LEARNING AS A SENSE-MAKING ACTIVITY

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Abstract

There are signs emerging of a dissatisfaction with constructivism as a means for wholly accounting for learning processes. Constructivism is the third of three major theories proposed this century to account for human learning, after behaviourism and information processing (Mayer, 1996). Constructivism has been very influential in learning and teaching theories in the 1980s and 1990s; however, there are signs that a point has been reached where the limits of constructivism need to be reconfigured. Though constructivism has reminded educators of the need to consider individual differences between learners, it does not easily explain the learning of culturally-situated subject matter such as mathematical or scientific concepts. The author suggests a theory of learning that incorporates aspects of both information processing and constructivism, and posits human learning to be principally a sense-making activity. A model is proposed which incorporates aspects of both information processing and constructivism, yet which goes beyond either.
Introduction

Theoretical discussions about teaching and learning have been dominated over the past decade or more by references to constructivism. As a theory of learning, constructivism is very powerful, and, as Cobb, Yackel and Wood (1992) claimed, educators “almost universally accept that learning is a constructivist process” (p. 3). However, one “sect” (Phillips, 1995) of constructivism, radical constructivism, seems to be gaining greater prominence, with significant consequences for teaching practice. The author argues that the radical constructivist position is primarily a philosophical position, whose central epistemological tenets are outside the domain of classroom teaching. In place of radical constructivism, a pragmatic position is recommended, that considers the actions and thinking of students in light of a proposed model of how new experiences are integrated with students’ prior personal beliefs and theories, in order to make sense of them.

This paper is divided into three main sections. First, the tenets of radical constructivism are described in the context of historical, philosophical, questions about existence and perception. Second, a proposed model of human learning as sense-making is described, and briefly discussed in light of published statements about constructivism. Third, supporting evidence for a sense-making view of learning is presented, from published and anecdotal sources.

Historical Background

It is the view of this author that radical constructivists, in presenting their strong views of how we learn, demand that educators engage in and accept a particular philosophical viewpoint*. Radical constructivists believe that since all experience is filtered through fallible human sense organs and mental faculties, no external reality can be assumed. The radical constructivist view is presently being widely disseminated in journal articles and at conferences, with the concomitant argument that the content of subjects such as science and mathematics cannot be taught as truly existing outside human thinking. This view has significant implications for education, to be discussed further in a forthcoming paper. However, it is important to realise that (a) this currently-fashioitable view of epistemology is far from new, and (b) through history there have been many notable thinkers who have accepted it, and many others who have rejected it.

The idea that absolute Knowledge or Truth could not be assured was first advanced by the Sophists of Ancient Greece (Gotterbarn, 1993). The best-known member of the Sophist school, Protagoras, “denied the possibility of objective knowledge”, and believed that “all truth is relative to the individual that holds it” (Concise Columbia Encyclopedia, 1994). His view is summed up in his famous statement that “man is the measure of all things”.

Another philosopher who investigated the distinction between mind and matter, or perception and the perceived, was Immanuel Kant (1724-1804). Kant distinguished between the Phenomenon, or the thing-as-it-appears, and the Noumenon, or thing-in-itself. He believed that “only objects of experience, phenomena, may be known, whereas things lying beyond experience, noumena, are unknowable, even though in some cases we assume a priori knowledge of them” (Concise Columbia Encyclopedia, 1994).

Difficulties with Radical Constructivism’s Philosophical Foundation

It is clear that the views of radical constructivists are not new. Further, it is also clear that at no time have they been universally accepted by philosophers.

In this paper a very important distinction is made between (a) claims of constructivist learning theory that individuals construct their own, somewhat unique, understandings of what they experience and (b) philosophical claims made by radical constructivists that
physical existence is in question. Whereas constructivism, in some form or another, is now widely accepted by the majority of educators, questions of the existence of external entities are a separate concern, and may be seen as extraneous to the business of teaching.

This paper does not attempt to argue the merits, or otherwise, of the philosophical arguments used by radical constructivists to justify their views of teaching and learning; that should be left to philosophers. Instead, a pragmatic approach is taken, which addresses the practical concerns of classroom teachers as they go about teaching students, and the question is asked, “Are the philosophical views demanded by the radical constructivist position useful to teachers?”

The central platform of the radical constructivist position, that distinguishes it from other educational views (including other versions of constructivism), is that no objective “reality” independent of an observer can be assumed. It is the contention of this author that far from assisting teachers in teaching students, this position hinders them from effective teaching. The basis for this statement is two-fold: (a) every person instinctively acts as if an objective world, separate and independent from the observer, existed; and (b) the content component of every school subject is founded on some level of acceptance of entities independent from the observer.

First, whatever one’s personal philosophy and epistemology, a person cannot fulfil the demands of everyday living without acting as if an “outside world” existed. Catching a bus, caring for one’s children, saving money to buy a house, and a multitude of other everyday actions, all require personal assent (either deliberate or unconscious) that buses, children, banks, houses, and so on, actually do exist. The second point is that this no less true in a classroom setting, where teacher and students generally behave in a manner consistent with belief in the existence of independent external entities. These include both physical entities, such as Japan, Shakespeare, or an orchestra; and conceptual entities, such as equilateral triangles, the Periodic Table, or the rules of football.

It cannot be stated too strongly that the distinction between one’s epistemological beliefs and one’s actions is crucial to questions of how to teach subject matter. In a very real sense it does not matter whether or not one believes in an independent external existence, so long as one is acting as if it exists. To repeat: Philosophical questions are best left to philosophers, and add little to debates about teaching practice.

Learning as Sense-making

The central argument here is that philosophical questions such as those discussed above do not assist educators to understand how learners learn or how they may best be taught. What is needed is a conception of the learner that (a) adequately describes the learner’s relationship with the world, (b) informs the practice of teaching on the basis of a model of how humans learn and allows for multiple forms of sensory experience as starting points for learning.

What is proposed is a perception of humans as sense-making organisms, and a model of learning as a sense-making process. In this discussion “sense-making” is defined as:

The exercise of human reason to consider available information, in an attempt to fit incoming information to existing personal beliefs and theories. The objective for the thinker is to avoid inconsistency or contradiction between sensory data and beliefs and theories about the world.

The idea that humans innately desire to make sense of their experiences is in accord with the statement by Leonard Bernstein that “There is a human urge to clarify, rationalize, justify” (The American Heritage Dictionary of the English Language, 1994). It is the contention of this author that sense-making is an essential element of human cognition, that is present from birth. The model of thinking proposed here attempts to describe what the
processes involved in learning may be that enable a person to react meaningfully to new experiences.

A Sense-making Model

A model for learning as a sense-making activity is illustrated in Figure 1. The model attempts to explain what occurs as an individual receives new sensory input, and shows one conception of what may take place as a person considers what his or her senses have received. In brief, the model portrays the sense-making process as one of comparing new information with existing beliefs and theories, and making decisions about whether to accept or reject the new data.

Assumptions

The model assumes the existence of personal theories and personal beliefs, as two distinct but closely-related components of a person's thinking capacities (see also Kouba & McDonald, 1991, for a discussion of "student belief systems"). These are defined as follows: Personal theories are "working hypotheses" about the world and how it operates. Statements concerning one's personal theories are expressed in somewhat tentative terms: they will include such phrases as "I think it is likely...", "In all probability..." or "I am fairly sure that...". Personal beliefs, on the other hand, are much more strongly affirmed by the individual: they will be evidenced by statements such as "I believe..." or "I am certain that...". Personal beliefs come about as the result of frequent confirmation of personal theories, so that they assume a more definite place in the person's store of personal knowledge.

An example may help to illustrate the distinction between beliefs and theory. A personal theory may exist about the occupation of one's neighbour, based on his or her work clothes, their time of leaving for work, the type of vehicle they drive, and so on. The personal theory may need to be modified over time as more data is collected, which may be illustrated using the model proposed here. A point may be reached, however, at which the theory assumes the status of a belief, meaning that the person assumes that the believed item is actually true. This will be revealed if the person acts and speaks as if the believed idea were true. Note that this does not mean that the belief has been "proved" in any sense. However, to the extent that the person accepts the belief as viable and useful, the belief has become an integral part of the person's thinking. Such a belief is not generally subjected to scrutiny or question, unless some new bit of information sets in motion the sense-making process described below.

Description

The model incorporates Piaget's terms assimilation and accommodation for the processes (a) of incorporating new information into existing beliefs and theories without altering them, and (b) of expanding or altering beliefs and theories in order to include the new data, respectively. The processes may be described in five main phases:

Initial sense-making: Categorisation. The first process is to test whether or not incoming data is recognised as belonging to an existing category. This may occur at the level of simple recognition. For example, if a person walks into the room, the individual will quickly decide whether or not the person is recognised. In many cases the input will not be instantly recognised, and so an attempt will be made to identify the category to which it belongs. For example, if a sound is heard, or a fleeting image is seen, the mind will attempt to categorise it according to some existing category. The sound may be recognised as a bird call; the image might be a reflection of sunlight from a window. If the category of the new data cannot be recognised, if possible the sensory input may be checked: the sound may be listened for to occur again, or an attempt may be made to catch sight of the fleeting glimpse again.
Test-of-fit: Does new data fit with existing theories? Once data has been categorised, a quick check is made to see whether it fits with existing beliefs and theories. In other words, the individual checks to see if an explanation for the new data can be made that is consistent with existing personal beliefs and theories. If the new data is not unusual, this process will be carried out quickly and with little effort. If, however, the new data is out of the person’s common experience, or is quite unexpected, more attention is commonly applied to find an explanation for the experienced data. For example, if a sound of footsteps is heard outside one’s bedroom window late at night, an explanation will be sought that explains the sound. If an explanation for the sensory data is found that is consistent with existing beliefs and theories, then the new data is assimilated into those personal systems (step (d) below); otherwise a judgement has to be made regarding the cause of the inconsistency between the data and personal beliefs and theories (step ©).

Reasoned judgement: Where is the cause of the mis-match? In the event that a discrepancy is found between the new data and what is already believed, a judgement is made as to the cause of the mis-match between the two. One cause of discrepancy that may be checked is the sensory input itself; in other words, the initial sensory input may need to be verified. For example, if you thought that you had seen a well-known person (such as a pop star or a prominent politician) walk past you in a shopping centre, you would most likely have another look before deciding that you were correct. Another important cause of mis-match is between what the individual already believes and the new input. This occurrence is the potential stimulus for new learning. If the individual finds that new sensory data does not agree with what he or she already believes about the world, then at least two choices are available: to modify personal beliefs and theories, or to reject the data itself.

Assimilation/Accommodation/Rejection of new data. The final step is to decide how to use the new data. The individual may choose from at least three options. First, the new information may simply be assimilated into existing beliefs and theories, which will tend to reinforce the strength of those beliefs and theories. Thus if the individual decides that the new information does not conflict with what he or she already believes, then the new data can simply be added to the “stock” of existing information in the mind. The second option is to modify beliefs and theories in order to accommodate new information. The individual modifies beliefs and theories as he or she deems necessary, so that the new information does not cause conflict or inconsistencies. The theory modification and accommodation of data occurs somewhat simultaneously; as the term suggests, theories and beliefs are modified in order to accommodate the new information. It is likely that an iterative cycle is used to alternatively propose new details of theories and beliefs, and test the fit of the new data with the modified beliefs. The third option is to reject the incoming data, which removes the conflict between existing beliefs and theories and the new data, without altering the beliefs and theories.

Figure 1 A Model of the Sense-making Process - contact the author for a copy.

Discussion

The development of a model such as that presented here is consistent with recommendations by a number of writers. For example, Kouba and McDonald (1991) stated that “in order to make effective use of students’ belief systems, educators need delineations both of the components of those systems and of the interactions of those systems with students’ cognition” (p. 1). As explained above, the sense-making model incorporates the notion of students’ beliefs and theories, and proposes a model of how they are incorporated
into learning. Cobb (1994) similarly stated that “the burden of explanation in constructivist accounts of development falls on models of individual students’ cognitive self-organization and on analyses of the processes by which these actively cognizing individuals constitute the local social situation of their development” (p. 15).

The model presented above is also consistent with a number of recent statements about the learning process that support the idea of children actively considering prior experience when reflecting on new information. Driver and Scott (1995), discussing the constructive nature of learning, stated that “the issue of importance here is that children reorganize and reconstruct experiences of their physical and social environment” (p. 28). Similarly, Cobb (1994) stated that there was a “generally accepted view that students actively construct their mathematical ways of knowing as they strive to be effective by restoring coherence to the worlds of their personal experience” (p. 13). Davis (1992) expressed the view that students will develop understanding in interaction with previous knowledge:

When the instructional program does not promote the development of appropriate ways of understanding, students (including even young children) invent their own ways of understanding.... Students are determined to understand, and they create their own ways of understanding. What they learn thereafter is built upon this foundation of previously-built-up understanding (and future learning is therefore limited by the form of this previous understanding). (p. 226)

Support for the Sense-making Model of Learning

There is considerable evidence to support the proposed model. Here evidence from two sources will be discussed: statements in the research literature and anecdotal evidence from a variety of research studies.

Sense-making in the Research Literature

The term "sense-making" has been frequently applied to constructivist views of learning. Mayer (1996), in outlining three major movements in learning theories this century, categorised the student’s role according to constructivist theory as “sense maker”. He commented that According to the constructivist interpretation of the information-processing model, mental processing involves an active search for understanding in which incoming experience is reorganized and integrated with existing knowledge. Three basic processes in active learning are selecting relevant incoming experiences, organizing them into a coherent representation, and integrating them with existing knowledge. In this view, processing is... a coordinated collection of processes aimed at making sense out of incoming experiences. (p. 156)

Such a view may not satisfy all constructivists, with its emphasis on the information-processing model of learning, but it is in broad agreement with the sense-making model presented here.

The idea of sense-making is closely related to mathematics educators’ notion of number sense, which has been identified by a number of authors) as an important goal of mathematics teaching (e.g., Booker, 1997; G. A. Jones et al., 1996; K. Jones, Kershaw, & Sparrow, 1994; McIntosh, 1993; Reys et al., 1991. Number sense involves “meaningful mathematics learning” and the need for students to be taught to consider the “reasonableness of results” (Booer, 1997, p. 1) of computation. As Booker noted, for mathematics educators, “mathematics as a sense making [sic] process is highly valued” (p. 1). A view of mathematics learning as an interactive activity, consistent with the model presented here, was emphasised by G. A. Jones et al. (1996):
Our research adopts the view that mathematical learning is an interactive as well as a constructive activity. As such, it takes the position that opportunities to construct mathematical knowledge arise from attempts to resolve conflicting points of view in a group; from attempts to resolve conflicting points of view in a group; from attempts to reconstruct and verbalize a mathematical idea or solution; and, more generally, from attempts to reach a consensus with others. (p. 314)

Other mentions of constructivism in connection with sense-making have been made in relation to science teaching by Tippins, Tobin and Hook (1993). Tippins et al. referred to constructivism as "a way of knowing and making sense of the world", and stated that From a constructivist point of view, learning is the process of making sense in terms of what is already known. It is an active process in which learners construct knowledge in a way that makes personal sense. And it is a subjective process, as learners draw on their own background experiences to make sense. [italics added] (p. 223)

Tippins et al. (1993) included sense-making as a component of both students’ learning and teachers’ decision-making. The particular focus they had was on science teachers’ decisions with regard to ethical considerations, such as assessment measures and safety procedures. They stated that “from a constructivist perspective, ethical dimensions of teachers’ practices are found in the sense-making process” (p. 226).

Sense-making was an important component of research into Year 5 students’ mathematics learning (Frid & Malone, 1994), and into Grade 11 and 12 students’ learning in “computerized learning environments” (Maor, 1991). Frid and Malone investigated students’ explanations of how they made sense of the learning environment in mathematics lessons; Maor investigated students’ learning about a computer database from the perspective of making sense of an unfamiliar domain. Maor summarised her study thus:

In the present study, students engaged in experiences which enabled them to develop higher-level thinking skills, be creative, and construct their understanding based on a computer program. The students engaged in making sense [italics added] and constructing understanding by negotiating their own meaning with the teacher and the other members of the class. (p. 2)

Anecdotal Evidence

The evidence described above, of researchers including the term “making sense” or “sense-making” in their descriptions of their research, do not demonstrate that learners actually engage in sense-making as described here, of course. The idea that learners make sense for themselves of their experiences is one of constructivists’ “articles of faith”, but on its own it is not convincing. Further evidence is needed showing learners actually involved in manipulating personal beliefs and theories in response to new experiences. Such evidence is presented here, from published research studies and from the author’s current work-in-progress. Sense-making is evident in a number of categories of student behaviour, including hypothesising, inferring and inventing.

Student Hypothesising in the Literature

A number of authors have described the hypotheses made by students as they attempt to make sense of a domain. Two examples are provided here: student explanations of aspects of numeration (Price, 1997) and of written symbols (Bialystok, 1992). A student called Nina (a pseudonym) explained (Price, 1997) that she believed that numbers in New Zealand differed in their place-value from those in Australia. Nina lived in New Zealand when she was of pre-school age. In the study in question, when she was in Year 3, she claimed that in New Zealand “ones blocks” were called “tens”. Clearly no teacher would have told her that. It
is hypothesised that her confusion came from having more difficult questions to answer at school in Australia, and she mistakenly attributed the differences experienced to differences in numbers in the two countries, rather than to differences in difficulty of the mathematical tasks.

Bialystok (1992) studied young children’s understanding of written symbols, and noted that children may form “incorrect hypotheses” about written communication. “Children, for example, believe that a written string must contain at least three letters to be a word, and that all the letters must be different” (p. 306). Bialystok's paper clearly shows that young children, exposed to written communication of others, attempt to make sense of it on their own terms. In particular, the notion of words having specific meanings is an idea that children have to come to terms with. According to Bialystok, young children will sometimes produce a scribbled “simulation of cursive written and insist that it means something” (p. 307). Children will have observed adults writing messages, and reading the messages of others, and will make sense of that in their own way. The sense-making model enables a description of such learning in terms of the children modifying their personal theories and beliefs in response to what they have observed.

Anecdotal evidence

The author has observed a number of instances of students making hypotheses to explain aspects of their learning task. For example, a Year 9 student was asked to explain what he believed was meant by an equation such as “2x + 3y = 16”. His response indicated that he believed that “2x” referred to a two-digit number, with “2” in the first place, and that “x” represented only a single digit. When questioned about this to confirm that this was what he believed, he remarked “Well, if they wanted it [“x”] to be a two-digit number, don’t you think they would have used two ‘x’s’?” Again, it is clear that the student had not been taught this by a teacher. His beliefs about algebraic expressions had evidently been constructed from his prior knowledge of numeration, with modifications to accommodate new forms of mathematical expression that include letters as well as numbers.

The second example concerns a Year 6 student who was asked to use either a calculator, mental or written methods of computation to answer a series of multiplication questions (Price, 1995). Students in the study were told that they could use any of the three methods available as they wished, and they were observed to see which methods they chose. The student in question, when a friend suggested that he use the calculator that was on the table, responded “Look how easy it is - you can use the calculator, it’s your choice. But you get better marks if you use your head.” This student’s belief was in contradiction to the given instructions. He evidently made sense of the governing situation, including an inference about underlying “rules” about how he was supposed to calculate answers to the questions. It is presumed that these inferences were made on the basis of prior experience in classroom situations, in which calculator use was frowned on, and mental computation was favoured.

The third example, from the author’s on-going PhD study, concerns a number of Year 3 students using computer-generated representations of two-digit numbers (described also in Price, 1996). The software has been designed to demonstrate “regrouping” actions on screen blocks, an important concept for later number operations. By clicking a “saw” tool onto a “ten block” the user can watch the block split up into ten one blocks. The user can also have the standard written symbol for the represented number displayed on-screen at any time. What a number of students have found (to their apparent delight) is that when a representation, such as 3 tens and 6 ones, is regrouped into 2 tens and 16 ones, the number represented, 36, remains the same. The following vignette was observed after two boys, Jock and Michael, had regrouped 7 tens and 7 ones into 6 tens and 17 ones.

Jock: [To Michael, with surprised look] 77!
Michael: Oh! We've still got ... Oh, cool, that's easy! 77! [To interviewer] How does it do that? It's still got 77. Oh yeah! [Understands; bangs himself on his head with his hand] Jock: [points to screen] It's still ... You cut it up, and it's still 77! [Looks at Michael]

Michael: Mmm. [Pencil in mouth, apparently thinking]

It would be pleasing to think that Michael was in the process of considering the evidence shown by the computer, in light of his existing theories and beliefs about numbers. There was evidence that there had been a change in his understanding, when in a later session he confidently volunteered the information that when blocks are “cut up”, the number represented remains the same. He stated that “I know what it’s going to be – it'll still be the same”. Michael's body language at the time lent support to the hypothesis that a change had occurred in his understanding of numbers: He was looking toward the other students, without touching the computer mouse or pointing to the screen. His demeanour appeared to indicate that he felt no need to check what he was saying on the computer, because he knew that he was correct.

This apparent change in understanding of numbers was observed in a number of students using the software. There is evidence that students using the software developed this notion quickly, based on their experiences with the software. Frequently a student would say “Oh yeah!”, as Michael did in the vignette presented above—the “ah-ha!” of recognition that teachers like to see in their students as they tackle new material. On the other hand, however, other students in the study using conventional place-value blocks do not appear to have understood this concept as well. It would appear that the students using the software were able to modify their personal beliefs and theories on the basis of the evidence presented by the software, in a very powerful and efficient way.

Summary

This paper has been written with the intent of raising questions regarding views of learning, in light of the current prominence of the constructivist perspective in much published work in education. Specifically, the radical constructivist position as a view of learning that is useful to teachers is questioned. It is claimed that the radical constructivist view of learning is more a philosophical view than a pedagogical one, and in its place a pragmatic view that focuses on reality as students and teachers construct it is recommended as being of greater practical use to teachers. It is asserted that philosophical questions such as those raised by radical constructivist should be argued by philosophers, and that they are not central to the everyday concerns of teachers.

A model of learning based on a view of humans as inherently sense-making organisms has been proposed for discussion. The model takes into account personal beliefs and theories, and posits a number of decision-making processes by which a learner evaluate new information in light of existing beliefs and theories. It is claimed that there is much support for the sense-making perspective, from a number of sources. First, many writers have used the phrase “making sense”, when referring to the learning process from a constructivist perspective. Second, published research shows students modifying their beliefs in response to sensory experiences that is consistent with the model presented here. Third, anecdotal accounts of children making sense of new subject content is provided that is similarly consistent with the sense-making model.
References


Footnote

- See, for example, Ernest (1991), for a comparison of absolutism and fallibilism, and his views of the educational implications that necessarily inhere each of these philosophical positions.

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