

From Misconceptions to Constructed Understanding
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Article Title: Is There a Need To Go Beyond Sense Making? A Metareflection

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Three assumptions, implied by the term misconception, presently important to science and mathematics education are:

1. There exists a body of scientific facts or knowledge which are Truths, to be taught, learned, and evaluated.
2. The goal of learning is to collect all the Truths.
3. Constructed understandings connected within a conceptual framework are misconceptions; hence, misconceptions can be replaced by scientific Truths.

Misconception denoted deficiency within learner, and sense-making is affirmation of learners as a people and learners as learners.

Two implications for science and mathematics teacher educators from the reflections of the author are:

1. Sense-making does not limit learning to learning in school.
2. Teachers are sense-makers.

Both of these build upon the understanding of children's learning. Learners learn before they begin school, outside school one they begin school, and continue to do most of their learning outside school. Also for children, a powerful means of learning is through imitation.

Reference

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Abstract

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As a sense-maker, I bring to my teaching the richness of my sense-making. I propose that teacher-as-sense-maker means teacher-as-learner; hence, I would like to argue that science is sense-making and learning and teaching begin with sense-making, rather than from misconceptions. Is there a need to go beyond sense-making to teach science?

WHO ARE YOU, DEAR CHILD, AND WHAT DO YOU WANT?

You recollect the day that you ran into your major professor's office and declared, "I am full of misconceptions!" With a childish grin, expressing the warmth swelling from discovering more of who you are, you tried to express a liberation that could move you further from the role of teacher-as-expert and more toward teacher-as-sense-maker. What you discovered inside yourself was that you made sense of your world. This world that you personally constructed was often different from the world that you were attempting to create within the minds of your students. You acknowledged how you had failed to create this world within yourself as well. Practically, you admitted that the world upon which you evaluated your students was in the textbook you chose for the class, which was different from the sense-making you have created in your life and experiences.

You wrestle with ideas. You label yourself student. You hope soon to return to the classroom. You have read a great number of works, but you know little. You are creating a sense that will guide your formal reentry into the classroom. You try to be true to the sense that you are making, although you know that you will change. You brood over the ideas that you have not explored to the depth of those who you have read and those who presented the ideas; however, you attempt to make sense of those ideas. You put the pieces of understanding together to create a conceptual framework as you continue to search for the connectedness which holds the trees of your forest together as a forest. You are a neophyte trying to acquire cultural knowledge about science and mathematics teacher education akin to a rite of passage (White, 1989).

You have read Wandersee, Mintzes and Novak's (1994) discussion of terminology concerning alternative conception and misconception. You agree

with Good's (1991) statement that "it is important to select words carefully in our efforts to convey our intended meanings" (p. 387). You question the title of this conference: *From Misconception to Constructed Understanding*. You believe that misconceptions do not exist at any moment in time. What is constructed and is important is what we see, how we educe what we see, and how we make use of what we see, or sense-making. In short, how do science and mathematics teacher educators create primary, secondary and tertiary science education as sense-making?

You hope to assert that sense-making is a term to answer Duit's concern, "maybe they do not hear us at all anymore, shouting out the wonderful new findings we have" (Wandersee, Mintzes and Novak, 1994). Misconceptions and alternative conceptions as pivotal points in science education have allowed science education to continue to limit access to science and thus students' understandings of the world, if only because misconception and alternative conceptions connote a right and a wrong. Access to and understanding of science are limited to those who "know the right." Sense-making, on the other hand, allows all students to understand the world, to experience ideas changing, to have a sense of belonging in time and place, and to see that the answer to all questions lives in the diversity of *Homo sapiens*.

And so you are a sense-maker. You want to bring to your teaching the richness of your own sense-making, but, more importantly, teacher as sense-maker means teacher-as-learner.

From a constructivist point of view, the emphasis is on the teacher as learner, a person who will experience teaching and learning situations and give personal meaning to those experiences through reflection, at which time extent knowledge, is connected to new understandings built from experiences and social interaction with peers and teacher educators (Tobin, Tippins, & Gallard, 1994, p. 48).

You present the sense you have made in order to share a hope for yourself as you ask yourself, "What is it to teach?"

WHAT I THINK I HAVE LEARNED

You stumbled upon constructivism while playing with the concept of inquiry in a social studies methods class and in a reading during a science education seminar. Constructivism brought a small measure of sense to days when you taught from the students' perspective, but they did not know the answer that the teacher guide promised you they would know upon completing

the investigation. Remember, you told them the answer, and you fumed when they would not memorize the answer for the “What did I learn?” section of investigation quizzes. You know, now, that they did write what they learned from the investigation.

You are trying to use constructivism as a way of knowing. Constructivism is a “philosophical explanation about the nature of knowledge” (Airasian & Walsh, 1997, p. 444) and not a method (Dunn, 1994) and claims that reality is more in the mind of the knower and the knower constructs a reality, or at least interprets it (Jonassen, 1991). Jaeger and Lauritzen (1992) propose tenets of a constructivist perspective to include:

1. learners come to school with a wealth of prior knowledge;
2. learners make meaning of their world by logically linking pieces of knowledge, communication, and experiences;
3. these belief systems are often incomplete explanations or misconceptions;
4. learners hold to their belief systems and are resistant to change;
5. direct instruction is unlikely to change belief systems;
6. learning takes place when confrontation with new experience yields dissonance;
7. a social context facilitates these processes; and
8. learning takes place best in a meaningful context.

From a constructivist perspective, you understand learning to be a social process of making sense of experience in terms of extant knowledge (Tobin, Tippins, & Gallard, 1994, p. 47).

You fell into sense-making as you wrestled with conceptual frameworks as focus for your dissertation research. Challenged by a professor with the question: “What does it look like? What does a conceptual framework look like?,” you needed to find a definition for conceptual framework. Finding it impossible at this time to define – conceptual frameworks, you were advised to seek the perception of student teachers; however, you attempted to hold onto seeking conceptual frameworks by using the word sense-making for perception. On one out of many dissertation proposal drafts, you inserted sense-making, which was crossed out by an editor and replaced with the suggestion of “concept.” Why did you persist with sense-making?

Sense-making is the process of individuals attaching meaning or interpretation to their experiences, examining the meaning or interpretation they

give to their experiences and considering how these meanings and interpretations influence the way in which they carry out a task (Lee, 1991). What does sense-making look like? In light of or through assimilation and accommodation of cognitive structures, comprehension is seen as a process of sense-making. (Harste, Woodward, & Burke, 1984). Myths, metaphors, beliefs, images, and personal epistemologies are tangible exhibitions of sense-making (Tobin, 1993, p.19).

These forms move you closer to finding a “look” for a conceptual framework. You propose a definition for the term – conceptual framework: the connectedness of (Smith, 1991) or relationships among (Wandersee, Mintzes, & Novak, 1994) the pieces of knowledge, communication, and experience (Jaeger & Lauritzen, 1992) which are products of our first-hand experience, common sense, what we have been told by others, media, books, and instruction (Stepans, 1996). Sense-making might be the connectedness.

In order to play with the interaction of sense-making as connectedness, you sought to think in terms of Smith, Blakeslee, and Anderson’s (1993) proposal: “new concepts can be established by constructing or identifying frameworks for the new idea (or borrowing them from other contexts through the use of analogies and metaphors)” (p. 113). You attempted to present a definition of conceptual framework through the metaphor of a quilt and the analogist context of the anthropological concept of culture.

A quilt is more than the pieces of cloth and the thread. A quilt speaks with one connected voice, which is many voices speaking at once. There is a unity to a quilt and a connectedness which is more than the physical materials or the aesthetic properties of color, shape, balance and the like. There is something that holds the quilt together; something that connects the pieces. There is something that allows a piece to be added, removed, exchanged or “just be.” This something is the connectedness which is the framework of quilt.

As an interconnected entity, culture is an analogy for conceptual framework. “Culture is that complex whole which includes knowledge, belief, art, morals, law, customs and any other capabilities and habits acquired by man as a member of society” (Tyler, 1958). Culture is more than the sum of the parts in which people participate and practice. Keesing (1971) defines culture as “the organized system of knowledge whereby people structure their experience and perceptions, formulate acts and choose between alternatives” (p. 20). White (1985) continues:

Each culture is seen as a unique, self-contained system or systems that must be studied holistically. Specific behaviors and beliefs are studied in terms of how they interrelate and function within the context of the whole. Therefore, patterns of practices and beliefs are not studied as if they had meaning apart from the group of people who generate them (p. 53).

The metaphor of quilt and the analogy of culture in itself begins your sense-making of conceptual frameworks. Sense-making and conceptual frameworks are similar as they seek to connect, but is not sense-making the process by which you form your personal conceptual framework?

However, sense-making and conceptual frameworks are different. Glynn, Yeany, and Britton (1991) comment that personal conceptual frameworks may incorporate many misconceptions. Your discovered misconceptions are “naive conceptions (Smith, 1991) or models” (Perkins, 1991), alternative frameworks (Duit, 1991; Smith 1991) or incomplete explanations (Jaeger & Lauritzen, 1992). In other words, when you use the term “misconception,” are you saying that sense-making is absent or not being used?

An affirmative answer to the question is to say that knowledge is fixed. Truth lies somewhere out there and is to be discovered, or for the student, knowledge is embedded in the textbook or in the teacher, at best. These artifacts of knowledge are sacred (Eisner, 1985). At a minimum, misconceptions denote that the body of scientific knowledge can be agreed upon as being unchangeable. You hear in misconception “an authoritarian perception of science as the quest for truth and final-form statements about the world” (Duschl, 1994, p. 449).

You would like to argue that science is sense-making. Is there a need to go beyond sense-making to teach science?

ASSUMPTIONS

You note some assumptions which are part of science education:

- The goal of learning is to collect all the “Truths.”
- There exists a body of scientific facts or knowledge which are “truths,” to be taught, learned and evaluated.
- Constructed understandings connected within a conceptual framework are misconceptions; hence, misconceptions can be replaced by scientific Truths.

For you, these assumptions contradict the constructivist way of knowing as well as the nature of science as a way of knowing. To move beyond sense-making

into misconceptions, or to begin instruction from the point or philosophy of misconception or deficiency, is unnecessary and not helpful for the learning of science, or more importantly, for people to become scientists.

The American Association for the Advancement of Science (1989) outlines the basic beliefs and attitudes scientists have about the nature of the world:

- the world is understandable;
- scientific ideas are subject to change;
- scientific knowledge is durable; and
- science cannot provide complete answers to all questions.

You argue that sense-making encompasses all these tenets, whereas misconceptions do not. From a sense-making perspective, there is no such thing as a “misconception.” What you more forthrightly argue is that sense-making allows for science to be for all people. Sense-making, as the way of knowing, allows the learner

- to understand the world;
- to change their conceptual framework for understanding;
- to maintain a context within which to place their sense-making; and
- to utilize diverse processes for making sense.

These actions are necessary and significant for people to have a voice.

MISCONCEPTIONS

You have read that learners do not have access to science. You have prefaced a class with the statement that you know not all your students will become scientists, but there is value in knowing what is science. You believe that in order to know science you must be allowed a voice. A voice is an expression of your sense-making. Sense-making is more than naming the baby. Sense-making is knowing who the baby is.

Misconceptions or alternative concepts have denied many learners access to science. Both connote the existence of a concept. In order for a misconception to exist there must be a true concept. Likewise for alternative to exist, there must be a mainstream or generally accepted concept. You have seen students not inquire or play with their sense-making during discussion which followed intense playing with materials. You fear you, as the teacher, had trained them either to expect you not to respect their sense-making, and to give them the answer. You communicated that you knew the “true” concept or the generally accepted concept. As a teacher, you stood in front of the class with the teacher’s guide of the textbook as the embodiment of science. Even when you proceeded

to socratically have them produce the intended answer, they knew that you knew the answer. Their ability to learn, in this case to know the answer, was independent of them. The instruction may have been student-centered as they supplied the information, but the understanding and the knowing was within you.

In your constructivist epistemology, if you begin with misconceptions, will you ever not have misconceptions? In other words, are misconceptions turned into misconceptions albeit new or novel ones? The nature of science clearly dictates that you will always have misconceptions. When do misconceptions become understandings?

You look for a meaningful way of realigning, reorganizing, or replacing existing conceptions to accommodate new ideas, or conceptual change (Smith, Blakeslee, & Anderson, 1993). You establish conditions:

- the learner becomes dissatisfied with existing conceptions
- the new concept is intelligible
- the new concept is plausible
- the new concept has the potential to explain new phenomena (fruitfulness)

which none are sufficient, but all of which are necessary according to Posner, Strike, Hewson, and Gertzog (1982) and Hewson and Hewson (1984). You continue to argue that learners do not have the true conception or generally accepted conception. You believe the notion of misconception and alternative conception denote a deficient model, or blaming learners for not knowing what they seek to know.

A VOICE

You believe sense-making gives voices to learners. In a collaborative community where learners have opportunities to originate, negotiate, and revise their ideas, Harste, Woodward, and Burke (1984) state voice is developed. In this atmosphere, voice allows decision making because learners have the opportunity to use their sense-making. Sense-making is not final (Burke & Short, 1997). Sense-making invites the voice to be spoken. Learners needs to be invited to express their sense of the world first in their own language before being given the terminology of science or mathematics (Whitin & Whitin, 1997b). How do you allow learners to constantly revise mental models about how things work and connect what goes on in class to other aspects of their lives (Stepans, 1996, p. 6)?

You have played with a definition of inquiry instruction. Inquiry learning is based upon the assumption that all learners are sense-makers. You have assigned the quality of open-endedness to inquiry. Inquiry is without predetermined outcomes. This is the difference between “discovery learning” and inquiry (Harste, 1993). Hand and Peterson (1995) describe an approach where students initially define their understandings of the topic, explore conceptual conflicts being presented to them, construct new or broadened understandings and use the new knowledge. You liken this to inquiry instruction. You see this as sense-making. You do not see misconceptions. Gallas (1994) remarks

John and other children have made me consider that the object of teaching sciences is not to teach the correct usage and application of scientific concepts and terminology, but rather to engage as many children as possible in observing, experimenting, talking, and writing about the world (p. 98).

The learner learns through argument, discussion and debate (Cunningham, 1991).

You believe learners make rich sense of the world by enjoying the experience of creating answers to new and puzzling questions like scientists and artists (Eisner, 1985, p. 27). It is out of the conversation that you see learners creating knowledge. You see learners seeking knowledge, concepts and beliefs which are “the product of our first-hand experiences, common sense, what we have been told by others, media, books and instruction” (Stepans, 1996). For you, inquiry allows for sense-making and the implied diversity of questions and answers. “We don’t inquire to eliminate alternatives, but to find more functional understandings, create diversity, and broaden our thinking” (Short & Burke, 1996, p. 101).

The diversity of questions and answers is what allows you to feel comfortable with less direction in curriculum and content. Sense-making denoted intra- and interdisciplinary curriculum and content. Whitin and Whitin (1997a; 1997b) supplants a language arts epistemology and pedagogy upon mathematics to demonstrate the breadth and depth of mathematical knowledge acquired by learners through inquiry. Gallas (1994) shows a “talk, walk, write, dance, draw, and sing” methodology to develop an understanding of the world across traditional disciplines. These are not an exhaustive list of curricula and content that demonstrate the exposing of sense-making as an learning objective. These are authors who told you that voice was necessary for learning. In quiet,

they told you that when students missed questions on your investigation quizzes, they were giving their voices that you so much valued during the procedure of your instructional plan, but did not know how to assess.

SUMMARY

You have restrained yourself from making the simple statement that misconception denoted deficiency within learners, and sense-making is affirmation of both learners as a people and learners as learners. In sense-making individuals are seen in terms of their potentials, not in terms of their limitations (Burke & Short, 1997). Mills, O'Keefe, and Whitin (1996) propose in the fields of reading, writing and mathematics, children are viewed as sense-makers, not mistake-makers. Can you construct sense-making as a foundation upon which to build learning?

For the science and/or mathematics educator, the question implies two assumptions:

- Sense-making does not limit learning to learning in school.
- Teachers are sense-makers.

These implications are based upon your notions that learners begin their learning outside school and continue to do most of their learning outside school. Also, a powerful means of learning is through demonstration. One of the periods of most intense learning occurs before learners enter school (Pipher, 1996; Swick, 1993). You remember the hand of an infant reaching into your mouth to feel how you made sounds.

Sense-making does not limit learning to learning in school

You remember driving out of the school gates with fear that you had not taught. You comforted yourself with the fact that the students learned. They did not necessarily learn what you taught. Students do make sense of their world. You, as a teacher, can influence the sense-making; however, you cannot learn for students. What sense do students make?

Rather than impose your way of making sense, you allowed the learner to have voice. You have experienced students making sense regardless of your intent. You, yourself, have made sense of the physical world, which is different than the world you created for tests and examinations in science classes, and you expected students to learn in your science classes. How did you make sense of the world?

You make sense of the world by interaction with the world; however, you believe that the world does not live within textbooks. The world lives within

your community and its rituals and artifacts. Science education is learning about the world.

You do believe that there is a need to know the sense-making of others concerning the world. Sense-makers gather the sense-making of others. This to helps sense-making; however, the sense-making of others most likely will not facilitate your sense-making (Gallas, 1994; Whitin & Whitin, 1997). In constructivist terms, learners hold onto their conceptual framework even when they have been instructed and have articulated an alternative conception (Pyramid Film & Video, 1988). You believe that everyone is a sense-maker and schooling needs to allow sense-making. Furthermore, within the definition of disciplines as constructed by educational institutions, sense-making will cross every discipline (Gallas, 1994). You are not sure that misconceptions, alternative conceptions, and conceptions can make this claim as these are discipline-specific. Sense-making demands expertise in the content (sense-making) of each discipline and in reading, writing, and 'rithmetic.

Teachers are sense-makers

As reforms in educational epistemologies and pedagogues have focused on what learners see, how learners educe what they see, and how learners make use of what they see (Driscoll, 1994), teachers need a new identity. Many metaphors have been suggested for teachers (Goodlad, 1985). You suggest teacher as sense-maker which means what teachers are rather than what teachers do to others. Teacher as sense-maker suggests an identity, who a teacher is includes what a teacher does.

You have toyed with Stepan's (1996) Conceptual Change Model as a programmatic model for teacher education programs between and within the courses of the program. You want to shape a Sense-making Model for teacher education. What you hope to find powerful, within a Sense-making Model, is that teachers are sense-makers as well as the students. Teachers will demonstrate sense-making. With students, teachers will make sense of their world.

Teachers can no longer continue to limit themselves to experts or givers of commonly accepted sense-making. They need to share their personal sense-making. You propose that teachers need to model sense-making. This grows out of the joy you experienced when you completed your first computer based instruction. You were challenged to use the computer in your classroom by readings and people, but computers were not part of your learning. For many

years and many lessons, you did not integrate computers into your instruction to any degree. You limited yourself by the classic myth that you taught the way you were taught. What would have happened if you were taught with a computer? The myth would say that you would include computers in your teaching.

Likewise, what if teachers, especially teacher educators, shared and modeled sense-making not only in their classroom and publications, but in their coming together or homecomings? You suggest that teacher educators would understand themselves as sense-makers and how they can use sense-making as a means of educating. All learners will make sense. Teacher educators gather to make sense of educating. For the teacher educator, schools are the “real world,” but what you would like to say is that teacher educators are lucky because they need to make schools the “real world.” Sense-making would make schools different and become “real world.” Although you want to place qualifiers within the next statement, you will allow “eloquence of simplicity” to state: there can be success for all students.

Teacher as sense-maker denotes risk taking. Although it is very clear that students are risk takers when they have taken a class from you, their risk is much greater than the risk you have taken as a teacher. You mean to say that you cannot be responsible for the way they see, the way they educate what we see, and how they make use of what they see, or sense-making, but you are responsible for the experiences and interactions for their sense-making. To model that you are actively making sense of the same world they are in and that your interactions with students are currently adding to your own sense-making, will encourage sense-making by students (Whitin & Whitin, 1997a). However, Burke and Short (1997) warn, “as learners, we venture out into new territory but we always stay within sight of what we already know how to keep us oriented” (p. 7).

You have fear that tertiary students will not want to make sense in your class because they do not see sense-making as what occurs in classrooms; however, as you make sense of the content of a science or mathematics methods class in addition to making sense of how to teach tertiary students, students will take the risk of sense-making. You are reacting to fellow tertiary students who have complained about classes that seek sense-making as useless classes. These are students who do not see learning as understanding the world.

CLOSING

You set out to argue that learning and teaching begin with sense-making, rather than from misconceptions. Sense-making is an active and continuous process that is occurring in the classroom that teacher educators cannot ignore, but rather build upon. Sense-making also denotes that all people make sense of the world, and there is a commonly agreed upon understanding of the world which is constantly changing. Misconceptions and alternative conceptions do not connote this active and continuous process. They limit learning to the sense-making of a few, who are usually less than the majority.

Hence, this conference should be titled: *Constructing Understanding*. You try to imply through sense-making that people naturally make sense of their world; thus, schooling should build upon what learners do. You sought to ask teacher educators to see themselves as sense-makers.

The objective of your exploration is that science and mathematics education, in particular, not limit itself in what it knows, how it knows what it knows, and who can know. You attempted to ask science and mathematics teacher educators to open the possibilities of what to know and who can know. You hope to have defined sense-making within the nature of science as a way to understand the world where scientific ideas are subject to change, scientific knowledge is durable and science cannot provide complete answers to all questions. You might have begun your sense-making with: What the learners already know may well be the most important factor influencing learning (Ausubel, 1978).

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