RESEARCH ARTICLE

A CONCEPTUAL UNDERSTANDING OF RESEARCH TRADITIONS UNDERPINNING INQUIRY BASED TEACHING PRACTICES

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A B S T R A C T

The overarching objective of this paper is to describe the conceptual and epistemologicalunderstanding of inquiry-based teaching practice and study how constructivism underpins inquiry. In a learning context, inquiry plays a vital role in developing students' conceptual understanding and critical thinking, thus emphasizing the importance of this discourse in this paper. Inquiry-based pedagogical approach involves active learning and application of constructed knowledge. In particular, inquiry-oriented pedagogical practice supports active engagement of students in their learning by encouraging them to: formulate questions, design investigations, test hypotheses, record observations, and draw inferences from data.The conceptual understanding of inquiry in this paper are described by analyzing research articles to illuminate how this pedagogy plays a vital role in developing students' conceptual understanding and critical thinking.The epistemological underpinning is delineated by drawing on the philosophy and research concepts of constructivists.Constructivism is a pedagogical reaction to didactic approaches such as traditional and transmissionist instructional models where the teacher is expected to transmit knowledge and students are viewed as passive recipients of knowledge. On the other hand, constructivism asserts that learning is an active process. Notably, constructivism advocates that knowledge is constructed based on learners' personal experiences, prior knowledge, and active engagement through social negotiations rather than acquiring it passively. Specifically, this paperdiscusses constructivism as conceptualized by Piaget, Vygotsky and Von Glasersfeld and illustrates how constructivism underpins inquiry.

INTRODUCTION

Epistemological understanding: This section of this paperdiscusses the epistemology of inquiry through the lens of learning theory-constructivism. Epistemology is the branch of philosophy that deals with how knowledge is acquired, constructed and value of knowledge (Audi, 2003; Dancy, 1987; Brandom, 1994). Study of key issues, ideas and values in the epistemology of a teaching practice plays a pivotal role in employing the instruction as a tool for knowledge construction (Audi, 2003; Dancy, 1987; Brandom, 1994). Thus learning about key ideas, structure and concept of constructivism which epistemologically can underpin inquiry becomes important in this section. The justification how constructivism underpins inquiry is explained in one of the sections of this paper.

Introduction to constructivism

Constructivism is a learning theory that has a philosophical viewpoint on how individuals acquire and construct knowledge and is drawn from the constructivist concepts of Jean Piaget, Von Glasersfeld, Bruner and Vygotsky. Constructivist theory proposes that learners construct their own understanding based on what they already know and believe in their understanding, phenomena, ideas and actions when they come in contact with it (Linin & Burbules, 1992; Richardson, 2003). The construction of knowledge according to constructivist theory can be compared to the process of assembling a furniture or an artifact (Ernest, 2010). The process of construction is based on an individual's prior knowledge/conception or what the individual knows about the subject and how the individual reconceptualizes the new experience based on prior experience (Steffe, Moore, Hatfield, & Belbase, 2014). "Hence, one's construction of knowledge depends on what he or she already

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has in the form of prior knowledge and how the new experiences adapts the new conceptions, schemes, or actions" (Steffe & Thompson, 2000 p. 14). There are different forms of constructivism in the literature which are labelled as cognitive, personal, social, radical, cultural, trival, pedagogical, academic, contextual and ecological. From the pool, the three major constructivist perspective discussed in this paper are (I)*cognitive (II) radical and (III) social constructivism*
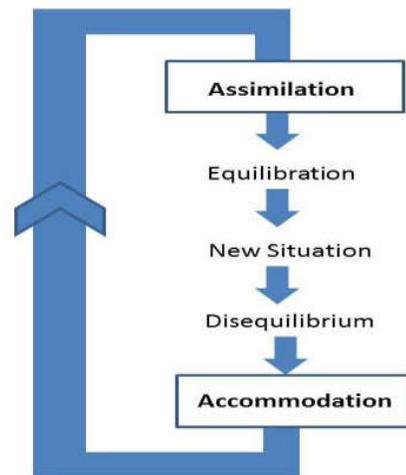
Cognitive constructivism

Cognitive constructivism is based on the work of the developmental psychologist Jean Piaget. Piaget (1958) believed that knowledge does not exist out there, rather, it is acquired and constructed through an active process of learning which involves formation of mental representations (cognitive) structures. Cognitive constructivism formulates that individuals construct knowledge as mental representations (cognitive structures) based on their understanding of the world around them and the experience of discrepancy between their prior experience and what they have discovered (Piaget, 1958; Piaget, 1970; Piaget, 1972). Jean Piaget argued that an individual has basic mental (cognitive) structures (genetically inherited) on which all subsequent learning and knowledge are constructed (Piaget, 1958). The cognitive constructivist framework suggests that knowledge is either "developed incrementally by expanding or by adjusting one's"existing mental representations or schemas" (Asghar, 2012, p. 58*). Thus, knowledge construction is viewed as a progressive reorganization of cognitive/mental structures (schemas) as a result of biological maturation and new experience gained (McLeod, 2018).* Piaget's theory of cognitive development includes few fundamental concepts based on which the process of knowledge construction is described, they are (a) schemas (b) assimilation (c) accommodation (d) equilibration (e) disequilibrium

Schemas: Schema are described as a set of cognitive structures that enables an individual to develop mental representations of the world around them which can be used to both understand and respond to a situation (McLeod, 2018). Jean Piaget asserts that individuals construct cognitive (mental) representations from experiences gained by interacting with materials, events, phenomena which he termed as schemas (McLeod, 2018 ;Piaget, 1958; Piaget, 1970; Piaget, 1972). According to Piaget, schemas are "a cohesive, repeatable action sequence possessing component actions that are tightly interconnected and governed by a core meaning." (Piaget, 1952, p.7). As such, schemas are an individual's mental representations to actively constructed to "interpret and assess a phenomena and an incoming information from existing situations" (Kharboush, 2003, p. 30). These schemas are incomplete and imprecise; as individuals engage in new experiences these schemas are used in the process of knowledge construction to assimilate new ideas (Llewellyn, 2002; McLeod, 2018; Kharboush, 2003). Wadsworth (2004) claimed schema as 'index cards' situated in the brain which gives an individual the directions on how to react to an incoming impulse/motive. These cognitive schemas are stored and applied when needed (McLeod, 2018). For example: When an individual buys a meal in a restaurant, the whole process of ordering a meal from the menu, eating it and paying the bill is stored as a schema. This schema is retrieved

and applied whenever the situation of being in a restaurant arises (McLeod, 2018).

Piaget's classical theory of cognitive development proposes that intellectual learning take place through a process of assimilation and accommodation*.(b)Assimilation* deals with the application and use of existing schema to deal with a new experience or a new situation (Llewellyn, 2002; McLeod, 2018; Kharboush, 2003). In other words, *assimilation* is the process by which new knowledge constructed based on a new experience is fused with the existing mental structures without transforming them (Llewellyn, 2002; McLeod, 2018; Kharboush, 2003; Labbo & McKenna, 2000) *(c) Accommodation* happens when the existing schema is unable to accommodate the new experience and has to be modified to accommodate the new experience (Llewellyn, 2002; McLeod, 2018; Kharboush, 2003). That is to say, *accommodation* necessitates the restructuring of existing schema to fit new information which eventually changes the learners view and understanding of the world (Llewellyn, 2002; McLeod, 2018; Kharboush, 2003; Reinking, Labbo & McKenna, 2000)*.(d) Equilibration:*A state of equilibrium occurs when the existing schema can accommodate the new information/experience (assimilation). However, a state of *(e) disequilibrium* befalls when the existing schema cannot incorporate the new experience/new knowledge and has to be rebuilt to reconcile the new understanding (accommodation) (Llewellyn, 2002; McLeod, 2018; Kharboush, 2003; Reinking, Labbo & McKenna, 2000). Thus in Piagetian model learners are gaining "increased level of maturity in their knowledge as they pass through several distinct stages, each of which comprises an iterative process in which assimilation gradually gives way to accommodation" (Reinking, Labbo & McKenna, 2000, p. 111).

This concert map shows the iterative process of knowledge construction in cognitive construction.

Radical Constructivism

Von Glasersfeld grounds his approach to learning as radical constructivism. He considers his version of constructivism to be radical because it went farther shifting the prevailing constructivist notion towards "adaptive cognition". On other hand this can be described as the constructed knowledge which "enable us to cope". This epistemological paradigm posits that knowledge is the product of an individual's active and dynamic

construction "and its own value is established by its viability in the individual's world of experience rather than in comparison to an external reality" (Cheli, 2018). Glasersfeld (1996) in his radical constructivism emphasizes that knowledge is constructed subjectively rather than acquiring it objectively through senses. For instance, Glasersfeld in his terms stated that "knowledge is not passively received but built up by the cognizing subject and that the function of cognition is adaptive and serves the subject's organization of the experiential world " (Von Glasersfeld, 1996, p. 18).

Von Glasersfeld's (1996) radical constructivism adopts knowledge construction as an evolutionary process. This paradigm of learning assumes that knowledge construction undergoes continuous evolution analogues to Darwin's theory of natural selection. The evolutionary process is described as continuous cognitive reconstruction to adapt better and clearer concepts/mental representation/schemas of the experiential world (Von Glasersfeld, 1996). Thus *this radical constructivist paradigm describes the individual knowledge construction process as a path towards more favorable thinking and acting for a better survival and existence (Von Glasersfeld, 1996).*This constructivist epistemology advocates that an individual actively constructs knowledge by continuous reorganization of mental representations formed based on prior knowledge (Belbase, 2014). Radical constructivism points to the "viability" of these mental structures. Glasersfeld describes viability as the adaptive nature of the mental representations that serves the purpose what they are assigned for, and solely supports the individual to achieve the purpose (von Glasersfeld, 1995).

Social constructivism

Social constructivism primarily emphasizes the importance of culture and context in understanding the activities of a society and construct knowledge based on that understanding (Derry, 1999; McMahon, 1997). This perspective of socio-constructivism is closely related and inspired by the philosophy of cultural psychologist Vygotsky's developmental theory. Vygotsky extended the current perspective of constructivism by conceptualizing knowledge construction as a process which develops through sociocultural mediation (Vygotsky, 1978). Vygotsky's argued that culture and collaborative interactions in the society play a pivotal role in knowledge construction (McLeod, 2018;Derry, 1999; McMahon, 1997). This theoretical perspectives developed as social constructivism and focused on cognitive process that occur within the context of shared learning (Palinscar, Magnusson, Marano, Ford, & Brown, 1998).

"Social constructivists state that meaningful learning occurs when individuals are engaged in social activities such as interaction and collaboration" (Amineh & Asl, 2015, p. 13). Vygotsky's theory of socio-cultural learning model acknowledges learners own version of constructed knowledge influenced by their background and identifies learners as integral part of the learning process (Wertsch, 1997). "From the social constructivist viewpoint, it is thus important to take into account the background and culture of the learner during learning process. The learner's background also helps to shape the knowledge and truth that the learner creates, discovers and

attains in the learning process" (Amineh & Asl, 2015, p. 14). Thus in a social constructivism cognitive growth progresses from social to individual level supporting the movement from social constructivism to constructivism (Vygotsky, 1978).

This concert map shows the three different perspectives of constructivism with a short description of their key concepts
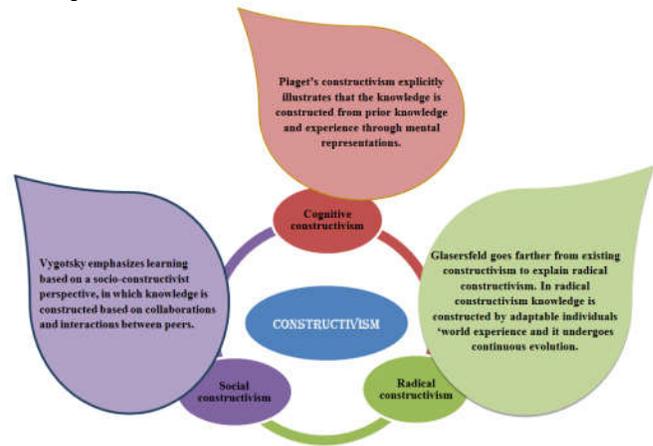
Conceptual understanding: This segment of the paper explains the conceptual understanding of inquiry. Conceptual understanding refers to developing deeper understanding of more than isolated facts and methods (Byrnes, 1992; Byrnes & Wasik, 1991). This understanding supports the viewpoint why such learning is important and the kinds of context in which it is applicable (Byrnes, 1992; Byrnes & Wasik, 1991). Therefore conceptualizing concepts, ideas and structure of inquiry in this section will support understanding its instructional approach and its association with constructivism.

Introduction

The inquiry-based teaching and learning practices was developed as a result of a longstanding continuous discourse on nature of teaching practices (Minner, Levy, & Century, 2010).Inquiry based instruction advocates an instructional approach in which students are given the opportunity to understand scientific ideas, pose questions, develop hypotheses and predictions, conduct investigations in groups, analyse and interpret data, and propose explanations (National Research Council [NRC], 1996). This pedagogical instruction includes hands-on experiential activities as a method to promote student engagement and motivation in a classroom setting to develop conceptual understanding of the learning concepts (Minner, Levy, & Century, 2010). Inquiry-based pedagogical instruction involves active learning and critical knowledge construction. This papers discusses the perspective of inquiry from the view point of two positivists' research article based on cognitive constructivism and social constructivism.

Inquiry and Minner et al (2010)

The study of Minner *et al* (2010) describes inquiry-based teaching and learning based on cognitive constructivism by using a positivists methodological tradition. This characteristics of the research article from the reviewed literature gives a prime importance for its conceptual analysis in this paper. Minner *et al* (2010) study illuminates that an inquiry based learning context

promotes active learning by drawing inferences from experimental data which supports students to develop a deeper understanding of the learning concepts and construct knowledge. As such, Minner *et al* (2010) in their study have identified inquiry as a pedagogical approach that involves an investigating cycle ("i.e., generating questions, designing experiments, collecting data, drawing conclusion, and communicating findings") (Minner, Levy, & Century, 2010, p. 493). This investigating cycle of the classroom instruction has a productive emphasis on students' active thinking and supports the development of their content learning skills (Minner, Levy, & Century, 2010). The authors in their study argued that active construction of knowledge through cycle of investigation in an inquiry-based instruction develops conceptual understanding (content knowledge) in learners (Minner, Levy, & Century, 2010).

Inquiry and Wilson et al (2010)

Wilson *et al*. (2010) in their study have described the inquiry based pedagogical instruction by grounding in social constructivist perspective. This study involves the analysis of 5Es' such as engage, explore, explain, elaborate and evaluate in an inquiry based learning/teaching context using a positivists' approach. Each 'E' described supports the teaching strategy and learning experience to provide students with the opportunity to construct knowledge based on content learning (Wilson, Taylor, Kowalski, & Carlson, 2010). Students involved in the practice and modelling of these (5E's) construct knowledge through scientific reasoning and argumentation (Wilson, Taylor, Kowalski, & Carlson, 2010). Wilson *et al* (2010) in their study documented that inquiry based instructional approach involving 5E's promotes critical thinking in students through social interaction and collaborations (Wilson, Taylor, Kowalski, & Carlson, 2010). Furthermore, the authors argued that Inquiry as a pedagogy supports knowledge construction consistently across race, gender, ethnicity and socioeconomic status (Wilson, Taylor, Kowalski, & Carlson, 2010). In addition, the authors asserted that student's develop deeper understanding of the learning concepts by retrieving information from prior knowledge and by developing evidence-based arguments (Wilson, Taylor, Kowalski, & Carlson, 2010). Thus the study of Wilson *et al*. (2010) describes the pedagogy of inquiry through the 5E's model and argues that inquiry based teaching and learning promotes deeper conceptual understanding in learning through engagement and collaborations.

Constructivism and inquiry-based approach:
This part of the paper discusses and describes how constructivism underpins inquiry by using evidences from the literature. In addition to the pieces of information on constructivism underlining inquiry from above two examples, this sections gathers information from various other articles from the literature to develop deeper understanding about the concept (constructivism underpins inquiry).

The inquiry-based pedagogical approach is closely associated with the principles of constructivism (Bell & Eaton, 2000; Flick, 1990; Kyle *et al*., 1985). Itisa constructivistapproach as it is learner-centered and supports students to construct scientific knowledge through participation in experimental discoveries, observations, discussions and collaboration with their peers (Lampert & Ball, 1998). In inquiry-based learning activities, students actively create knowledge by building on their prior knowledgethrough assimilation and accommodation (Windschitl, 1999).In particular, inquiry-based pedagogical practice supports learners' conceptual understanding by encouraging them to formulate questions, test hypotheses, record observations, and draw inferences from data (Tella, 2007; Van Uum, Verhoff & Peeters, 2016).As advocated by constructivists, in an inquiry-based setting students are given the opportunity to conduct real science based inquires to mimic the work of a practitioner (e.g. scientist, environmentalist) (Furtak, 2006). As in a constructivist classroom, in an inquiry-based classroom "students access prior knowledge, face cognitive dilemmas, cooperate with one another to wrestle with real problems and construct their knowledge and understanding of the scientific world" (Elliott, 2007, p. 32).

Following the footprints of constructivism, inquiry-based learning allows a generative learning process which is characterized by collaborative interaction between peers in which students value and learn from each other viewpoints and expressions (Brown & Meller, 2006). Seemingly, by promoting student engagement and motivation in active learning, inquiry learning facilitates in-depth learning of scientific concepts and models (Morrison, Lowther, & DeMeulle, 1999). In resemblance with the philosophies of constructivism, inquiry supports the knowledge construction based on an individuals' experience rather by memorizing the concepts without associating it to prior knowledge (Martin *et al*., 2001). As in a constructivist learning context, inquiry allows knowledge construction based on each other's viewpoint in a collaborative learning (Morrison, Lowther, & DeMeulle, 1999).

CONCLUSION

The first section of this paper discussed the epistemological underpinning of inquiry by drawing on the constructivist concepts of Piaget, Glasersfeld and Vygotsky. Piaget's constructivism explicitly illustrates that the knowledge is constructed from prior knowledge and experience through mental representations. Glasersfeld goes farther from existing constructivism to explain radical constructivism. In radical constructivism knowledge is constructed by adaptable individuals 'world experience and it undergoes continuous evolution'. Vygotsky emphasizes that learning is based on a socio-constructivist perspective, in which knowledge is constructed based on collaborations and interactions between peers.

The second section of thispaper discussed the conceptual understanding of inquiry-based learning and teaching by conceptualizing the ideas of: (i) Minner *et al*. (2010) and Wilson *et al*. (2010) and (ii) few more research articles. Although both studies resembled each other in content-based understanding of the inquiry based pedagogy in a positivists' approach, skimpy nuances were existing in framing its' schema. Minner *et al* (2010) defined inquiry based pedagogical instruction as a cycle of instruction which follows the pattern of assimilation and accommodation in a constructivism based on cognitive constructivism. While, Wilson *et al*. (2010) framed a social constructivist model of inquiry involving 5Es' such as engage,

explore, explain, elaborate and evaluate. Thus from the review of analysis in this paper, it is evident that the constructivist-inquiry centered learning context facilitates knowledge construction from prior knowledge, individualized experience through mental representations and social interactions.

A concept map matching few characteristics between inquiry and constructivism to illustrate how constructivism underpins inquiry
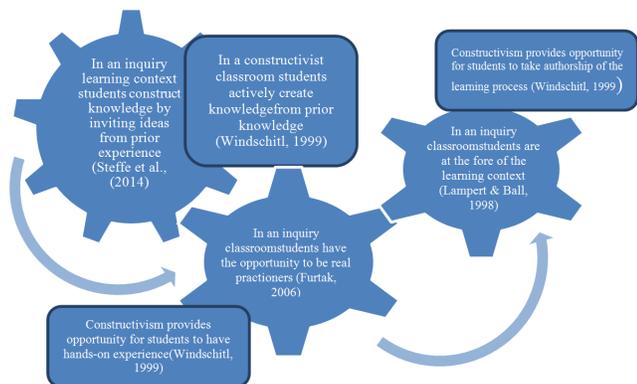
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