the dynamics of the relationships governing the different component and sub-component parts that constitute the learning system.

Basic declarative knowledge constitutes verbal or written statements that express relations between two or more named objects or events and details about their properties (Gagne, Wager, Golas & Keller, 2003). Such information could also be details on episodes, cause/effect sequences, time sequences or general principles. Examples of such statements include “Plants are usually green in colour”, “The war was lost due to lack of logistical planning”, “Length is defined as the physical distance between two points “, “Boiling point is defined as the temperature at which a liquid turns from a liquid state to a gaseous state”, “President Kennedy was assassinated on November 22, 1963.” Such statements convey meanings that could be related to other existing facts and integrated to build-up a larger set of knowledge or extended to learn new facts in multiple contextual situations. I call this second category of knowledge as connected/extended declarative knowledge in recognition of the fact that such knowledge is a natural expansion of basic declarative knowledge. When acted upon to execute a set of actions involving either mental or motor skills, connected/extended declarative knowledge becomes transformed to procedural knowledge. Connected/extended knowledge includes the learning of a variety of concepts, rules and principles to gain intellectual processing capabilities. For example when the concept of length is understood in mathematics, it could be logically extended in its usage to understand Pythagoras Theorem and its corollary applications. In science the basic principle of boiling point could be further extended to explore how various environmental variables could alter the boiling point of a liquid.

The maturation of such a learning process results in the development of vital procedural knowledge or knowledge in the doing. Encompassing psychomotor and cognitive components, procedural knowledge is inherently functional, enabling performance of varied tasks. Such procedural knowledge is the consummation of declarative knowledge which originally being descriptive is now employed to execute a set of actions to accomplish a task. Such tasks include psychomotor activities such as diagnosis, troubleshooting and repairing of mechanical systems as well as cognitive activities such as learning a foreign language. The performance behaviours of an expert possessing procedural knowledge are so well-endowed internally and of second nature that the expert is unable to express, be it orally or in writing the nuances of the ‘hows’ and ‘whys’ of executing the steps and procedures. This is why I argue that almost all forms of procedural knowledge are tacit and unable to be codified and articulated. I concur with Nickols (2000) in his conclusions that though some knowledge theorists are of the opinion that the outputs of procedural knowledge could be represented as heuristics, algorithms or instructional/flow charts in actuality such explicit descriptions of acts could only be termed as implicit knowledge and not procedural knowledge which is fundamentally tacit. To quote Nickols: “A description of an act is not the act just as the map is not territory.” (p.4)

He cites Nonaka’s example of the product developer who developed specifications for a bread making machine. Though the developer was able to devise a set of product specifications based upon what she learnt in the course of apprenticing the chef, it was hardly likely that she captured in expressed writing the chef’s tacit knowledge. What she was able to articulate was some declarative knowledge that consisted of rules or principles that could be useful in the design and development of the bread-making machine. Another example that I could put forward to emphasize this point is the case of an expert troubleshooter who is able to analyze a malfunctioning air-conditioning system for its faulty state configuration and repair it accordingly. Though he or she may be able to present a procedural manual to guide novices on the techniques of how they could on their own perform the troubleshooting task in a systematic manner, such explicit specifications could hardly be considered as the fitting match or representation of the entire body of tacit knowledge held by the troubleshooter. The expert troubleshooter’s base of procedural knowledge could be rich and vast, having been collected from previous working experiences that he or she may intuitively depart from the natural order of course of action expressed in the original set of guidelines at a certain juncture of the troubleshooting process to ensure a more rapid and efficient completion of the task. The same could be said of an expert doctor who would not be able to reduce in mere words his or her consolidated tacit medical expertise on the procedures of detecting various ailments and prescribing cures for them. All that the expert doctor could do may be to articulate in a limited way some generic recommendations of how beginner doctors could approach the diagnosis of their patients. Such recommendations at best can be categorized as declarative knowledge.

Conclusion

In order to encourage reflective teaching practices amongst educators and transformational learning amongst learners, many schools and tertiary institutions are promoting the design and implementation of constructivist-based curriculum models. Constructivism exposes learners to the richness and rigours of objective reasoning, self-inquiry and critical-openness which in turn improves their scholarship and analytical skills. However this does not mean that learners are to be left in the deep end to fend for themselves in their pursuit of gathering knowledge. Rather educators as facilitators need to be cognizant of the inter-dependent relationships between the diverse cognitive demands of different disciplinary subjects. They also need to be aware of the epistemological attributes of declarative and procedural knowledge representations in effectively formulating and organizing curriculum content. Such an approach calls for the progressive development of learners in their self-directed endeavours at actively constructing new knowledge through generative learning experiences.

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