Teaching Culturally and Linguistically Diverse International Students in Open and/or Online Learning Environments: A Research Symposium

Bridging the Gap between Conceptual Change Research and Bilingualism

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Abstract

Strike & Posner (1992) identified a flawed assumption, held by themselves, when conceptualizing conceptual change, namely, assuming that learners have well-articulated conceptions, or misconceptions, about most topics, which is unrealistic. Unfortunately, many current investigations on the same topic heavily rely on students' verbal expression and are still subject to such criticism. One way to address the expressed concern is to examine the theoretical and methodological cracks from a new angle. Given the reality of Ontarian science classrooms accommodating culturally and linguistically diverse students, this study proposes to extend Zhou's (2012) cultural perspective of conceptual change to bridge conceptual change and bilingualism. From this perspective, international students in Ontarian science classrooms are seen as language learners, and conceptual change as a bilingual class of such students, gathered to solve a common problem using a common dynamic source code. The bilingual metaphor of conceptual change in science education is relevant to teaching linguistically and culturally diverse international students. To date, a comprehensive theoretical framework of such conceptual change is still out of reach. In this study, a dynamic system approach, based on conceptual change, in time, is sketched for more inclusive science education and promoting a further extension of the multicultural perspective of conceptual change.

Keywords: conceptual change theories, bilingual students, science education, human reaction time, dynamical system

Introduction

Living in a bilingual society, many Canadians are familiar with bilingualism, which refers to speaking or writing in two languages. For Ontarians living in the city of Windsor, bilingualism also means their children may have to obtain a second language credit so that they can graduate from high schools. However, in the field of science education, conceptual change is separated from bilingualism. The separation makes it even harder for international students to achieve learning progress, particularly when they are delivered online. A critical literature review and analysis has identified two types of cracks: theoretical and methodological. What are the cracks? How can researchers contribute to bridging the gap? These questions are central to this study.

Two cracks that separate conceptual change and bilingualism will be introduced. Next, two revisionist views of conceptual change will be examined. Finally, the abstract will be brought to a close by suggesting bridging the gap in time.

Literature Review

First, a theoretical crack between conceptual change and bilingualism can be identified from the definition of conceptual change in science education. According to Davis, conceptual change in science education refers to an ideal learning process"…that changes an existing conception (i.e., belief, idea, or way of thinking)….This shift, or restructuring of existing knowledge and beliefs, is what distinguishes conceptual change from other types of learning" (2001). In this sense, merely memorizing new facts or learning a new skill is not conceptual change. Instead, the definition reminds second-language learners of something bitter, such as memorizing the spelling of a new word, or learning, by heart, a whole passage for dictation.

Thus, conceptual change and bilingualism seem to point into two opposite directions at the theoretical level. The former represents an ideal teaching and learning approach aimed at understanding, whereas the latter is for daily uses, and no more. To be more specific, imagine how to achieve a conceptual change effect in a lecture introducing Albert Einstein's Special Relativity theory. Some would argue that it is irrelevant for a learner to explain the notion of spacetime, with a native or a second language, if he or she understands the theoretical construct, the mathematics, and the connections.

Similarly, the crack can also be found when American scholars Posner (1982) and his colleagues put forward their original conceptual change teaching approach in the early 1980s. At that time, they recommended greeting a class of science students with a conceptual conflict, such as time dilution for shaking the students' pre-instructional conceptual ecology. Next, substantial time should be spent on diagnosing students' errors regarding the discrepancies between their current conception and Einstein's theories. Then, the teachers should address possible student responses to prepare them to accommodate the new concept. Again, it does not matter whether students express their understanding in their first or a second language.

Another type of crack can also be found in measuring the change. Commonly, in the 1980s and 1990s, the researchers adopted qualitative research methods, such as observing the class or conducting an interview. After analyzing the collected verbal responses, researchers would extract helpful information for explaining what they had observed. To some extent, early conceptual change studies have relied on various verbal responses (Posner et al., 1982; Zhou et al., 2008; Moore & Dawson, 2015). Implicitly, they assumed a necessary precondition of clear verbal expression, which often implied typical white male science students in elite universities.

For other students with a diverse cultural and language backgrounds, reporting such reflective re-examination of an intense conceptual learning experience may not always available.

In brief, two types of cracks separate conceptual change from authentic bilingual learning experiences and keep them independent from each other. However, in the 1990s, a revisionist view of conceptual change emerged in the literature (Strike & Posner, 1992). Two of the founding theorists, themselves, expressed their concerns over their own theoretical initiatives. In their own words:

> "Critique of the (initial) theory
> A. The theory was based on the assumption that learners have well-articulated conceptions or misconceptions about most topics.
> B. The theory was too linear.
> C. The theory was overly rational" (p.147).

This author's reading of the first comment led him to believe that some not-so-well-articulated information is also important and worth further exploration. Likewise, this reflection on the second guides the imagination to the possibility of introducing non-linear cognitive processes to conceptual change. Also, from this reading, it is known that the third comment has inspired other scholars to propose a new, warm approach to conceptual change research (Pintrich et al., 1993), but the last two are not the focus of this session.

In addition to the reflections, a connection that might help bridge the gap has appeared in the literature. The updated view of conceptual change sees science students as unique knowledge seekers. Their learning of western science contradicts what their first-language environment has offered and reinforced in their minds. For example, Zhou (2012) adopted a postcolonial framework to deconstruct the past literature of conceptual change. He argued for a new socio-cultural revaluation with the goal of modern science education. According to this view,

> Cultural studies of science education over the last decades have drawn our attention to many issues such as integration of Indigenous knowledges, inclusion of different worldviews, and school education as cultural transmission. Such postcolonial thinking questions the legitimacy and effectiveness of the colonial process behind the term of conceptual change and advocates a coexistence between the life-world based ideas and Western [sic] science-based concepts. In other words, the cultural perspective to conceptual change suggests a rethinking of the goal of science education. (p.124)

Inspired by the possibility of bridging the gap, this author discovered a long history of measuring not-so-well-expressed information in history. Moreover, a small set of current conceptual change studies features a "new" research method, which I call Conceptual Change in Time (Babai, Levyadun, et al., 2006; Potvin, Masson, et al., 2015).

Methods

Several academic databases were further searched for a conceptual-change-in-time studies. The search keywords included 7 terms: conceptual change, priming, reaction time, misconception, conceptual ecology, knowledge structure coherence, and science education. These keywords, and their combinations, were submitted to the databases like Web of Science, JSTOR, ERIC, PsychINFO, ProQuest Dissertations & Theses, and Google Scholar. In addition, the reference lists of the returned results have been further scanned for more valuable links.

Results

On measuring not-so-well-articulated information, the history of science has recorded a long history of measuring psychological activities. For example, in the early 1820s, astronomers were among the first researchers who noticed this human-reaction time difference. Bessel formulated the personal equation in 1823, but his voice went unnoticed.

The ignorance remained the same, until the German physicist and physiologist, Hermann von Helmholtz (1850/1853), came onto the scene. He first measured the propagation speed of neural signal transmission. He revealed a finite nerve conduction velocity roughly from 25.0 to 42.9 meters per second (Jensen, 2006; the rate varies from 0.5 to 90 m/s as we now estimate). This fact means that what we see or hear is slightly delayed, relative to the presence of external stimuli; in Boring's (1950) words, the duration "brought the soul to time." The fact, and the ripples it had generated, opened a golden age of reaction time-based research in history.

Afterwards, researchers of the nineteenth and twentieth centuries saw the ups and downs of such an endeavour, stretching from a Golden Age (1850 -1900 A.D.) to a Dark Age (1900 – 1950 A. D.) and its Renaissance (1950 A.D. to present) (Meyer et al., 1988). When cognitive psychology gradually came to the front stage in the 1970s, their renewed influences can also be felt beyond psychological research.

Besides these historical records, the contemporary literature of conceptual change in science education has also documented a small conceptual change study following such a research tradition. Commonly, these studies were designed to measure conceptual change without relying on the precondition of a clear verbal expression of students' own learning experiences. In this aspect, conceptual change in time fits the bill for making not-so-well-articulated information measurable.

Table 1

Reaction Time (RT) in Conceptual Change (2006-2019)

Article	School Subject	Focused Concept	Paradigm	DVs	Participants
Babai et al., 2006	Mathematics	The perimeter of a shape	Comparison	RT & Accuracy	68 Students (G11)
Babai et al., 2006	Probability	Drawing likelihood	Comparison	RT & Accuracy	22 Students (G11 & 12)
Babai & Amsterdamer, 2008	Physics	States of matter	Classification	RT & Accuracy	41 Students (G9)
Babai et al., 2010	Biology	Living and non-living objects	Classification	RT & Accuracy	58 Students (G10)
Babai et al., 2012	Mathematics	The perimeter of a shape	Comparison	RT & Accuracy	51 Students (G11-12)
Potvin et al., 2015	Physics	Weight of objects	Negative Priming	RT & Accuracy	565 Students (G5-6)

Article	School Subject	Focused Concept	Paradigm	DVs	Participants
Potvin et al., 2015	Physics	Buoyancy	Negative Priming	RT & Accuracy	128 Students
Potvin & Cyr, 2017	Physics	Buoyancy	Forced Choice	RT & Accuracy	62 Preschoolers, 557 students (G5 & 6), 22 teachers
Roell et al., 2017	Mathematics	Decimal number	Negative Priming	RT & Accuracy	26 Student & 37 Students
Van Hoof et al., 2013	Mathematics	Fraction	Comparison	RT & Accuracy	129 Students
Vosniadou et al., 2018	Science and Mathematics	Force, volume, and fraction	Recategorization Sentence Verification	RT & Accuracy	133 Students (G 4 & 6)

Note: DV represents dependent variable, RT reaction time, and G, in G5, is for Grade.

The selected articles, shown in Table 1, cover mathematics and science education. Within the subcategory of science education, three groups of researchers from Israel, Greece, and the Canadian province of Quebec have studied physics and biology-related topics. For example, in 2006, Israeli researcher, Babai, and his colleagues compared their participants' reaction times of judging areas and perimeters under the influence of activating intuitive or counterintuitive rules. In this experiment, they did observe a reaction time difference: about 360 milliseconds, roughly one-third of a second.

Though brief, this type of reaction time evidence is significantly different from verbal responses or personal reflections. It marks one aspect of the actual dynamics of conceptual change. Similarly, other researchers also reported significant reaction time differences from their studies. In common, they have obtained a new type of evidence showing intuitive reasoning taking less time than its counteractive counterpart, without relying on verbal expression.

In sum, the literature has revealed that the time is right for researchers to expand the theoretical basis to enable a more inclusive framework for showing the conceptual change. On the methodological side, the new paradigm helps them to go beyond the limitation of relying on verbal expression, tapping into the not-so-well-articulated aspect of the conceptual change process.

Discussion And Conclusion

Although bridging the gap through introducing the conceptual change paradigm is promising, current practice is far from satisfactory. Some concerns may impede the advance of our understanding of conceptual change in a more inclusive socio-cultural framework. Among these concerns, the reaction time-reversal inference problem is common in these studies. More seriously is a misreading of a typical negative priming procedure implemented in the conceptual change in time studies. At the same time, the theoretical understanding of such reaction time differences has largely been ignored.

Given these concerns, it is suggested that a careful reading of the priming literature and the proper use of experimental design can quickly solve the design problem. Also, statistical analyses can be planned with a pre-defined data analysis protocol, given the experimental design structure. In so doing, they can confirm a hypothesis or explore a field. In this way, the analyses of variances would help a researcher tell whether what he or she has observed is a real effect, or is caused by chance.

In summary, an updated theoretical and empirical basis has been established to further explore the dynamics of conceptual change through the lens of human-reaction times. In the long run, it opens new connections, helping to bridge the gap between conceptual change and bilingualism. It is hoped that this timely critical view serves as an invitation to those who might be interested in joining these types of studies. Together, meaningful progress in the inclusive conceptual change research can be expected.

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