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Second Language Teaching With STEM

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The American Council on the Teaching of Foreign Languages World-Readiness Standards for Learning Languages, also known as ACTFL *5 Cs*, aims to guide pre-kindergarten through higher education second language (L2) educators in what L2 learners at every level should do to progress in each standard. The ACTFL's 5Cs includes five goal areas: Communication, Cultures, Connections, Comparisons, and Communities. Empirical research has shown that of these standards, Connections, where the languages are connected to academic disciplines for strengthening the learning, is one of the least utilized standards in L2 classrooms. Incorporating Science, Technology, Engineering, and Mathematics (STEM) as the connection discipline can help post-secondary language learners in STEM and non-STEM fields develop the ability to effectively communicate technical and scientific STEM content within global STEM markets. This paper discusses the rationale for and the need to utilize the ACTFL's Connections standards through STEM to grow and sustain L2 learners' advanced language proficiency, as well as their employability and effectiveness in a highly competitive global work environment.

Keywords: STEM, L2 teaching, L2 learning, ACTFL World-Readiness Standards, ACTFL 5Cs

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INTRODUCTION

A Science, Technology, Engineering, and Mathematics (STEM) workforce is essential to remaining globally competitive and to sustaining global economic leadership. According to the United States Department of Education, building students' skills, content knowledge, and literacy in STEM field is essential for solving the complex challenges of today and tomorrow and meeting the demands of the dynamic and evolving workforce (Office of Elementary and Secondary Education, 2016). The development of STEM skills can further students' interest in STEM, which expands their career choices as adults (Kalogiannakis and Papadakis, 2020).

Given the impact of the COVID-19 pandemic, the United States Bureau of Labor Statistics projects a much stronger occupational growth than the pre-pandemic period (U.S. Bureau of Labor Statistics, 2021). According to the United States Department of Commerce report (Office of the Chief Economist, 2017, p. 2), STEM occupations "grew much faster than employment in non-STEM occupations over the last decade" (24 percent versus 4 percent, respectively). Of the majority of the world's ten fastest growing emergent market economies (India, the Philippines, Indonesia,

China, Malaysia, Turkey, Thailand, Chile, Poland, and South Africa) (Burroughs, 2019), none have English as their first language. Moreover, both the United States STEM-related industries and its economy are closely tied to languages, and the "language industry is essential to expand and strengthen STEM fields and workforce" (Transparent Language, 2016, p. 3).

According to Bill Rivers, former Executive Director of the Joint National Committee for Languages and a leader in United States language policy development, STEM business is global, and as such requires multilingual communication for today's scientific collaboration and progress, which means the language industry is fundamental to furthering every aspect of STEM professions and business (Rivers, 2013).

The STEM field workforce in the United States thus requires an increasing number of engineers and scientists who can effectively communicate technical and scientific STEM content *via* L2 to open the doors to global STEM markets. This STEM field workforce also requires the collaboration of a non-STEM workforce that is linguistically and culturally competent in languages and can collaborate with STEM workers in globally connected careers. An advanced attainment of languages would pave the way for more lucrative career pathways for individuals connecting to STEM *via* target languages. This would require blending the STEM discipline content into the L2 curriculum.

AMERICAN COUNCIL ON THE TEACHING OF FOREIGN LANGUAGE WORLD-READINESS STANDARDS IN SECOND LANGUAGE TEACHING

The American Council on the Teaching of Foreign Languages National Standards document, World-Readiness Standards for Learning Languages (National Standards Collaborative Board, 2015), guides L2 teachers in terms of what L2 learners at every level should do to progress in each standard. The document is based on the Common Core State Standards, College and Career Readiness, and 21st century skills. ACTFL's World-Readiness Standards for Learning Languages is based on five goal areas known as the 5Cs (National Standards Collaborative Board, 2015): Communication, Cultures, Connections, Comparisons, and Communities. Communication is considered to be the key to second language learning, and its effectiveness is based on being able to function in a multitude of situations, such as face-to-face, virtual, written, and textual communication. The Cultures goal requires that learners to demonstrate an understanding of the relationship between the practices and perspectives of the culture being studied, as well as the products and perspectives of that culture. The Connections goal helps learners expand their knowledge of other disciplines and access and acquire information from diverse perspectives. The Comparisons goal stresses how learning a target language and culture impacts one's understanding of their native language and culture. According to the ACTFL's 5Cs, "the understandings gained about the nature of language and its interaction with culture carry over future circumstances where they, as learners and workers in the 21st century, will have the confidence and competence to interact in other cultural settings" (National Standards Collaborative Board, 2015, p. 2). Thus, the Comparisons goal should be vital not only for developing learners' L2 proficiency, but also for improving their critical thinking skills and preparing them for the workplaces in a rapidly changing world. The fifth goal, Communities, highlights two standards in target language learning: active use of the target language for face-to-face and virtual collaboration, and goal setting for lifelong learning. As in the Comparisons goal, the Communities goal goes beyond securing language learners' success in the classroom by equipping them with the necessary skills to communicate and teaching them to strategize and collaborate so that they can succeed in a diverse technology- and information-driven global workforce.

SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS RELATIONSHIP TO 21st CENTURY LANGUAGE LEARNING

As a content area, STEM has been of interest to the Language for Specific Purposes (LSP) field for decades. Previous research from Long (2017), has established that 58 to 62% of college programs offer a wide range of LSP minors and/or courses. However, LSP course offerings have been limited to the more commonly studied languages in North America, such as Spanish, French, German, Arabic, and Chinese. For those languages, "division caused by the specificity of many LSP courses (e.g., Spanish for healthcare, Chinese for business) also affect students who may decline to enroll in an LSP course because of a narrow focus on one specific professional field" (Long, 2017, p. 7). Offering LSP courses in less commonly studied languages is even more challenging due to low enrollments and the unavailability of language instructors specializing in LSP fields. Hence, defining the current curriculum as preparation for students entering international internships and careers in LSP-related fields may not be sufficient (Zinggeler, 2003). Rather, the goals need to focus on raising students' linguistic and cultural competencies by integrating a 21st century interdisciplinary field, such as STEM, into regular language courses (Battelle for Kids, 2009). Teaching universal competencies and skills by tapping into the STEM discipline and focusing on real-world problem-solving, critical thinking, and rigorous inquiry, can lead to higher language proficiency and significantly impact students' employability and effectiveness in a highly competitive global work environment.

AMERICAN COUNCIL ON THE TEACHING OF FOREIGN LANGUAGES CONNECTIONS GOAL IN SECOND LANGUAGE TEACHING

The importance of the STEM connection was emphasized in a Position Statement by the American Council on the

Teaching of Foreign Languages (ACTFL): "The goal area of connections broadens the content for learning languages to any area where learners might use language." Project- or Problem-based language learning with STEM content develops problem solving, critical thinking, and inquiry skills. . . (American Council on the Teaching of Foreign Languages [ACTFL], 2013, p. 2). This statement aligns with Connections, one of the five goals of the ACTFL's *5Cs*. The Connections goal emphasizes the importance of combining languages with other disciplines to obtain diverse perspectives as well as utilizing languages for academic and career purposes (National Standards Collaborative Board, 2015). The Connections standard has three objectives: (a) to expand L2 learners' knowledgebase of other disciplines through the target language, (b) to help them improve their critical thinking and creative problem-solving skills by exposing them to important 21st century issues and global challenges, and to (c) use their target language to advance in their careers (National Standards Collaborative Board, 2015).

Three groundbreaking, large-scale empirical studies conducted with college L2 learners have shown that students have not considered the Connections standard of the ACTFL's 5Cs (American Council on the Teaching of Foreign Languages [ACTFL], 2011; Magnan et al., 2014; Miller, 2019) as important for their learning. Magnan et al.'s (2014) study involving 16,529 students learning 31 L2 languages in 11 post-secondary institutions examined the connection between students' goals and ACTFL Standards, as well as how students prioritize the 5Cs in L2 learning. The results indicated that of the 5Cs, Connections was ranked the least important goal area for L2 students (Magnan et al., 2014).

Similarly, the ACTFL survey also illustrated that the "teachers have not embraced the Connections" (American Council on the Teaching of Foreign Languages [ACTFL], 2011, p. 11), as the Connections standard was found to be one of the least prioritized goal areas for L2 teachers at 11%, when compared to 79% for Communication, 22% for Cultures, and 12% for Comparisons. The teachers' survey findings were consistent with the students' goal area priorities for the Connections standard findings, as both L2 educators and students perceived Connections as a low-priority goal area. Miller's (2019) quantitative research investigating the relationship between Spanish L2 students' self-selected goals and the ACTFL's 5Cs also corroborated previous research. The study showed that Communication and Cultures were the only goal areas that students mention in the surveys, while all were unaware of the remaining three goal areas: Connections, Communities, and Comparisons.

FUTURE DIRECTIONS: CONNECTIONS STANDARDS AND SECOND LANGUAGE EDUCATION

The three key research studies discussed above indicate that L2 students were not aware of the existence of the wide range of 5C goals, nor of the interrelationship among those goal areas. The focus of L2 students was primarily the Communication standard, leaving the other four goal areas, especially Connections, largely untapped during L2 learning. Compared to the other goals, the Connections goal has been the least focused area for educators in the American Council on the Teaching of Foreign Languages [ACTFL] (2011). One of Miller's (2019) pedagogical implications specifically pointed out that when educators focus on covering the material in a textbook rather than guiding learners to connect language with other disciplines, those learners will tend to limit their own goals. Therefore, Miller calls for instructional designers, language policymakers, curriculum coordinators, and language educators to make a concerted effort to "explicitly teach students what language learning entails and what it means to be linguistically and interculturally competent" (p. 250).

Cutshall explained the disconnect as "teachers often did not feel that they knew enough about another content area to accurately include information beyond the language structures they taught" (p. 37). One way to mitigate this is to incorporate regular professional training opportunities that include ample resources to help educators become more aware of the interdisciplinary and interconnected aspects of the ACTFL 5Cs, as well as to provide the guidance to understand STEM concepts. The quality of training provided to teachers to attain proficiency in integrating STEM is crucial (Papadakis et al., 2021). Another suggestion is to collaborate with colleagues in STEM and non-STEM fields (Cutshall, 2012; Murphy-Judy, 2016) to integrate STEM literacy and 21st century competencies (Honey et al., 2014) into L2 curricula. In order to plan for such a curriculum change, instructional designers and educators in STEM and non-STEM fields need to make an effort to combine effective pedagogical practices and STEM content with technology to provide a relevant, meaningful and transformative 21st century learning experience.

One other way to facilitate the integration of Connections standards in L2 classrooms is to help the L2 teachers see the practical applications of the Connections standards in real classrooms. There is an abundance of examples and programs employing Connection into L2 teaching, but they are limited to K-12 English language immersion and selected college programs offering STEM-emphasized accredited language courses (Cutshall, 2012). Additionally, college programs and practical applications are limited to more commonly taught languages (MCTL), such as English, German, and Spanish (see Banergee, 2016; Stoehr, 2017), yet the implementation of less commonly taught languages (LCTL) appears non-existent.

The successful implementation of these interrelated goals will propel L2 learning beyond the mastery of language and culture. It will also help students deal with the challenging and diverse global issues of 21st century interdisciplinary fields such as STEM. With increased understanding, knowledge, and experience, this implementation will also bolster skills, such as creative and analytical thinking, adaptability, problem-solving, collaboration, and effective communication. This can also enhance L2 learners' capabilities and competencies as well as their readiness to work in globally connected, STEM-based technical and industrial work fields. There is a need for more research focusing on designing and connecting STEM integrated

L2 frameworks and curricula, especially for LCTL. Future efforts also need to concentrate on providing L2 educators evidence- and research-informed teaching practices based on successful implementations of STEM Connections in L2 classrooms.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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