The development of Earth Science concepts in English by Spanish-speaking middle school students

Starting my second year in the PhD program in ETAP at the State University of New York at Albany—SUNY, my research interest is focused on understanding newly arrived Spanish-speaking middle-school immigrant L2 learners’ longitudinal conceptual development in science at an ESL free-standing program in Albany, New York. By conceptual development I refer to integration, defined as the cognitive restructuring of mental representations, resulting from incorporating new information through the L2 channel. The outcome of such change is a complex network of knowledge structures blending and coordinating efficiently additional knowledge to prior experience in science (Gibson et al., 2000; Piaget, 1929). Moreover, conceptual development in the L2 is understood as a product of conceptual socialization. As a function of proficiency and exposure to the target socio-cultural reality, “the conceptual system undergoes characteristic changes to fit the functional needs of the new language and culture (Kecskes, 2007, p. 54). The main question emerged in conversation with Dr. Kecskes, in which he suggested examining how language learners integrate conceptual knowledge gained through the L2 into the existing L1 cognitive structures and continue conceptual development. As a corollary, this project also explores how a partially developed L1 concept becomes firmly established in the mind if the rest of the encounters with the concept occur through a language other than the first language. Based on the findings of this investigation, a cognitive-based Concept Learning Procedure (CLP) to vocabulary learning will be designed to investigate the extent to which the process of integration can be facilitated with work on English collocations.

In the next pages, I will elaborate on how my research interest originated, the guidance I received this past year, how the coursework in ETAP has helped me advance the project, my topic’s importance for the field of Education, the theories informing my study, and how I plan to pursue this scholarly endeavor.
Second Language Acquisition (SLA) and school achievement in an L2 have always fascinated me. Being a bilingual Spanish/Catalan speaker from birth; a French, Korean, and English language learner; and an ESL teacher, I have had direct experience with the variability in language learning and success. This personal fascination of mine was solidified through my formal studying of SLA during my undergraduate studies in English Philology at the Autonomous University of Barcelona. Soon I learned that the complexity in this area of study stems from the interplay of multiple factors, such as individual characteristics, environmental factors and prior language development and competence, affecting learning outcomes to varying degrees. My fascination for these language acquisition issues was channeled after Dr. Kecskes’ seminar at the Autonomous University of Barcelona in my early graduate years. His book *Foreign Language and Mother Tongue* (2000), co-authored with Tunde Papp, presented one particular aspect—conceptual development—as crucial in L2 and FL acquisition. This approach illuminates the issue of language development as cognitively driven while socioculturally influenced. The Dual Language Model, one of its major assumptions, postulates a unique conceptual store (Common Underlying Conceptual Base, CUCB), developing as a function of integration processes, proficiency, and exposure to in the L2. In this approach, language acquisition consists of both grammatical and pragmatic competence, contingent on the successful integration of concepts and blending of conceptual nuances as a function of proficiency through both language channels. My first scholarly production in this line explored the availability of merged mental representations in FL learners and the direct link between the L2 and the CUCB (Kecskes & Cuenca, 2005), concluding that neither direct links nor conceptual fluency were available in FL learners despite content instruction in English.

**RECENT INFLUENCES**

Later, when I moved to the United States, I focused my interest on immigrant students in the target-language environment. In fact, for two years during my academic hiatus from 2005–2011, I worked as a volunteer, tutoring recently arrived Somali students enrolled in the Lewiston Educational Achievement Program at Lewiston High
School in Maine. In contrast to the FL learners mentioned above, these L2 students not only received content instruction in English, but also lived in the L2 target language culture, which, I thought, might promote stronger links between the CUCB as well as conceptual fluency. However, I realized that that may not the case, resembling Johanne Paradis’ (2013) findings on immigrant ESL students in Canada. In fact, L2 students needed from 5 to 7 years to catch up in terms of school achievement with their L1 peers, an indication that conceptual fluency may not be entirely dependent on L2 target environment presence alone. Immigrant students’ school achievement lag could have been related to the arduous task of making sense of L2 semantic labels while simultaneously acquiring new conceptual loads, for example, in history, mathematics, and science. Their learning reality was aggravated by the fact that, after age seven, ESL students seemed to struggle to acquire anchoring concepts through English to a greater degree and had greater difficulty in the process of L2 concept formation than other students. With that question in mind, as a first-year PhD student, I embarked on my coursework and independent literature review.

COURSELOAD

This first year as an ETAP Ph.D student has been instrumental in furthering my understanding of newly arrived Spanish-speaking middle-school immigrant L2 learners’ conceptual development in science, envisioning a learning procedure and grounding my project in the purposes of research in Education.

Firstly, Dr. Kecskes’ guidance, both in the form of independent studies, lectures (Perspectives on Bilingual Education, ETAP 652B and Second Language Acquisition, ETAP 536), as well as the Barcelona Summer School on Bilingualism and Multilingualism, were key in helping my exploration of the nature of L2 students’ challenges in science in middle school. Particularly, during my initial independent reading, I synthesized the literature and issues on ESL science learning. A large body of literature focuses on the obscurity of academic-style language in school as a source of difficulty (Beck et al., 2002; Corson, 1997). Other studies emphasize another externality, namely, the complexity of the language used in the sciences (Millar, 1991; Sharp, 1994; Wellington & Osborne, 2001). In terms of internal factors, L2 students’ inflexible conceptual representations and preconceived notions about the worlds around them are
put forth as possible reasons for hindered high school science learning (Sinatra et al., 2003; Willingham, 2002). Yet, the prior issues are not specific to immigrant L2 learners of English, but general in science learning. The question of ESLs’ challenges and achievement lagging may also be partially explained in terms of literacy and perceptual learning difficulties (Gibson et al., 2000). In fact, Bialystock rightfully raises the issues of level of proficiency, differences in writing systems or scripts, and idiosyncratic spelling rules in the L2 as barriers to meaning derivation and to concept formation (Wellington & Osborne, 2001, p. 109). However, as Paradis (2013) observed in her longitudinal study of young immigrant L2 students in Canada, past the initial literacy issues, conversationally highly proficient speakers with no apparent language barrier still lagged behind in their academic performance in comparison to their L1 counterparts. In fact, Cummins’ (1991) raised this issue, attributing the differences to the difficulty in acquiring Cognitive Academic Language Proficiency (CALP) (vs Basic Interpersonal Communication Skills, BICS). Yet, difficulty in the mastery of academic language, as stated earlier, is not specific to L2 students. So why does it take longer for immigrant L2 students to come up to par with their counterparts? The challenge and complexity in L2 language and science learning may not simply be accounted for by proficiency, but instead by underdeveloped lexical underpinnings (Biemiller, 2001) and by lack of conceptual fluency in a language other than their L1.

In terms of conceptual fluency, as Dr. Kecskes emphasizes in ETAP 652B and 536, learning a language is challenging for children in general because these differ in their partitioning of the world (Clark, 2010). This problem seems to be aggravated when learning a L2. In fact, L2 language learning consists in the idiosyncratic cognitive mapping of particular linguistic knowledge, its use and unique worldviews (concepts) conveyed by such linguistic overlay. Yet, as Kecskes (2009) observes, “the code (lexical items and structures) in the new language is relatively easy to learn. The difficult thing is to acquire the lexical and socio-cultural load attached to the new linguistic code through limited experience or explanations in school or with limited access to the target culture” (p. 4). Thus, learning concepts, understood as dynamic interfaces between the psychological and sociocultural planes (Kecskes, 2007), are the heart and soul in this difficult endeavor. Apart from the challenge associated with acquiring a new world
partitioning, age of exposure is also a decisive aspect in this enterprise. In fact, while younger L2 learners might be able to undergo socialization in the L2 and learn its particular worldview, immigrant L2 learners in middle school and beyond face a more difficult task: “reconceptualization.” With prior acculturation in their L1, learning the sociocultural background of English through experience and exemplars in that L2 may be neither easy nor feasible (ibid, p.5). While this is not specific to middle school L2 learners, it could partially account for school success differences.

As I gathered from directed readings, further difficulty may lie in the progressively symbolic nature of learning, possibly explaining L2 learners’ underdeveloped conceptual fluency and achievement gap in middle school. Early learning and conceptual development counts on a universal pre-verbal conceptual organization influenced by experience with physical entities and perceptual salience (Clark, 2010). Clearly, L2 acquisition and conceptual integration is facilitated in younger children. Gradually, in middle school, pre-verbal categorizations and physical experimentation have lesser effects on language acquisition. At this developmental stage, symbolic systems, such as language in the form of adult speech and conventionalities, acquire gradual importance for the internalization of mental representations and community knowledge. Moreover, as Vygotsky (1986) observed, linguistic experience regulates thought and higher order mental processes in the sense that the former plays a key role fostering cognitive development. Then, students at this age begin to rely entirely on language as a vehicle for mental processing, concept formation, and, ultimately, cognitive development. Increasing reliance on the English symbolic system, in which middle-school immigrant L2 learners have limited proficiency, may affect their cognitive development pace and L2 concept formation, partially explaining the achievement gap as well.

Secondly, my current exposure to developmental theories of intelligence, perception, memory, and language acquisition in Dr. Vellutino’s Educational Psychology 614 is presently informing my understanding of the nature of middle-school L2 immigrants’ cognitive challenges. From an epigenetic process-oriented point of view, a student needs to internalize and reorganize new into prior knowledge, fostering concept maturation, increasing complex mental structuring, cognitive development (Piaget, 1929)
and school achievement. Thus, cognitive development is determined by success, or lack thereof, in a previous stage. Alternatively, the connectionist information-processing approach conceives cognitive maturity as contingent on the quantity, strength, and breadth of conceptual connections. Given weak connections or non-existent ones, porous mental structures hinder further cognitive development (Novak, 2004), hence, school success. Irrespective of the developmental approach one takes, success in school and language learning seems reliant on the integration/connection of new into prior knowledge. In this conceptual endeavor, our targeted population may differ from other sectors in terms of the difficulty encountered. On the one hand, since younger immigrant children have a barely developed L1 conceptual base, concept development may primarily occur with experiential episodes in the L2 target language environment in school. Similar to natives, then, most concepts would grow in the process of L2 scholarization and socialization. Older students, on the other hand, have completed their basic cognitive development in L1 and have a further developed L1 conceptual base. Through immersion in the L2 target environment, the acquisition of new L2 particularities, such as linguistic labels and conceptual features can be added in connection to existing L1 abstract concepts, even if it inevitably may take longer than for younger children. The source of problems for newly arrived middle-school-aged immigrants may lie in that they start schooling in the United States at the concrete-operations stage with a partially developed L1 conceptual (porous) base resulting from insufficient encounters with concepts in their primary language. Lacking a firm conceptual establishment to begin with, middle-school immigrant L2 students’ development continuation in a distinct language, in which they are not proficient, may have profound implications. From an epigenetic process-oriented perspective, these students may not be able to move onto the formal operations stage unless assisted. Or if so, they may do so at a much slower pace and later time, accounting for the achievement lag Paradis (2013) observed. Alternatively, a connectionist approach would hypothesize that our targeted participants have weak or non-existent connections among L1 concepts as well as underdeveloped networks. If so, establishing connections and integrating information to an existing L1 knowledge base through a poorly mastered L2 channel would delay development, partly explaining differences in school performance. Bearing
this in mind, a question arises as to how a partially developed L1 abstract concept can become firmly established in the learner’s mind if the rest of the encounters with such a concept occur through a language other than the primary source in a science class. As I continue to explore other learning theories, such as Eleanor Gibson’s Perceptual Learning, I hope to better tailor the extent to which the CLP can help L2 students succeed in science classes.

Thirdly, apropos of addressing concept formation in a language other than the primary, Dr. Carol Rodgers’ ETAP 720, Foundations of Curriculum and Instruction, has been instrumental in grounding both the Conceptual Learning Procedure (CLP) as well as my research interest in the elements of the practice (á la Hawkins’ I/Thou/It framework, 2002). As for learning procedure, authors such as Freire (2009), Dewey (1902), and Hooks (1994) and their understanding of educational pedagogies have contributed significantly to my conception of students not so much as recipients but as developing containers of knowledge. A pioneer of this idea, Dewey conceives students’ experiences as operating forces instrumental to the incorporation of more knowledge. Thus, when designing the learning procedure, I bear in mind that immigrant students who move to the United States are not simply empty vessels but come to the classroom with prior L1 experience and world knowledge of science. According to Kecskes (2009), they have learned a unique linguistic system of signs underpinned by “developing” culture-specific conceptual representations and science notions in their minds. In this sense, I follow Freire’s (2009) critical pedagogy approach, harnessing their knowledge and circumstances to foster learning of the new material. Particularly, in this project, the science content through the English language. Bearing these tenets in mind, the CLP will gather students’ prior linguistic experiences and foster links between existing L1 and new L2 conceptual notions as key to empowering them, promoting their learning, and enhancing conceptual integration. With respect to grounding my research interest, Ball and Forzani (2007) argue that inquiry in Education has to inform the elements of the practice—I/ Thou/It. In this vein, exploring conceptual integration between the L1 and the L2 with a CLP, my project will contribute to enlightening the dynamics between the I, Thou, and It in this particularly vulnerable sector of the immigrant L2 population. In this
sense, the CLP could be a useful teaching tool, enhancing student science knowledge integration and illuminating the incorporation of content through the L2, respectively.

HOW MY RESEARCH INFORMS THE FIELD OF EDUCATION

As mentioned above, at this point in my graduate studies, personal experiences, coursework, independent literature reviews as well as professors’ guidance have played an essential role in shaping my research interest. Despite how motivated my interest is, the importance of any study lies in its potential service to the field of Education. In this vein, I believe that understanding newly arrived Spanish-speaking middle-school immigrant L2 learners’ longitudinal conceptual development in science has important implications for the nation’s human capital as well as the fields of Language Acquisition and Education in general. First, cognitive development may be crucial to school achievement and full participation in a democracy and a nation’s workforce. The ideal of a democracy-participating, technologically and scientifically prepared citizenry ready to face the challenges of an ever-changing interconnected global marketplace may prove quite challenging when young immigrant population sectors may consistently lag behind 5 to 7 academic years. Considering that projections in the United States for year 2030 estimate about 40% of school-aged children to be English Language Learners (ELL), examining longitudinal conceptual development in this sector of the population may illuminate how L2 language and cognitive progress is crucial to school achievement; and ultimately, the field of Education. While many aspects contribute to the complexities of immigrants’ educational success, conceptual development, in the form of integration of new knowledge and complex cognitive structure development deserves further attention.

A further motivation in my project is to address a gap in the literature on SLA and Education. In fact, the majority of SLA studies tend to favor cross-sectional research, even though most issues regarding timing and learning a language could be more comprehensibly understood by a longitudinal perspective (Ortega & Iberri-Shea, 2005; Osterhout et al., 2006). Additionally, recent literature only focuses on older students, disregarding learners in early years of the educational cycle. Partly, the significance of my study lies in the attempt to fill that gap by employing this underrepresented practice while addressing the scarcity of longitudinal data on early SLA. I believe that a
longitudinal methodology can provide valuable insight into immigrant middle-school L2 students’ conceptual development, possibly illuminating school achievement lags.

Last, my project further advances a more acceptable notion of multicompetence (Cook, 1991) and emphasizes cognitive vocabulary approaches to learning in SLA. On the one hand, a cognitivist separation of levels of representation (Gibbs, 1998; Giora, 1997, 2003; Kecskes, 2002) affords bilinguals and L2 learners to be considered far different than two monolinguals (Grosjean, 1989). Contrary to the Interlanguage Theory view (Selinker, 1972), this project considers proficient L2 language learners and bilinguals not in an in-betweeness state moving toward an ideal “nativelikeness.”

Following a Dual Language System (DLS) approach (Kecskes, 2007; Kecskes, 2009; Kecskes & Papp, 2000), bilinguals and L2 learners are more accurately described as conceptually synergic individuals with “one conceptual system that may operate more than one language” (Kecskes, 2009, p.6), hence not “deficient” native speakers. On the other hand, from a cognitive perspective, language and science learning are contingent on lexicon development and growth, since the latter is “an interface between the conceptual level and the linguistic” (Kecskes, 2009, p.5). In the DLS, the Common Underlying Conceptual Base (CUCB) is the primary locus of conceptual development, to the extent to which new world (e.g., science) is integrated into existing world knowledge. In this view, the targeted population’s conceptual development and school success rests on vocabulary growth rates as well as conceptual networks’ associations and density. Therefore, my study is important for education not only furthering a more “politically correct” view of L2 language learners, but also emphasizing the importance of vocabulary learning in SLA and science to help develop conceptual fluency and reduce achievement gaps.

DIRECTIONS FOR FURTHER RESEARCH

In the light of the targeted population’s pressing reality, further exploration is necessary for understanding concept formation in this vulnerable population segment through a new symbolic system. Rather than documenting the development of the L2’s linguistic system, I plan on reporting the longitudinal state of affairs, modulation, modification, and possible integration of the mental representations after a Concept
Learning Procedure (CLP) intervention. Two steps are clearly identified in this possible direction.

Firstly, I will target and identify recently arrived Spanish-speaking Delaware Community School fourth and fifth graders with the help of teachers. Their language characteristics will be elicited by parental questionnaires (Gutiérrez-Clellen et al., 2012; Gutiérrez-Clellen & Kreiter, 2003). Such parental survey will collect biographical information on Spanish and English language use at home; comprehension and production rating scales, age of arrival; time of arrival; parents’ language and education; and interaction time with mother, father, and other members of the community. Additional information, including language background, placement, and proficiency scores will be drawn from the NYS Education Department Office of Bilingual Education database for the targeted participants. A spoken child questionnaire might be administered to sample the targeted population’s motivation, multiple intelligence, aptitude, cognitive style, and personality. Ultimately, these will keep track of other variables influencing learning to help identify individuals for a possible case study on science learning and conceptual development.

Secondly, the project will design a testable intervention that will facilitate concept formation of Spanish speaking students relying on their L1 knowledge and amalgamating it with new knowledge gained through L2. A six-stage Concept Learning Procedure (CLP) will be implemented on different dates in a one-year period. The six stages are identified as follow:

- **Step 1:** Concept awareness in L1
- **Step 2:** Developing concept map in L1
- **Step 3:** Relating L1 knowledge to L2 knowledge through lexical connections
- **Step 4:** Reconceptualization in L2: Continuing concept building in L2
- **Step 5:** Developing concept map in L2 and comparing it to L1 concept map
- **Step 6:** Use concepts in L2 problem-solving tasks

First, in the concept awareness in L1 phase, we will combine several modes of data collection to generate a richer description of students’ conceptual structures in the L1. Following Katja Wiemer-Hastings (2005), I will use property generation tasks instructing participants to list in their L1 all characteristics of a group of selected English science words that they can recall. This task will tap into conceptual knowledge and
allow for an unbiased exploration of the knowledge and structure associated with a reduced group of concrete science concepts in Spanish (e.g., Rosch & Mervis, 1975). However, according to the former, “participant-generated features unlikely reflect exact conceptual content” (Katja Wiemer-Hastings, 2005, p. 5). In the second stage, then, we will need supplemental information on the relations among item features for a more complex understanding of L1 mental representations. Individuals’ mental organization and world knowledge will be assessed by concept maps (Cañas et al., 2003) or clustering (Rico, 1983) in the L1, in which they will be trained first (Kinchin et al., 2000; Novak, 2004). Next, as the population’s existing L1 knowledge baseline is established in some science domains, an interactive interview protocol in L1 could complement conceptual maps, providing insight on the tangled nature of concepts in the L1 (Novak, 2004). These interviews will be transcribed and analyzed.

Each subsequent step is envisioned to take place in different days over a month period, contingent on the careful application of both human, i.e., instructors, and technological support. Particularly, the third stage focuses on vocabulary knowledge-oriented tasks helping connect prior concrete L1 to new L2 knowledge. Cognitive work on translation equivalent concept pairs (crust-corteza/ belt-cinturón) (Shavelson & Ruiz-Primo, 2000, p. 318) will be promoted, aiming at strengthening the lexical relation of equivalents in both English and Spanish (Boers & Lindstromberg, 2008; Csabi, 2004; Tyler, 2004). Following Ijaz (1986), the goal is to observe the “degree an L1 influences the development of sense relations and lexical networks” (p.329) in the L2. The fourth stage is a work in progress at this point, yet tasks will aim at reconceptualization, provided differences between the L1 and the L2, as well as continuing metaphorical concept building in the L2. For example, exercises with frequent collocations will be presented to automatize the L2 label-concept interface, instrumental for fostering concept learning and strengthening connections in the new channel. Needless to say, tasks will target breadth and depth of domain exposure, as well intense L2 vocabulary work in science to promote network building, ultimately conceptual development. In the fifth stage, a second concept-mapping activity will assess the state of affairs after the intervention, paying close attention to possible conceptual changes in the L2 learners’ mental organization in comparison to earlier conceptual maps in L1, as a result of
knowledge growth through the L2 channel. As in stage two, an interactive interview protocol will be conducted to complement understanding the mapping connections of the L1 and new L2 information in students’ minds. The idea is to shift the L1-dominant language-concept connection automaticity to L2, subsequently establishing firm science concepts though the L2. Finally, in stage six, while mental structures shown in their concept maps may indicate the existence of new L2 nodes in their cognitive structuring, it would be essential to determine whether these skills and knowledge are simply receptive or productive as well. At the end of the one-month intervention, I will propose to use science concepts in L2 problem-solving tasks to assess to what extent students can operationalize the knowledge incorporated in their mental structures. A possible follow-up task at the end of this longitudinal 1-year period study might be implemented to observe any operationalization differences in comparison to an earlier date.

CONCLUSION

I hope to have accomplished what I set out to do at the beginning of this document. First, I provided an account of how my research interest, understanding newly arrived Spanish-speaking middle-school immigrant L2 learners’ longitudinal conceptual development in science, originated and developed. I elaborated on how my advisor’s guidance and the coursework as a first year in the ETAP Ph.D program had a profound impact on fine-tuning this project. Then, I delved on the significance for the fields of SLA and Education as well as the nation’s human capital. In fact, cognitive development may be crucial for immigrants’ full participation in the US democratic system as well as labor market, especially with projections of 40% of school-aged children being ELLs in 2030. Moreover, apart from trying to fill a gap in the literature, my research interest advances a more acceptable notion of multilingual learners as “not deficient”, while emphasizing the role of vocabulary growth rates and concept network density in conceptual development. Finally, I described an embryonic six-phased Conceptual Learning Procedure, harnessing students’ knowledge in their first language to continue concept formation in the L2 in this vulnerable population. At this point, it is premature to make any claims, yet this intervention may potentially contribute to the teaching of science as well as enlighten the incorporation of content through the L2 in newly arrived Spanish-speaking middle-school immigrant populations in the US.
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New York State Education Department Office of Bilingual Education


