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HOW TO ACQUIRE "THE HABIT OF CHANGING HABITS": THE MARRIAGE OF CHARLES PEIRCE'S SEMIOTIC PARADIGM AND CONCEPT MAPPING

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Abstract: This paper grapples with the problem of how to track a student's real progress in learning, which cannot be absolutely quantified at any given point as a result of a particular intervention. Here, only some results are presented for a long-term qualitative and quantitative classroom study, during which the method of concept mapping was applied and interpreted in light of the semiotic paradigm developed by Charles Sanders Peirce (1931–1958). Peirce's semiotic paradigm was thought to have sufficient rigour and flexibility to give new access to the multiplicity of processes at work in the classroom.
A natural learning environment was built over a four-year period in a Finnish primary school. The students, ranging in age from 9 to 12 years, were encouraged to use qualitative judgement (intuition, tacit knowledge) to give them greater intellectual access to the meanings of the concepts taught. The goal was to bring them to Vygotsky's stage of 'conceptual learning', and to evaluate the effectiveness of concept mapping as an 'advance organiser' used in conjunction with Peirce's semiotic paradigm.
This paper concentrates on the theory building of concept mapping. However, the four-year longitudinal study results (Kankkunen 1999; 2001) show that concept mapping provided a means for students to discover tentative meanings for the concepts taught. In parallel, Peirce's semiotic paradigm provided a pragmatic framework for tracking the process of 'updating meanings' (the habit of changing habits) which is intrinsic to learning. The marriage of Peircean theory and concept mapping is lasting.
Keywords: abductive reasoning, concept mapping, connection-making, establishing meaning, learning environment for understanding, longitudinal study, students as evaluators

1 Introduction

Concept mapping is an effective 'advance organiser' for learning in the classroom. One of its key strengths is how it helps the teacher track a student's conceptual development in relation to the curriculum. Another is how it keeps the teacher focused on the process of meaning-making. The goal is to bring the student to Vigotsky's (1962) stage of 'conceptual learning', whatever his or her intellectual ability level is. In reaching this goal, the founder of concept mapping, Joseph D. Novak (e.g. 1992) said 'less is more'. That is, it is better for the student to understand 'completely' a handful of important concepts than to misunderstand a hundred lesser ones. The central hypothesis of this article is that concept mapping – a consciously artificial and pragmatic method of visualising thinking – helps students to recognise the reasoning process and control it on the road to conceptual learning.

2 In Search of a Third Dimension

"In point of fact, human semiosis and education are one and the same thing; that is, if by semiosis we mean the lifelong building of structures of experience, then education is precisely that field which attempts to understand, nurture and make people more reflective about this process." (Cunningham, 1987, p. 197)

Michael Apple (1999) reminds us that there is no one-to-one correspondence between psychological theory and educational theory. I was left wondering if a theory could be found which could better handle the human complexity of the meaning-making process in the classroom. In other words, a third dimension was needed to illuminate the existing two dimensions: a concept's 'perceived regularity' and its meaning as 'propositions and concept labels in a semantic unit'. Novak himself has touched upon the need for this third dimension when referring to the student's *innate capacity* to sort out concepts. If such a third dimension could be found to provide a framework for understanding the 'connection-making of meaning-making', it would be very useful in evaluating students' individual learning for understanding in the social classroom context.

3 Peirce's Semiotic Paradigm: The Third Dimension

Charles Sanders Peirce (1931–1958) developed a semiotic paradigm which describes how people construct an understanding of reality. In the long-term project on which this paper is based, this semiotic paradigm provided the third dimension ('connection-making') that was lacking in the preliminary study. The theory of building meaning applied in this paper is based on Peirce's semiotic paradigm and pragmatic approach. Its use of abductive reasoning in relation to learning is also based on Peirce. Throughout his discourse on semiosis and

logic, Peirce emphasises the importance of the social community in constructing knowledge (i.e. social constructivism).

In the field of teaching and learning for understanding, Richard Prawat (1999, p. 72) has stated that the abductive approach deserves a chance in the classroom. In the research described in this paper, concept mapping provided an empirical approach to investigate how students use abductive reasoning – and other modes of reasoning as well – to establish meanings useful in their learning. On the whole, little research has been devoted to how to organise a real-time, longitudinal approach that examines 'meaning-making' in normal primary school learning environments.

4 The Study

The study described in this paper was preceded by a preliminary study conducted in Helsinki (Kankkunen, 1991). This three-year longitudinal study (1989-1991) attempted to investigate how primary school students (Grades 4–6) learned to use concept mapping and whether the method generated information useful in understanding the meaningful learning process. The goal of the study was to improve teaching and meaningful learning by taking into account the classroom experience after each learning project. According to Carr and Kemmis (1986), this kind of approach qualifies as action research when it is carried out by the teacher. The strategy of triangulation was used as an alternative to validation (Fielding & Fielding, 1986), by applying a combination of methods (essays and interviewing) to support the concept mapping. The design of the study as well as its adoption of Ausubelian theory followed the ideas presented by Novak and Gowin (1984).

Although the results of the preliminary study were promising, it was deemed necessary to replicate it: it was evident that the process of establishing meaning was much more complex and versatile than described in Ausubel's theory, especially when the social classroom work was taken into account. The preliminary research therefore served as a 'pilot case study' (Yin, 1989) for the research presented here.

The four-year longitudinal study presented here was conducted in Lappeenranta, Finland (1993–1996). The study incorporated both analytical (concept mapping) and synthetic (verbal utterances) methods in the evaluation of building a learning environment for understanding.

The action research was divided into two sections:

1. The theory concentrates on concept mapping and the process of establishing meaning.
2. As a methodological experiment, the study attempts to discover in practice whether the learning environment constructed helped students to focus on the knowledge (concepts) taught in curriculum-based learning.

However, this paper concentrates on the theory-building behind concept mapping. The general objective of my research projects was to use concept mapping as a constructivistic and qualitative method for applying and elaborating meaning-making theory in the classroom.

The basic principle in the empirical study was that evaluation of learning must concentrate on measuring what students actually know, not on what they do not know. Also, the students were fully authorised evaluators of their own learning results. From this perspective, the research reported here also deals with how concept mapping aids students' self-assessment so as to encourage a positive attitude towards learning.

5 Peircean Approach to Constructing Meaning

This paper seeks to increase our comprehension of a student's conceptual learning and the world of meaning by taking into account the views of the founder of pragmatism, C. Peirce (1931–1958):

> "To learn is to acquire a habit. What makes men learn? Not merely the sight of what they are accustomed to, but perpetual new experiences which throw them into a habit of tossing aside old ideas and forming new ones." (Peirce, 1976, p. 142)

Peirce emphasises that habit alone cannot produce development: "It is catastrophe, accident, reaction which brings habit into an active condition and creates *a habit of changing habits"* (Peirce, 1976, p. 142; the italics are the writer's emphasis). Peirce reminds us that "every man exercises more or less control over himself by means of modifying his own habits" (Peirce, 1931–1958, 5.487, pp. 334–335). If a person is ready to acquire the 'habit

of changing habits', it means that the person is willing to change his or her opinion. The following discussion attempts to elucidate the Peircean semiotic paradigm.

Peirce developed a semiotic paradigm that helps us understand how signs (such as words) acquire their meanings (become concepts) and also how those meanings are subsequently 'updated'. The process of acquiring meaning starts with intuition. In addition to verbal utterances, also non-verbal signs and metaphorical processes must be taken into account in 'meaning-making'. Concept mapping serves as a tool for logical and analytical learning as reproduction. The rest of the methods – the accounting interviews, group interviews, written essays and questionnaires – tend to reflect a verbal (or synthesising) attitude to learning (detailed presentation in Kankkunen, 2001, pp. 287-324). Peirce's paradigm allows investigators to take into account both semiotic and semantic aspects in learning. That is why it also helps investigators to understand the complexity in students' 'connection-making of meaning-making'. The following discussion attempts to clarify how this process works in connection with meaning-making and how Figure 1 can be of help *for a teacher* in understanding Peirce's semiotic paradigm.

In his 'method of thinking', Peirce draws an analogy between semiotics and logic which is based on the observation that all thought is represented by signs. In practice, therefore, it is impossible to separate phenomenal and logical elements from Peirce's semiotic paradigm. The Peircean semiotic paradigm is organised around three elements: 'firstness', 'secondness', and 'thirdness':

1. Firstness ('Idea'): "First is predominant in the ideas of freshness, life, freedom ... stop to think of it, and it has flown!"
2. Secondness ('Brute Actuality'): "The second category of elements of phenomena comprises the actual facts."
3. Thirdness ('Sign's Soul'): "By the third, I mean the medium or connecting bond between the absolute first and last" (Peirce, 1931–1958, 1.302–358, pp. 148–185).

The idea of 'firstness' (involving abduction or hypothesis) brings in the student's qualitative ideas and 'beliefs'. According to Peirce, "cognition arises by a process of beginning, as any other change comes to pass" (Peirce, 1931–1958, 5.263, p. 155). The idea of 'secondness' (object, referent equals induction) brings in the world of verbal and non-verbal signs that the student has already assimilated through experience, and without which effective learning and thinking cannot take place. It brings in the world of personal, chaotic experience and uses 'facts' in verifying tentative hypotheses.

In my research projects, students were encouraged to include their 'beliefs' and 'facts' in their concept maps. The idea of 'thirdness' ('updated' meaning or interpretant equals deduction) is an attempt to describe how meaning is elevated to the level of generality and how the human mind, step by step, moves through a reasoning process. The idea of 'thirdness' gives tools (meaningful concepts) for assessing the qualities that bind 'firstness' to 'secondness'. This is not to say that 'updated' meanings are perfect and immutable. On the contrary, they are pragmatic in the strict Peircean sense – useful until no longer useful. In this connection, one should also remember the importance of the 'interpretant', which is not an interpreter but a social convention or habit which indicates a social constructivist paradigm when seeking a shared meaning or concordance in some particular situation. Concept mapping can be deductive by nature, but the students' own ideas, 'beliefs' and 'facts' are essential in the making of connections.

Practically speaking, I agree with those educators who believe that it is an artificial exercise to separate the reasoning process and the learning process. However, Peirce reminds us that 'sound' reasoning is not the only tool of pragmatism. 'Bad' reasoning can start from true premises and lead to a false conclusion which can nevertheless be used successfully in real life.

Peirce emphasises that reasoning must be a conscious (deliberate, voluntary, critical, controlled) act. This is not to say that we must be aware of the whole process of the mind in reasoning – this is impossible. Peirce implies that phenomena are simply appearances. "All that we can find out by directly watching consciousness are the qualities of feeling, and those, not as they are felt, but as, after being felt, they are grouped" (Peirce, 1931–1958, 2.184, p. 108). The reasoning process starts with abduction, and any advance made in learning brings in abductive processes as a matter of course.

Abductive reasoning (intuition) involves the making of assumptions. It is the first step in understanding the phenomenon of being observed ('firstness'). From the beginning, Peircean abduction is the process of carrying meaning. However, good abduction seeks to explain the facts via hypothesis. Abduction and induction therefore work together in the construction and verification of assumptions in light of personal experience. The 'logic machine' is in a state of constant readiness to 'update' a meaning when it is no longer useful.

Abduction [Aristotle's 'retroduction'; the explanation of the concept's etymology in Peirce 1931–1958, 1.65–1.68, pp. 28–29] is closely related to the metaphoric process (Prawat, 1999). William Whewell (1860, p. 21) underlined Aristotle's contribution to understanding the growth of knowledge: "Sagacity is a hitting by guess"; and "Intuition must be the beginning of Science". The best way to learn and understand the meanings of new concepts is to master the use of metaphor (Aristotle, 1954, The Rhetoric III, Ch. 10–11; see also Ricoeur, 1991, pp. 9–43). Metaphor acts as a mediator between the three Peircean elements, 'thirdness of firstness', in trying to clarify 'secondness' (object).

Peircean 'pragmatism' concentrates explicitly on the study of meaning. As a thinking method, concept mapping shares the same concentration. Learning and thinking skills usually improve gradually, interspersed by 'leaps of intuition'. In the classroom, concept mapping can help to show how reasoning, thinking and learning are developing and changing. It is a practical tool for tracking abductive processes. Peirce says that every sign represents a process of change. In itself, therefore, the concept map is an 'updated' network of signs representing the student's thinking and learning process. These signs are the basic signs of Peircean semiotics (icon, index, symbol), which exist to clarify the meanings of concepts.

The central hypothesis of this paper is that concept mapping helps students to recognise the reasoning process and learn to control it.

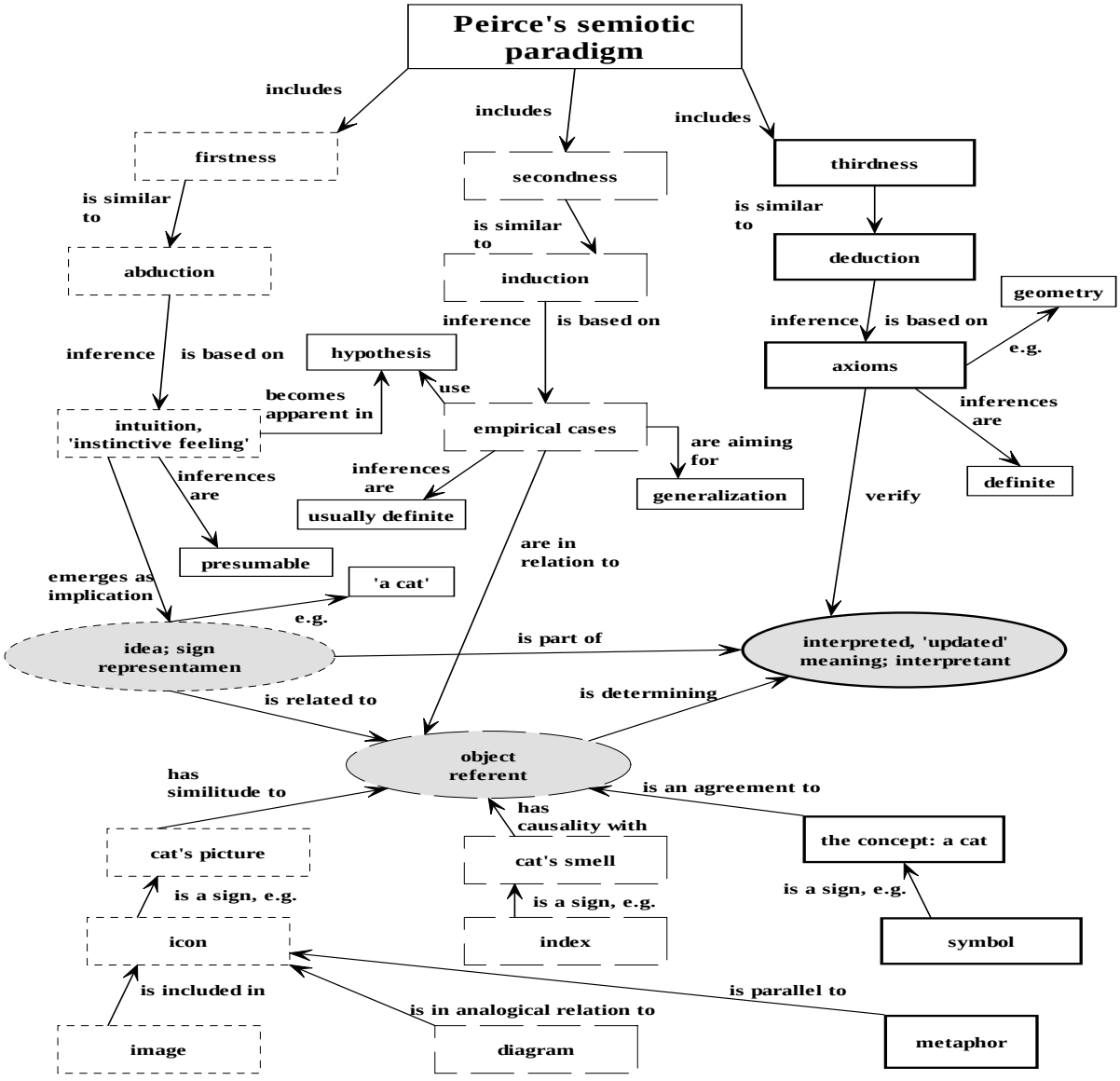

Figure 1. A concept map of the essential elements of Peircean triadism

6 Research Questions

The study sought to answer the following basic research questions:

- Does concept mapping illuminate the learning process? Does concept mapping help the teacher understand students' thinking patterns?
- Are the qualitative materials (concept maps + a combination of other methods) and quantitative criteria of the concept maps adequate for building an accurate assessment of the meaningful learning environment?
- When is the most appropriate time to start using concept mapping as a tool for meaningful learning?
- Does concept mapping help the student to comprehend the meanings of the concepts being taught?
- Is the Peircean semiotic paradigm useful in interpreting the learning process and concept mapping results?
- What do students think about concept mapping after four years of use? Do they think that it is a useful tool for learning?

7 Some Results: Attitudes Towards Concept Mapping After Four Years of Use

On the last school day of primary school, student attitudes towards concept mapping were gathered through inquiry (questionnaires) and account sessions (interviews). Such last-minute data gathering was necessary: the students knew with certainty that their opinions could not influence their academic reports, and thus their response was as honest and direct as possible. Moreover, the validity of the questionnaire in assessing students' views has the backing of Harré and Secord (1972): "Why don't we ask them?"

The classifications used in the questionnaire were word-by-word excerpts from the research diary, voiced by different students during account sessions. All the students (N = 23) participated in the debriefing and their views are presented in Table 1. After using concept mapping for four years, it was important to take every student's opinion into account because substantial bias can be expected in this kind of sampling (Patton, 1990). Table 2 provides a summary of their free-form opinions.

TABLE 1: Student Attitudes Towards Concept Mapping (N = 23)

Classifications and opinions about concept mapping	Response frequencies				
	SA	A	N	D	SD
1. Concept maps have been of help to me in my studies.	15	7	1	0	0
2. Concept maps require a lot of work.	5	7	7	2	2
3. Concept maps help me organise my learning.	15	6	1	1	0
4. Concept maps are of help when reviewing large areas of study.	14	4	4	1	0
5. The concept map clearly shows what I have learned.	8	7	4	1	0
6. While concept mapping, I must analyse what I am learning more carefully than when learning in the traditional way.	11	7	5	0	0
7. Constructing a map makes it easier to find the essential information in a text.	13	5	3	2	0
8. In the beginning, constructing a map seemed to be a lot of work but, since learning the technique, there have been no problems using them.	9	11	1	2	0
9. I would like to use workbooks instead of concept mapping.	1	1	1	6	14
10. With the help of a concept map, I can better show all of what I have learned compared to ordinary workbook exercises.	11	7	5	0	0
11. The network of links (arrows) between concepts and thoughts teaches me to get an overall view of a topic.	9	8	5	1	0
12. When I think in terms of a concept map, I remember the things I am studying better than after reading about them in an ordinary way.	10	5	5	2	1
13. Concept mapping sometimes helps me to figure out the meaning of a difficult word (e.g. ecology).	7	9	5	2	0
14. There is no sense in using concept maps as frames for essays and writings.	0	0	1	8	14
15. Concept mapping is fun.	10	7	3	2	1

SA: Strongly Agree; A: Agree; N: No Opinion; D: Disagree; SD: Strongly Disagree.

TABLE 2. Students' Free-Form Characterisations Concerning Concept Mapping After Using Concept Maps for Four Years

Favourableness of comments	Short statements
Favourable comments (n = 17)	When your thoughts are in order you can infer what the concepts mean. (n = 5) Mapping connects the concepts to their context. (n = 4) Maps help me to take into account the essential knowledge. (n = 4) Mapping polishes my thoughts and helps me to organise them. (n = 2) I do like the freedom of mapping. It gives space to my own thinking. (n = 2).
Neutral comments (n = 4)	The network of concepts does help, but sometimes you just have to guess. (n = 2) It is good that you have to think so carefully, although it is not always fun. (n = 2)
Unfavourable comments (n = 2)	Perhaps maps are of help in learning, but they require far too much work. (n = 2)

8 Discussion: Answering the Research Questions – Results and Interpretation (Kankkunen 2001)

Concept mapping as a learning tool for understanding allows the teacher and student to build a communication structure around the central concepts of the subject being taught. Students' concept maps are 'snapshots' tied to a moment in time. They show that the teacher can accurately track students' individual learning patterns and their learning progress through the continuum of the curriculum. Students stressed that concept mapping is a method that helps them to find the essential information and also helps them to organise their thoughts .

It must be stressed that assessment of the concept maps should take place in the normal classroom context. Concept mapping is qualitative by nature, and assessment focuses on the structure as a whole: What does a student's learning 'look like'? In practice, this will be sufficient for most teachers in the classroom. When a more detailed assessment is required, a combination of other methods including quantitative assessment can be used.

Both qualitative and quantitative evaluations are needed to build an accurate assessment of meaningful learning environments. The criteria used in this study gave a detailed picture of how students developed in their concept mapping tasks. The results show that the 'better' concept maps included many 'central concepts' and 'valid propositions'. These are the essential quantitative criteria in assessing the quality of 'the connection-making of meaning-making'. These 'better' concept maps work like 'close-up snapshots', cutting out extraneous background information to focus on the central concept(s) of the topic.

The results show that the transition to conceptual learning, marked initially by a deeper understanding of 'connection-making', usually occurs in the fifth grade at the age of 10 or 11. However, the individual differences are huge. The transition can be seen particularly clearly in the greater number of 'valid propositions' and in the quality of 'central concepts' through the comprehensive assessment of concept maps and accounts. This finding is similar to the results of the preliminary study.

In the final account sessions, 22 of 23 students described Novak's 'less is more' philosophy using a variety of their own words. In assessing themselves, they concentrated on key concepts which they understood and left out the concepts they did not understand. The evidence in the accounts and questionnaire shows that concept mapping helped the students find the essential knowledge in their learning.

When the student's learning process is put through Peirce's semiotic paradigm applied to concept mapping, the teacher can reach a more complete understanding of how concepts are taught and learned. In interpreting the concept maps, Peirce's semiotic paradigm was instrumental in illuminating the 'connection-making of meaning-making'. The results show many parallels between concept mapping and the Peircean semiotic paradigm,

including how abductive reasoning works as a carrier of meaning. Moreover, concept mapping serves as an aid to abductive reasoning (a tool to help students to acquire 'the habit of changing habits') because it allows for continuous concept updating and gives the student access to the verbal and non-verbal signs needed to build new and meaningful connections.

Concept mapping as a method and discipline helps students to gain control over their reasoning by allowing them to visualise it. For the teacher, applying Peirce's semiotic paradigm (Figure 1) in interpreting concept maps helps in following the student's conceptual development. It provides a detailed model of how the reasoning faculties develop, step by step, in relation to the connecting-making (meaning-making) process. The results of my study show that the students' development in meaning-making clearly lay within the framework of Peirce's semiotic paradigm. Concept mapping clearly promoted the conscious use and refinement of reasoning during the learning process.

After having used the method for four years, most of the students found concept mapping to be demanding (Table I) and very useful for their studies: 15 of 23 'strongly agreed' that concept maps had been helpful.

8.1 Implications

Conceptual learning is the intermediate goal of the learning process, which cannot be reached unless the student consciously understands how the concepts being taught are connected. The results of this study support Vigotsky's assumption that learning precedes development, and show that concept mapping is a powerful 'advance organiser' (Ausubel) on the road to conceptual learning. Concept mapping allows students to apply more of their intellectual abilities in making reasoned assumptions by helping them to identify and visualise the complexity of the thinking process.

Concept mapping provides a means for teachers to study their own professional development within the 'less is more' philosophy. Over the long-term, the teacher can follow students' development at suitable intervals, time allowing. Concept mapping is also flexible enough to be used in conjunction with other tools that promote learning: we have developed with my colleague, BA Jyrki Ylärakkola, a concept mapping multimedia software (Konsepti) in order to promote the network learning (Ylärakkola & Kankkunen 2002).

During this study, students were attracted to concept mapping in part because the method does not (or should not) enforce a 'right and wrong' learning dichotomy. Mistakes are allowed because they are essential to the learning process – too great a reliance on quantitative testing and scoring can inhibit the 'liberality' of concept mapping. The moments in learning when concepts are 'updated' can be caught by the free-style concept mapping 'snapshots' and the free-form accounts ('photograph explanations'). This process works naturally within the Peircean semiotic paradigm and the abductive reasoning dimension: the natural rhythm of learning is rarely linear, being more a matter of 'one step forward and two steps back'.

The empirical foundation of Peirce's semiotic paradigm makes it a suitable theoretical framework for use with concept mapping in clarifying concepts and tracing meaning-making and connection-making in learning. Students are encouraged to take past experience into account in 'updating' to more precise meanings for their concepts, just as Peirce described. His social constructivism emphasises the intuitive aspects of the meaning-making process, in practical opposition to the followers of 'radical constructivism' often cited by Novak.

How exactly can Peircean theory help the teacher to interpret concept maps and other data? The answer depends a lot on the evaluator. Gary Shank (1987, p. 289) has pointed out that "using abduction and semiotics in educational research is like learning to read another language. You do not have to give up your native tongue to read another language, but it will never look the same again. Likewise, when you adopt abductive strategies in research, you don't have to abandon empirical testing, but empirical testing will also never look the same again." This is very true of how Peircean theory can be applied to interpret empirical concept mapping 'snapshots', and of how it can help the teacher to 'read' students' thoughts more accurately than before.

Moreover, the accounting method of interviewing and the group discussions give students 'another chance' to clarify their thoughts verbally. When focusing on the semiotic side of meaning-making in the classroom, Jay Lemke (e.g. 1987) has emphasised the need to look beyond the immediate communication context to the myriad influences of social systems. The logically organised structure of Peircean theory is very useful in organising and understanding the great number and complexity of social semiotic interpretations that exist in the classroom. Learning involves the interaction of a universe of signs, objects, and interpretants while our concepts move closer and closer to their 'final' interpretants. Nathan Houser (1987, p. 273) talked about the Peircean semiotic theory of learning and invited investigators to develop it further. In this study, Peircean theory could be brought

to bear in clarifying the interpretations of concept maps throughout the duration of the action research – at any point. Without this total applicability, would it even be possible for a teacher to focus systematically and consciously on his or her teaching of the 'connection-making of meaning-making'?

The signs in the concept mapping 'snapshots' created during this study are evidence of the method's suitability for promoting 'good reasoning' in the learning environment. In Peircean logic, the reasoning process moves from 'true premises' to 'valid conclusions'. In concept mapping 'snapshots', this is seen in the movement from 'valid propositions' to useful 'updated meanings'. In this study, the 'most advanced' group and the 'least advanced' group showed development in logical thinking. This is seen in the quality of their concept maps and, quantitatively speaking, a number of misconceptions and unconnected concepts no longer appeared in the later examples. In Peircean terms, their connection-making abilities were seen to improve across the board.

The question remains: What part of this improvement is attributable to concept mapping in isolation, and what part is attributable to all the other dynamics of the learning environment constructed during the study? A Peircean pragmatist would answer that, because the arrangement produced 'good' results, concept mapping was a pragmatic tool that clearly promoted learning for understanding.

Another question then arises: Were the results 'good'? To answer that question, the voices of the students themselves should be listened to because they are, perhaps, the best evaluators of their own learning. The students in this study had used a wide variety of different learning methods in their schooling, and found concept mapping to be very useful in learning for understanding. To build better meaningful learning environments, teachers should be more interested in students' attitudes towards the practicality of school learning – whether it makes sense to them. Methods such as concept mapping can help to encourage useful discourse on this subject.

Although A.N. Whitehead (1929) was perhaps the first, many scholars have confronted the paradox that school learning often has little to give to the student in 'real life'. School should be a place where diverse areas of knowledge are organised in meaningful forms, regardless of where the knowledge comes from. For students, school can be a place of knowledge integration – where they can display all the knowledge and information they possess, whatever the source. Concept mapping provides a means for doing just that in a naturally-structured way.

Teachers seeking to help learners to understand more cannot be too selective in the natural learning context. Many manifestations of thinking should be taken into account, to make learning an overt phenomenon in which both individual and social learning occurs. This requires the teacher as practitioner continuously to search for methods – and new combinations of methods – that give the student 'room to think'. They must adapt and elaborate theories so as to monitor meaningful learning more accurately. In this sense, educational research can 'step inside' the classroom more, to study what is happening over the long-term in the natural learning environment. The Peircean semiotic paradigm provides a good basis for such work in future concept mapping studies. Concept mapping and Peircean theory can meet in the classroom for the benefit of students and their meaningful learning.

Learning rarely becomes learning for understanding with mere repetition, although repetition certainly has its place. Throughout his writings, Peirce warns us of the dangers of routine and repetition, and emphasises the importance of 'something stopping us doing the usual' – that is, we should search for something that makes us acquire 'a habit of changing habits'. In visualising the knowledge structure as an explicit tool, concept mapping can be a method that encourages the student to acquire 'a habit of changing habits'.

Learning how to learn is to some degree an innate talent. However, it is also a skill that can be nurtured and developed. In promoting this goal, a school succeeds when students feel that school learning makes sense. This positive attitude towards learning will grow if the student's voice is listened to. Usually, this motivates them to take responsibility for their own learning. The student self-assessments in this study show that students are capable of evaluating themselves and their abilities in a mature way given the chance. Concept mapping allowed them to evaluate their own progress in parallel with normal quantitative evaluations, without being put in the spotlight in the classroom. Students can be allowed to decide the pace of this process; once they have bought into it, their self-motivation can spur their progress in learning.

After using concept mapping for four years, the students in my study were very positive about concept mapping and had become skilled practitioners of the method. As their learning progresses through Vigotsky's stage of conceptual learning and into adulthood, the discipline of honest self-assessment nurtured by concept mapping can become a 'good habit' that can sustain a lifelong desire for learning.

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