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Community Based Engineering Design Challenges for Adolescent English Learners

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Community Based Engineering Design Challenges for Adolescent English Learners

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This modified proposal was submitted in 2011 (with information deleted to protect confidentiality).

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* EAGER - EArly-concept Grants for Exploratory Research
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Community-Based Engineering Design Challenges for Adolescent English Learners

Project Summary: This exploratory DRK-12 proposal targets the Explore, Hypothesize, and Clarify component of the National Science Foundation's cycle of research and development. This proposal is designed to generate a body of knowledge that will encourage more Latina/o adolescents to enter the field of engineering. Specifically, the purpose of this ethnographic research is to describe the social/cultural and linguistic resources from which Latina/o English learners draw as they complete a community-based engineering design challenge. This knowledge will provide the foundation for the later development of culturally and linguistically responsive engineering curricula in high schools. This proposal thus relates to the fifth goal of the DRK-12 Program's Learning Strand because it moves toward "substantive STEM learning activities that effectively engage and serve the diversity of learners found in contemporary US classrooms." Toward this end, this ethnographic study draws from data collected as the adolescents enact engineering design processes, including *identifying a need* in their communities through interviews with community leaders; *gathering information* from oral, digital, and printed sources in both English and Spanish; and *seeking feedback* on their proposed models from community stakeholders. Data sources will include a variety of interviews; products generated by the participants; retrospective and concurrent protocols of the participants' thinking as they read and design engineering texts; and field notes and audio or video-recordings of their interactions with each other and with community members. A constant comparative analysis of these sources will indicate the linguistic practices and the social resources used to complete the design challenge. By identifying how Latina/o adolescents' everyday linguistic practices and social resources can be connected to formal engineering processes, this study will produce a body of knowledge necessary for creating culturally responsive engineering curricula.

Intellectual Merit: Heretofore, the National Science Foundation has done much to advance culturally and linguistically responsive instruction in secondary schools through projects that sought to connect formal STEM learning to adolescents' out-of-school linguistic practices, social and cultural practices, and digital literacy practices. The published findings of these earlier grants (e.g., Barton & Tan, 2009; Celedón-Pattichis, Musanti, & Marshall, 2010; Moje et al., 2004), which have largely been in the fields of mathematics and science, have informed this current proposal in the field of engineering. Nonetheless, engineering is sufficiently distinct from other STEM fields (Lewis, 2006; National Research Council, 2011) to warrant in-depth investigations of how adolescents use particular sets of cultural, linguistic, and representational resources as they enact engineering design processes, an area that has thus far been understudied. In-depth exploratory research is therefore necessary to inform further research and instruction in several ways: (a) by describing the social/cultural resources the adolescents use to conceptualize and complete their designs (e.g., parents' job-related expertise); (b) by describing the literacy practices that influence their designs (e.g., representational practices used to create personal social media pages that are also used to generate engineering models); and (c) by documenting the difficulties that the adolescents face in completing the design process (e.g., linguistic barriers in translating websites from English to Spanish). This type of knowledge will lead to more culturally responsive instruction through informing the creation of engineering materials that account for these social/cultural resources and literacy practices while also addressing the identified difficulties.

Broader Impact: Previous ethnographic research in engineering education has primarily addressed cultural differences between women and male-oriented engineering programs (Godfrey & Parker, 2010), but virtually no research has been published on the differences and similarities between the cultural practices of engineers and the cultural practices of Latina/o adolescents (Stevens et al. 2008). By beginning to generate this body of knowledge, this study moves toward culturally and linguistically responsive engineering education in at least two ways: (a) through providing necessary information for the development of engineering curricular materials grounded in diverse students' cultures and interests; and (b) through providing information necessary for the development of learning models and materials, written for in-service and pre-service teachers, that offer frameworks for connecting diverse students' backgrounds with formal engineering processes. This project will also directly result in researcher publications, practitioner publications, national workshops and conference presentations, and an adolescent-generated website that will disseminate the findings to a wider audience.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Community-Based Engineering Design Challenges for Adolescent English Learners

1. Introductory Scenario

Gabriela, a 15-year-old student who immigrated to Utah from Mexico at the age of five, logs onto Facebook and begins to use the chat function to send messages to extended family members in Cuernavaca and friends from her local gymnastics class, alternatively writing in Spanish and English depending on her audience. After uploading and sharing a few images she had sketched of scenery in her neighborhood, she plays with SimSocial, a popular Facebook app with over 29,000,000 monthly users. In previous months, she had used the app to build and design a home with her available game currency; today, she re-organizes the virtual furniture based on aesthetic and functional considerations, and she requests a virtual land extension from a Facebook friend so she can add to her crops. After considering the growth time required for each crop, she decides to plant lettuce, a plant she had tended in a previous garden owned by her family.

Her father comes home after working at a construction site and helping a neighbor with house repairs, and he asks Gabriela to help him translate legal documents required for his mother to move to the United States. Toward this end, Gabriela and her father search English and Spanish websites for additional information, with Gabriela paraphrasing English texts for her father. At her cousin's quinceñera that evening, her father speaks with a neighbor who recently helped somebody immigrate to America and gives him advice about the process. Gabriela and her younger brother volunteer to help another neighbor sell baked goods at a local fair over the weekend, calculating profits from the sale when it is over.

On Sunday, her family attends mass, listening to a sermon about the importance of caring stewardship toward the earth and the people who live therein. Gabriela renews her commitment to serve her community when she grows up, even though she does not yet know the exact career she wants to pursue.

Gabriela is recognized as a caring, helpful, talented, competent, and literate person in her neighborhood—one who can translate important documents and assist with a variety of financial or physical tasks when needed—but her STEM teachers view her as lackluster at best, using terms such as "average" to describe her understandings of their disciplines. She doubts her ability to succeed in advanced and elective STEM classes under the premise that they should be reserved for "high level" students; consequently, she does not enroll in these classes.

Although Gabriela is fictional, this scenario points toward a wealth of "strategic and cultural resources," or "funds of knowledge" (Velez-Ibáñez & Greenberg, 1992, cf. Moll, Amanti, Neff, & González, 1992), that could be used to facilitate her success as an engineering student, such as neighborhood exchanges of knowledge and labor (in this case, familiarity with legal systems and codes); knowledge of construction and agriculture; and knowledge of how to use technologies to accomplish tasks. Moreover, this scenario points toward a series of linguistic, literacy-related, and representational practices that could likewise facilitate her success in engineering, such as locating relevant information online; reading, writing, and speaking in Spanish and English to potential clients and stakeholders; and making visual representations such as hand-made sketches or digital images. This scenario also points to several habits of mind that are essential to engineering design processes, including Gabriela's awareness of constraints in the design process (e.g., limited financial resources and time) and including ethical considerations regarding how a design might influence the environment and other people.

Perhaps most importantly, like other youth from underrepresented populations (Moje et al. 2004), Gabriela feels a sense of responsibility to her community and a desire to contribute to it in constructive ways, a reason that may be especially effective for drawing underrepresented populations to STEM fields (Hsu, Roth, Marshall, & Guenette, 2009). Engineering—with its focus on identifying people's needs and seeking socially responsible solutions to those needs—seems to be the perfect venue for appealing to this sense of civic responsibility and social justice. With so many relevant representational, linguistic, and social resources at her fingertips, and with so many habits of mind that resonate with those of engineers—why is it that Gabriela and many other adolescents like her do not pursue a career in engineering? We argue that one plausible explanation is because very little research has been conducted with the purpose of connecting engineering design processes and habits of mind with the rich funds of knowledge that inhere in adolescents' neighborhoods and online communities. Accordingly, the purpose of our study is to conduct in-depth ethnographic studies in Latina/o neighborhoods, documenting the funds of knowledge, social networks, and linguistic and representational repertoires that are available in the adolescents' online and offline communities. Ultimately, we hope that by describing how the adolescents connected these informal resources to more formal engineering design processes, and by describing any difficulties and tensions they faced while making these connections, this project will advance engineering instruction that is grounded in students' everyday worlds while also promoting engineering skills outlined in national frameworks (e.g., National Assessment Governing Board, 2010).

2. Statement of the Problem. STEM fields in the US continue to be dominated by people whose cultural backgrounds are White, English-speaking, and middle class (National Academy of Engineering and National Research Council, 2009). Many reasons have been offered to explain this phenomenon: Students' backgrounds may include worldviews, beliefs, and communicative practices that do not cohere with those practiced in STEM classrooms (Aikenhead & Jegede, 1999; Lee, 1999); instructional materials may present STEM fields as a-cultural, decontextualized practices with no evident connection to students' lives and communities, such as the routine completion of numerical exercises (O'Halloran, 2005); students' identities—shaped in part by their desired life trajectories, their personal histories, and the social groups by which they want to be accepted—may contrast with identities as STEM experts (Aschbacher, Li, & Roth, 2010); scientific and mathematical discourse, difficult for many adolescents to comprehend and use, may be especially challenging for those who are learning English (Fang, 2005); and societal inequities and prejudices may actively work to drive people of color and women out of STEM fields (Johnson, Brown, Carlone, & Cuevas, 2011).

To address some of these challenges, the National Research Council (2011) has argued that STEM instruction "needs to connect with students' own interests and experiences" (p. 2-4). While a growing body of research has begun to address how teachers might draw from adolescents' diverse cultural resources, linguistic resources, and community concerns in science (Barton, Tan, & Rivet, 2008; Moje, Collazo, Carrillo, & Marx, 2001) and mathematics (Civil, 2002; Martin, 2006), very little research has been conducted on how the same task might be accomplished with adolescent English learners in the field of engineering. This study is therefore based on a theoretical model that embeds engineering design within social, cultural, and linguistic activity, seeking to understand (a) how adolescent English learners draw from various linguistic, representational, and social resources as they work toward solving community-based engineering design challenges; (b) the problems they face in working on the challenges and how they seek to overcome those problems; and (c) adolescents' willingness to conceptualize themselves as future engineers before and after participating in the project. Ultimately, we hope that obtaining information in these domains will enable engineering education to be more responsive to the cultural and linguistic needs of diverse learners.

3. A Sociocultural Model of Adolescent Engineering Design Processes. As late as 2005, engineering educational research was designated as a "new discipline" (Haghighi, 2005), one that largely presented engineering as a series of relatively decontextualized processes without rigorously accounting for the social and cultural contexts in which engineering education occurs (Godfrey & Parker, 2010; Stevens et al., 2008), with only a handful of studies serving as notable exceptions to this trend (e.g., Ambrose, Lazarus, & Nair, 1998; Bucciarelli, 1994; Tonso, 1996). We argue, however, that national calls for engineering diversity and inclusiveness (e.g., National Steering Committee of the National Engineering Education Research Colloquies, 2006) require a more situated view of adolescents' engineering design processes, one that embeds their designs within larger social and linguistic activity. Our theoretical model, outlined in the following section (see Figure 1), provides this situated view of engineering design.

3.1. *Design processes.* According to national educational frameworks (International Technology Education Association, 2000; National Assessment Governing Board, 2010) and a large body of research and theoretical literature (e.g., Asunda & Hill, 2007; French, 1999; Jonassen, 2000), a central and distinguishing feature of engineering is *design,* defined by Dym and colleagues (2005) as "a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients' objectives or users' needs while satisfying a specified set of constraints” (p. 104). Using similar definitions, many researchers and theorists (Dixon & Johnson, 2011; Koen, 2003; Lewis, 2006) have conceptualized the work of engineers in terms of a series of design processes, identifying the specific methods necessary for producing successful designs among professional and novice engineers.

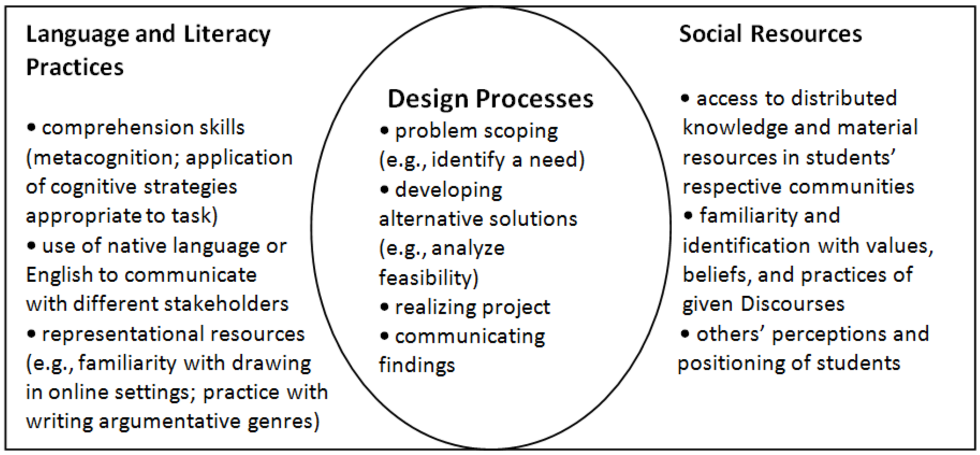

Figure 1. A sociocultural model of adolescents’ engineering design process.

Atman and colleagues (Atman et al., 2007; Atman, Cardella, Turns, & Adams, 2005), for example, divided the design process into three stages: (a) the *problem scoping* stage, which includes identifying a need, defining the problem, and gathering information about the task; (b) the *developing alternative solutions* stage, which includes generating ideas, building models, analyzing the feasibility of different solutions, and evaluating each solution; and (c) the *project realization* stage, which includes making a decision, communicating the results, and implementing the design. Other researchers have provided further specifications for these processes, dividing them into sub-processes and clarifying “habits of mind” necessary to engage in them. For instance, proposed national frameworks (National Assessment Governing Board, 2010) have suggested that the single component, *evaluating solutions,* may entail the following related thought processes: (a) considering systems dynamics, including the scientific concepts behind the physical systems that make the product work, the systems of resources required to produce and maintain the product, and the environmental systems affected by the product; (b) making estimates that account for degrees of uncertainty; and (c) considering the ethics of producing and using the product, including the populations it will benefit or harm.

In most cases, these prevalent models of engineering can be viewed as largely *cognitive.* Although these models acknowledge that engineering entails social interaction (such as communication) and material activity (such as building models), they tend to focus on relatively uniform frameworks for thinking and “habits of mind” that should be practiced by emerging engineers as they approach these material and social interactions. This line of research has led to claims that certain types of cognitive activity over a particular duration of time can lead to better designs (e.g., Atman et al., 2007; Bursic & Atman, 1997).

3.2. ***Social resources.*** Although our theoretical model recognizes the centrality of cognitive activity to engineering, this model also foregrounds the sociocultural context in which design processes occur. The following description of Discourses (Gee, 2008) serves as a foundational heuristic for our understanding of engineering design:

> *[A Discourse] is composed of distinctive ways of speaking/listening and often, too, writing/reading coupled with distinctive ways of acting, interacting, valuing, feeling, dressing, thinking, believing, with other people and with various objects, tools, and technologies, so as to enact specific socially recognizable identities engaged in socially recognizable activities* (p. 155)

In accordance with this definition, we conceptualize engineering design processes as an enactment of a larger engineering Discourse. Godfrey and Parker (2010) described this Discourse as including “the Engineering Way of Thinking” and “the Engineering Way of Doing” among people who practice “Being an Engineer” (p. 8). These people are recognized as ‘one of us’ by other engineers who deem their "physical, tangible Artifacts and visible behaviors" to align with the norms of engineering (p. 8). For example, many engineering experts believe that the Engineering Way of Thinking requires an "empirical attitude" (Apedoe & Ford, 2010), wherein conclusions and evaluations are grounded in a "tangible, definable, measurable, quantifiable reality" (Godfrey & Parker, 2010, p. 10; cf. Hacker, 1983). To many theorists (e.g., Koen, 2003), canonical design activities, such as gathering information and testing models, are synonymous with The Engineering Way of Doing. The tools of practitioners within this Discourse often include cutting-edge technologies (Bucciarelli, 1994), visual representations such as formal and informal diagrams (Ullman, Wood, & Craig, 1990), and numeric/symbolic mathematical representations (Cardella, 2008). Depending on their home and school experiences, some adolescents may have acquired ways of thinking, doing, valuing, communicating, and using particular sets of tools that align closely with those of "engineers"; theoretically, they would be more likely to develop identities as engineers as compared to adolescents whose cultural worldviews, values, tools, and practices did not cohere with Discourses of engineering.

Although we could not find published research that described the possible connections and/or disconnections between Latina/o adolescents' everyday Discourses and the Discourses of engineering, a sizeable body of research in science (e.g., Barton, Tan, & Rivet, 2008; Bouillion & Gomez, 2001; Buxton, 2006) and mathematics (e.g., Brilliant-Mills, 1993; Civil, 2002; Tate, 1995) has offered several heuristics for conceptualizing connections between students' everyday practices and the more formal or institutionalized practices of scientists and mathematicians. This body of literature informs the types of resources that we expect to find in the adolescents' communities that can enrich their understandings of formal engineering design processes. This body of literature also points toward possible tensions we may find between their everyday Discourses and established engineering Discourses.

Earlier sociocultural research often highlighted points of divergence between underrepresented students' beliefs, communicative practices, and identities as compared to those required to succeed in academic Discourses. For instance, Lee's (1999) findings suggested that African American and Hispanic students' worldviews, as indicated by their explanations of the cause of Hurricane Andrew, tended to diverge from "scientifically compatible views." Heath's (1983) famous ethnography of communities in South Carolina revealed how some children's linguistic patterns diverged from those used by their teachers, leading to a school experience that was alienating and confusing. Martino's (1999) research with working class male students found that some adolescents enacted versions of masculinity in which being "bad" was preferable to trying hard in school. To them, trying in school was an activity reserved for "squids," a derogatory term for high-achieving students. In sum, a large body of research indicates that students' sociocultural backgrounds—including their gendered norms, cultural values, socioeconomic status, language, and ethnic identities—may be in direct opposition with school norms (cf. Brown, 2004; Welch & Hodges, 1997). Consequently, Aikenhead and Jegede (1999) described underrepresented students' transitions between their home cultures and science classrooms as a type of "cultural border crossing," a metaphor that suggests a "student's life-world and school science" are two distinctly bounded, separate entities (p. 269). By implication, like travelers who must learn the unfamiliar cultural and linguistic practices of foreign countries in order to succeed in them, students from underrepresented populations often must cross a clearly delineated boundary to learn the foreign Discourses of science.

A more recent body of research (e.g., Gutiérrez, 2008; Lee, 2001; Seiler, 2001; Tan & Barton, 2008), rather than emphasizing incompatibilities between home and formal Discourses, has sought to find points of contiguity. For example, rather than viewing vernacular language and scientific language as being antithetical, Warren et al. (2001) described a bilingual teacher who used everyday Haitian-Creole terms to enhance bilingual students' understandings of challenging science concepts. Lee (2007) proposed *cultural modeling* as "a framework for the design of learning environments that examines what youth know from everyday settings to support specific subject matter learning" (p. 15). Although Lee's work has primarily addressed how rhetorical practices of African American students are analogous to figurative language in literary texts, other researchers have used the concept of 'cultural modeling' to apply across other cultural groups and academic disciplines. For instance, Orellana and Reynolds (2008) showed how Latina/o immigrants' common practice of translating difficult texts for their parents can be leveraged to help them with school paraphrasing tasks. Nasir (2000) similarly illustrated how cultural displays of

African American youth, such as playing dominoes and basketball, could be connected to formal mathematical concepts such as averages and algorithms.

For many scholars (e.g., Basu & Barton, 2005; Upadhyay, 2006), the concept of "funds of knowledge" (González, Moll, & Amanti, 2005) has served as a useful heuristic for understanding these connections. Velez-Ibáñez & Greenberg (1992) define funds of knowledge as "strategic and cultural resources…that households contain" (p. 313). Moll, Amanti, Neff, and González (1992) emphasized the social nature of these resources, arguing that "social relationships facilitate the development and exchange of resources, including knowledge, skills, and labor, that enhance the households' ability to survive or thrive" (p. 133). These resources include funds of knowledge related to religion (e.g., ethical and moral knowledge); economics (e.g., labor laws and building codes); household management (e.g., maintenance and repair); construction (e.g., design and architecture); agriculture (e.g., soil and irrigation systems); and more, depending on the neighborhoods. Previous ethnographic studies have described how these funds of knowledge might be connected to formal science learning. For example, Barton and Tan (2009) and Moje et al. (2004) demonstrated that students' experiences with work outside of the home, with work inside of the home, with popular culture, with health (e.g., managing diets), with international travel, and with the environment were all generative platforms on which to base engaging, socially relevant science curricula.

We reiterate here that the framing concepts of our proposed study—including the related heuristics of 'funds of knowledge' and 'Discourses'—are inherently *social,* constructed in and through relationships, which themselves are also often vital resources that can promote or prevent ethnically diverse adolescents from pursuing STEM careers. Aschbacher, Li, and Roth (2010), for example, found that the microclimates in which adolescents participated, especially their immediate relationships, "framed students' perception of their SEM study, abilities, career options, and expected success, thereby shaping their science identities and consequent SEM trajectories" (p. 264; cf. Reveles, Cordova, & Kelly, 2004). Some microclimates may be constituted through supportive familial, neighborhood, institutional, and peer relationships, but other microclimates actively discourage people of color from pursuing STEM fields (Barton & Yang, 2000; Brickhouse & Potter, 2000; Johnson, Brown, Carlone & Cuevas, 2011). Within the field of engineering, a relatively limited body of studies (e.g., Foor, Walden, Tryten, 2007; Walden & Foor, 2008) has similarly suggested that supportive or exclusionary peer and institutional relationships can be a determining factor as to whether undergraduates who are underrepresented in engineering decide to stay in the field.

Given this body of literature, what do we mean when we state that we will examine the "social resources" available to Latina/o adolescents as they plan a community-based engineering design challenge? We mean that we will document available funds of knowledge, the types of support found in relationships, and everyday Discourse practices and values that connect to formal engineering design processes. We do not, however, believe that the end purpose of this type of research is to use adolescents' everyday resources to improve their knowledge of engineering processes, thereby privileging formal engineering processes as the end goal. Instead, we believe, along with Moje et al. (2004), that "everyday resources [can be] integrated with disciplinary learning to construct new texts and new literacy practices, ones that merge the different aspects of knowledge and ways of knowing offered in a variety of different spaces" (p. 44). In other words, as the adolescents merge their available social resources with established engineering processes, we anticipate that new Discourse practices may emerge, ones that reflect their everyday lives *and* formal engineering processes, enriching both domains in the process. Ultimately, we hope our research can help move engineering education toward this type of "third space" that integrates the first and second spaces of students' home Discourses and engineering Discourses, leading to hybrid practices and porous exchanges among them.

3.3. *Language and literacy practices*. In addition to documenting the *social resources* that Latina/o adolescents used to complete their engineering design, we also intend to document their *language and literacy practices*, including their approaches to reading and producing multi-representational and multi-lingual texts related to the project. Like Norris and Phillips (2003), we believe that successful participation in many Discourses often depends on people's ability to understand and create texts within that Discourse. To justify this assertion, Norris and Phillips argued that "science literacy," including benchmarks outlined by the American Association for the Advancement of Science (1993/2009), is derived from what they called '*fundamental literacy*,' or the ability to read and produce texts. For instance, if 'science literacy' includes "valuing evidence that can be verified, hypotheses that can be tested, and theories that can be used to make predictions" (AAAS, 2009), then this form of 'literacy' cannot be achieved without the ability to first comprehend and evaluate other scientists' reports, including tabular, graphical, and visual displays of data. Moreover, if aspiring scientists are not aware of the conventions for producing texts whose characteristics cohere with norms of science, then other scientists will not recognize them as legitimate members of the scientific community. Full participation in Discourses of science, therefore, is dependent on one's ability to both *understand* and *generate* a variety of oral, written, and multi-representational texts.

Issues surrounding fundamental literacy, or the ability to read and produce a variety of Discourse-appropriate texts, may be especially salient for adolescent English learners. Science and mathematical texts are notoriously difficult for many adolescents (and adults) to understand, regardless of their linguistic and cultural backgrounds (Halliday & Martin, 1993; Hayes, 1992). This problem is compounded by the findings of the National Assessment of Educational Progress (NAEP) (2011), which suggest that 71% of English learners in the U.S. read at a "below basic" level. Even if Latina/o English learners have strong social support networks and a desire to be engineers, therefore, they may be barred from access to this Discourse if they cannot understand texts that are relevant to engineering tasks, such as websites they read during the "information gathering" stage of the design process. Likewise, producing Discourse-appropriate texts is also challenging to many adolescents regardless of their linguistic and cultural backgrounds. Recent NAEP data (2007) indicates that only 24% of all twelfth graders in the US write at or above a "proficient" level, with Latina/o students earning significantly lower scores on writing tasks than White students. This second aspect of fundamental literacy—namely, the ability to produce Discourse-appropriate texts—may also discourage many Latina/o adolescents from pursuing engineering careers if they do not believe they have the skills necessary for effectively communicating their knowledge of engineering.

At the same time, however, we believe that Latina/o English learners' literacy skills may not be as dire as national statistics suggest. In non-testing contexts, if adolescents do not understand a particular text—for example, an English website—then they can use Google Translate to change it to Spanish; they can find another website that is written in simpler or more engaging language; and they can ask an expert on the subject to explain it to them. We believe these are all potentially powerful literacy practices that can enable adolescents' understandings of the content of a given engineering text. Moreover, there is much room for debate over what constitutes a "correct" reading of any text. Hull and Rose (1990) conducted research with a Caribbean American student whose interpretation of a text was considered "not on the mark" (p. 268) by most conventional school standards, yet the researchers' conversations with this student suggested that his understanding of the text had logically cohered with his neighborhood experiences. In the field of engineering, Bucciarelli (1994) similarly maintained that reading texts "like an engineer" is by no means an innate practice; instead, appropriate readings are learned through enculturation into the Discourse of engineering. Reading, therefore, may always be an act of interpretation shaped by one's past social and material experiences with no one "correct" reading (Rosenblatt, 1994). Similarly, Latina/o adolescents' writing skills may not be as dire as national statistics suggest. Latina/o adolescents' out-of-school texts are often produced in collaboration with other people, combining Spanish with representational forms such as music and video, which can lead to more personal investment in the writing task and to higher quality products (Wilson, Chavez, & Anders, 2012).

Under the belief that adolescents' engineering design processes are dependent on their 'fundamental literacy' and language skills, we intend to examine the language and literacy practices that formed the basis of their engineering project. By so doing, we hope to identify ways that engineering teachers might explicitly incorporate these fundamental literacy skills into their instruction. Although we were unable to find research connecting diverse adolescents' language and literacy practices to engineering, a body of research on adolescents' scientific and mathematical literacy informs the framework of our study (e.g., Draper, 2002; Klein, 2006; Moje, 2008; Wilson, 2011). Specifically, we intend to look for two types of language and literacy practices: (a) ***receptive*** language and literacy practices, such as the adolescents' approaches to *locating, comprehending*, *interpreting*, and *evaluating* a variety of oral, written, numeric, graphical, and visual texts in Spanish or English; and (b) ***expressive*** language and literacy practices, such as the adolescents' approaches to *using* and *producing* a variety of communicative tools and technologies to reason through problems and share findings. These tools include sketches, videos, numeric representations, and written and oral speech in Spanish and/or English.

What type of *receptive* language and literacy practices might the adolescents use to approach their engineering project? Researchers in the field of science education (e.g., Klein, 2006; Yore & Treagust, 2006) and literacy education (Alvermann, 2004) have suggested that 'fundamental science literacy' requires metacognition, or the ability to monitor and adjust one's cognitive processes when reading scientific texts. Metacognitive adolescents monitor their comprehension, recognize when they do not understand something, ask clarifying questions and consult outside resources, ask critical questions about the author of the text, make inferences beyond a literal level, and apply other related comprehension strategies as they seek to understand multi-representational texts in science (Alvermann & Wilson, 2011). Coiro and Dobler (2007), in their research on comprehension strategies required to understand online texts, argued that youth must make predictive inferences as they read search engine results and as they evaluate whether or not individual entries might be useful for their purposes. This process is recursive as adolescents continually develop and refine search plans and evaluate texts' utility, comparing and synthesizing what they learn across multiple sources. As the participants in our study seek information relevant to the engineering task, we intend to describe the approaches they use in *locating, understanding, interpreting,* and *evaluating* a variety of oral, digital, and printed texts, including the prior knowledge that shapes their interpretations (cf. Coiro, 2011).

In addition to examining adolescents' approaches to reading engineering-related texts, we also intend to describe the *expressive* language and literacy practices enacted throughout the engineering project. To this end, we draw heavily from diSessa's (2004) conception of 'metarepresentational competence.' DiSessa coined this term to describe how students in mathematics and science use task-specific parameters (e.g., the need to represent rate) and their knowledge of the purpose of different kinds of representation (e.g., uses for line graphs) to choose representations that most fully enable them to achieve a particular purpose. DiSessa also used this term to explain how novices can generate representations even when they have not yet learned the formal conventions of a particular Discourse. In describing this latter aspect of metarepresentational competence, diSessa and colleagues (diSessa, Hammer, Sherin, & Kolpakowski, 1991) argued that youth draw from a variety of representational resources, such as their experiences with sketching and their use of color, to communicate mathematical concepts even before they have been introduced to standard notations. Because we will work with adolescents who likely will not have extensive experiences with the formal conventions of texts in engineering, we intend to document how they draw from available representational and communicative repertoires (e.g., experiences with designing digital texts) to solve problems and share their findings.

We do not believe that the above list is an exhaustive account of the expressive and receptive language and literacy practices that the adolescents will use throughout the engineering design process. We anticipate that other practices will be relevant to the engineering project as well—for instance, the ability to speak in English and Spanish to various stakeholders and collaborators. The aforementioned studies simply point toward the general types of language and literacy practices that we will examine, while simultaneously looking for literacy practices that we did not anticipate. We hope that this examination will provide a body of knowledge that can improve the instruction of engineering teachers who seek to support their students' reading and representational skills.

3.4. *Reciprocity among elements of model.* We close this description of the 'sociocultural model of adolescent engineering design processes' by clarifying that we view all three domains of the model—design processes, social resources, and language and literacy practices—as being mutually constitutive and reinforcing. Design processes, for example, entirely depend on receptive literacy practices such as locating and comprehending relevant texts during the information gathering stage, and expressive literacy practices such as producing representations used to reason about the design. Furthermore, although our visual model (Figure 1) separated "language and literacy practices" from "social resources," in essence we believe that language and literacy practices *are* a social resource, tightly intertwined with one's identity and participation in engineering Discourses. Moreover, we believe that the three domains are in some ways interchangeable; for instance, if one adolescent cannot understand a particular website (e.g., categorized as an ineffective *receptive literacy practice*), then he or she may know somebody in the neighborhood who can explain similar concepts more easily than the website (e.g., categorized as effectively drawing from a *social resource*). The contextualized nature of this sociocultural model enables us to paint a situated picture of adolescents' engineering design processes, which heretofore has been absent from the research literature.

4. Research Questions

1. *What design processes, social resources, and language and literacy practices do the Latina/o English learners use as they worked toward implementing a community-based engineering design?* Grounded in our theoretical model, this first research question seeks to identify potential connections among formal engineering design processes and adolescents' social resources and literacy practices. By identifying points of connection across the three domains, this study will provide a body of knowledge that works toward the construction of a "third space" in engineering education (cf. Moje et al. 2004), one that blurs boundaries between Latina/o adolescent' home Discourses and literacy practices, and formal engineering Discourses and literacy practices.

2. What challenges do the adolescents face as they seek to select and implement the design, and how do they seek to overcome these challenges? Unlike the first research question, whose purpose was to identify possible points of connection between everyday and engineering Discourses, the purpose of this second question is to identify possible *dis*connections between them. Conflicts between adolescents' everyday and engineering Discourses may be one challenge that limits design activity. Other challenges might include difficulties with reading and writing engineering texts; still other challenges may be related to unsupportive social networks. Whereas the first question will lead to a body of knowledge about the funds of knowledge that can be connected to engineering design processes, this second question will identify potential difficulties and tensions that engineering teachers can help their students overcome as they conceptualize and realize their designs.

3. Do adolescents' perceptions of engineering and their willingness to view themselves as future engineers change after participating in the community-based engineering project? If so, how do they change? To many Latina/o adolescents, the field of engineering is simply 'not me'; consequently, the purpose of this third research question is to address issues related to identity construction. The community action component of this study is expressly designed to show adolescents that engineering is not separate from the social networks and cultural values available in their neighborhoods; instead, engineering activities can draw from these networks and values in service of enhancing their local communities. Through providing in-depth descriptions of changes in adolescents' identities, including possible identities as 'future engineers,' this study will contribute to a body of knowledge on how to make engineering education more inclusive of diverse populations.

5. Research Design

Like previous studies that documented connections between students' funds of knowledge and formal scientific and mathematical Discourses (e.g., Basu & Barton, 2005; Moje et al. 2001; Nasir, 2002), this study is based on ethnographic methods of data collection and analysis (e.g., Barton, 2001; Murillo, 1999). As researchers who had studied connections between African American students' cultural practices and formal mathematics, Nasir and Saxe (2003) asserted that "ethnographic techniques are well-suited for identifying important sites for analysis in which tensions between ethnic and academic identities may arise" (p. 16). Kelly, Chen, and Crawford (1998) similarly argued that ethnographic inquiry is essential for describing scientific activities situated within local, social, and cultural contexts. Although the field of engineering education is not characterized by a robust history of ethnographic research to the same extent as other STEM fields (Godfrey & Parker, 2010), Foor, Walden, and Tryten (2007) nonetheless argued that qualitative methods are necessary in engineering educational research because they provide "a microphone for the voices of the marginalized to be heard. Ethnography of the particular allows us to hear each and every voice that would otherwise be lost in…statistical analyses" (p. 113). In sum, this study is grounded in a large body of theoretical and research literature suggesting that ethnographic methods are fitting for research purposes that seek to connect adolescents' everyday Discourses with formal engineering processes.

This study does not, however, purport to be an objective description of adolescents' naturally-occurring engineering activities from the perspective of a proverbial "fly on the wall." Instead, it draws from critical ethnographic traditions (Barton, 2001; Carspecken, 1996), which assert that the design of the ethnography should promote positive social change. In our proposed study, Latina/o adolescents will interview their neighbors and community leaders, asking them to identify a pressing local problem that will serve as the basis for the design challenge. If necessary, the researchers will provide minimal intervention to ensure that the adolescents' selected design challenge can be addressed through engineering. Participants will then work toward realizing a design that solves the problem. Depending on the nature of the problem, some designs may be impossible for the adolescents to implement fully, but they will be able to present a well-developed model to community leaders. This study is therefore intended to be a catalyst for community action and positive change, incorporating elements of "critical social relevance" that Buxton (2006) has asserted is essential to powerful science learning.

This ethnographic study requires researcher intervention in at least one other way as well. Many Latina/o English learners may not have the technological and material resources necessary to complete the design challenge; consequently, it may be necessary to provide these materials for them (e.g., a laptop computer and wireless access). Because many adolescents do not have easy access to school and library computers—and because the theoretical model of this study assumes that many young people do not want to be seen hanging around school for hours after the regular school day is over—the participants must have easy, consistent access to these technological resources at home to enable them to enact engineering design processes, such as information gathering.

5.1. *Timeline of activities.* The ethnographic research will be conducted over the course of three years. The first year will include a pilot study in which approximately four Latina/o adolescents from the same community will identify an engineering design project and work toward implementing it. Upon completion of the pilot project, the advisory committee will review the data collection instruments, the observation and interview techniques, and the data analysis methods. The data collection techniques and data analysis methods will be revised prior to Year Two of the study based on feedback from the advisory committee, the graduate assistant, and the research participants. Year Two will include a scaled-up version of the ethnography, in which two groups of five to seven adolescents will identify a need in their respective communities and will spend the remainder of the school year on addressing that need through an engineering design. Due to the copious amounts of qualitative data we will have collected, Year Three will be devoted to analyzing data in conjunction and cooperation with the research participants, the graduate assistants, and the advisory committee. (See Figure 2 for a detailed timeline of activities.)

5.2. *Participant selection.* Dr. Christine Hailey, co-PI, has established relationships with advisors of high school MESA (Mathematics, Engineering, Science Achievement) chapters throughout Utah. We will use this after-school program as a venue for introducing the research project to Latina/o students, asking them if they are interested in participating along with a few of their friends. PI Dr. Amy Alexandra Wilson formerly taught and tutored in a local Upward Bound program for over five years; the director of this program also expressed her interest in allowing us to introduce the challenge to Upward Bound students. Because MESA is a program targeted toward ethnically diverse adolescents, and because Upward Bound is a program targeted toward ethnically diverse first-generation college students, we hope to find several participants who meet our selection criteria (e.g., Latina/o, English learner, high school student), who are willing to participate in the project, and whose friends are also willing to participate in the project. In all, up to 18 participants (4 in the first year and 14 in the second year) will be selected through a combination of direct recruitment and peer recommendations.

5.3 *Graduate assistant selection and mentorship.* We will select two graduate students to assist with data collection based on three criteria: They must be (a) bilingual in Spanish and English; (b) committed to serving populations who are underrepresented in STEM fields; and (c) familiar with research in relevant fields, such as anthropology, education, engineering, literacy, linguistics, and cultural studies. Preference will be given to Latina/o graduate students in the field of engineering. One graduate assistant (GA) will help with data collection during the first year, collaborating closely with participants in the pilot study, conducting interviews in Spanish and/or English, and shadowing the adolescents as they complete relevant design activities, such as collecting data from their communities. In Year Two, a second GA will be added to the project. GA1 will work with one group of adolescents, while GA2 will work with the second group, conducting similar activities as in the pilot study. Both GAs will participate in data analysis in Year Three.

Activity	Year One			Year Two			Year Three		
	T1	T2	T3	T1	T2	T3	T1	T2	T3
Phase I: Pilot Study									
Study group with first graduate assistant	X	X	X						
Consultation with advisory committee	X								
Select participants	X								
Life history interviews; introductory interviews	X								
Participants interview community leaders and identify need	X								
Community observations with participants	X	X							
Begin design challenge		X							
Concurrent and retrospective protocols		X							
Interviews on design processes, social resources, and language and literacy practices		X							
Video-record group discussions on design challenge		X							
Present design to community		X							
Final reflective interviews with students			X						
Complete member checking and co-analysis of data			X						
Consultation with advisory committee members			X						
Revise interview protocols and data collection techniques			X						
Phase Two: Ethnographic Study with Two Groups									
Study groups with both graduate students			X	X	X	X			
Select participants			X						
Life history interviews; introductory interviews			X						
Community observations with participants			X	X					
Participants interview community leaders and identify need			X						
Begin design challenge				X					
Concurrent and retrospective protocols				X	X	X			
Interviews on design processes, social resources, and language and literacy practices				X	X	X			
Video-record group discussions on design challenge				X	X	X			
Present final draft model to community					X				
Revise draft and build model					X	X			
Obtain feedback from community						X			
Participants make digital stories of design process						X			
Final reflective interviews with students						X			
Ongoing member checking and co-analysis of data					X	X	X	X	
Consultation with advisory committee members						X			
Phase Three: Finalize Analysis, Publish Results									
Constant comparative analysis across three groups							X	X	
Continue discourse analysis							X	X	
Continue analysis of multimodal concordance charts							X	X	
Final evaluative meeting with advisory committee								X	
Write findings								X	X

Figure 2. Timeline of proposed activities. Trimester one extends from August 15 to December 1; trimester two extends from January 1 to May 30; and trimester three extends from June 1 to August 14.

Ongoing mentorship for GAs is built into the research design. For instance, prior to the pilot study, GA1 will read articles related to funds of knowledge, engineering design, and culturally responsive ethnographic research. The GA will discuss these articles with the PIs, identifying implications for data collection techniques. GA1 will consult with advisory committee members and the PIs after the pilot study is over, reflecting on the results from the pilot study and providing recommendations for adjustments to the study in Year Two. Prior to Year Two, GA1 will also offer advice to GA2 during a summer study group, which will again include reading and discussing relevant articles and their implications for data collection techniques. Finally, the GAs will participate in ongoing reflective study groups in which they identify adjustments they can make to their data collection procedures. Near the end of each year, these study groups will also include discussions of data analysis. By giving preference to Latina/o graduate students in engineering, this grant application further works toward racial equity in engineering education.

5.4. *Data sources*. We will collect five types of data over the course of the first two years. First, we propose to conduct different types of *interviews* with the participants, their parents, and relevant stakeholders, such as community leaders. In all, five different types of interviews will be conducted. First, at the outset of the study, we will conduct life history interviews (Atkinson, 1998; Vélez-Ibáñez, & Greenberg, 1992) with the participants and their parents in order to identify relevant funds of knowledge available in their households and neighborhoods. Second, we will conduct another initial interview with the adolescents to address their perceptions of engineering, their sense of self-efficacy in engineering, and their degree of perceived social support for participating in engineering, using modified versions of existing interview protocols and survey questions (e.g., Basu & Barton, 2005; Hailey, Austin, Denson, & Householder, 2011). Third, we will conduct ongoing interviews (approximately once every three weeks) with the adolescents in which we ask open-ended questions intended to elicit information about their design processes, social resources, language and literacy practices, challenges in completing the project, and approaches to overcoming those challenges. Specific research questions will arise based on what we learned from previous data (Rubin & Rubin, 2005). Fourth, we will conduct one interview with relevant community stakeholders in which we seek to ascertain their perceptions of the adolescents and their designs. This type of interview is necessary because one “social resource” in our model includes how the participants are perceived by others. The fifth type of interview will be a final reflective interview with the adolescents in which we ask questions related to the following domains: (a) their current perceptions of engineering and their willingness to pursue a career in engineering (as a follow-up to the initial interview on the same subject); and (b) their overall reflections on completing the engineering design project. These interviews will be held in the adolescents’ homes or other community locations, such as local libraries (González, Moll, & Amanti, 2005).

The second type of data, *adolescent-generated products,* will include the following: informal representations generated throughout the design process; a record of the websites that they visited in relation to the engineering design task, as recorded through a tracker placed on the their laptops (they will be aware of the presence of this tracker); more formal products, such as drafts of their final designs; and other relevant artifacts. For example, if we find that certain aspects of their design (e.g., informal diagrams) are similar to their recreational drawings, we may request that they share a few recreational drawings with us so that we can describe how their everyday communicative practices can be connected to their engineering communicative practices. Finally, we will ask the adolescents to generate a digital story (Hull & Nelson, 2005) at the end of the project to present to the community. Their digital stories will explain their final design, the need for the design, the process of making the design, and the impact that it will have on the community. We will post these digital stories on a website so other adolescents can access them.

The third type of data, *retrospective and concurrent protocols* (Ericcson & Simon, 1993; Smagorinsky, 1994)*,* will require adolescents to articulate their thinking as they read and generate texts relevant to the design process. Each adolescent will conduct one concurrent protocol in which they explain what they are thinking as they search for relevant information and read an engineering text. Each adolescent will also participate in at least one retrospective protocol in which we show them *adolescent-generated products* (e.g., diagrams, models) and ask them to explain what they were thinking as they produced those texts.

The fourth type of data is *transcripts* of audio- or video-recordings of adolescents’ conversations with each other and with community stakeholders. We will video-record several meetings in which adolescents speak with each other to discuss their project; we will also ask the adolescents to audio-record relevant conversations they have with community stakeholders and each other when the researchers are not present.

The fifth and final source of data is *field notes and photographs* from observations (Emerson, Fretz, & Shaw, 1995). At times, we hope that the GAs and PI will be able to shadow the adolescents as they go about everyday community activities (cf. Moje, 2004). For example, at the outset of the project, we will ask the adolescents to show us around their neighborhoods, explaining and pointing out their favorite locations or showing us 'problem areas' (e.g., areas with high erosion) that we will photograph. We also intend to take field notes on major events throughout the design process, such as when the adolescents present the final product (or model) to community stakeholders. (See Figure 3 for a chart explaining how each data source responds to each research question.)

Research Question	**Relevant Data Sources**	**Analytic Methods**
What design processes, social resources, and language and literacy practices do the Latina/o English learners use as they work toward implementing a community-based engineering design? (Note: DP, LLP, and SR indicate that the data source is intended to ascertain design processes, language and literacy practices, or social resources.)	-initial life history interviews (**SR**) -field notes from community observations (**SR, LLP**) -concurrent and retrospective protocols on reading and production of engineering texts (**LLP, DP**) -ongoing interviews about challenges faced, social resources used, etc. (**SR, LLP, DP**)	constant comparative analysis (CCA)
	-products generated by adolescents, such as drawings and digital stories (**LLP, DP**)	multimodal concordance charts
	-audio- and video-recordings of conversations with community leaders and each other (**SR, DP**)	discourse analysis; CCA
What challenges do the adolescents face as they seek to select and implement the design, and how do they seek to overcome these challenges?	-field notes from community observations -concurrent and retrospective protocols on reading and production of engineering texts -ongoing interviews	CCA
	-audio- and video-recordings of conversations	discourse analysis; CCA
How do the adolescents' perceptions of engineering and their willingness to view themselves as future engineers change after participating in the community-based engineering project?	-initial interviews and post-project interviews about perceptions of engineering and anticipated career trajectories	CCA

Figure 3. Data sources that respond to each research question.

5.5 *Data analysis*. We will use three qualitative analytic methods to understand different aspects of the data. A modified version of *constant comparative analysis* (Strauss & Corbin, 1998) will be the prominent analytic method used to interpret a majority of data sources. Although CCA was originally developed as an extension of 'grounded theory' (Glaser & Strauss, 1967), in which the researchers allegedly have no preconception of the categories that they will find, our version of CCA will be shaped by our theoretical model and by previous research connecting adolescents' everyday Discourses to science Discourses (e.g., Barton & Tan, 2009; Moje et al. 2001). For example, we anticipate that possible superordinate codes for our first research question will be *design processes, language and literacy practices,* and *social resources.* We will develop sub-categories that classify adolescents' activity under each domain, using anticipated labels such as 'funds of knowledge drawn from popular culture' (to quote from an example in Moje et al.'s 2004 study) to categorize particular excerpts from the data. The PIs and GAs will work together to develop clearly defined codes that are simultaneously grounded in previous research, in findings from the pilot study in Year One, and in data from Year Two. At the end of Years One and Two, we will share our coding system with members of the advisory committee and the research participants in order to receive their feedback prior to applying these codes to the entire data set.

We will also use Gee's (2005) *discourse analytic methods* to interpret the adolescents' conversations with each other and with community leaders. These methods were based on Gee's concept of Discourses and were intended to identify the identities and values that speakers communicate to others. This method will enable us to identify the specific Discourses enacted by the adolescents as they make decisions regarding the designs.

The third and final analytic method, *multimodal concordance charts* (Baldry & Thibeault, 2006), will be applied to the adolescent-generated products. We anticipate that the participants will generate multiple forms of representation (e.g., numeric, visual, written) throughout the course of the project. Multimodal concordance charts are useful for understanding specific components of each mode (e.g., a particular shape in an image) as well as for understanding how different modes as a whole work together to produce a coherent meaning (e.g., how images and words each contribute unique information to the overall message of the text). Multimodal concordance charts are also useful for comparing related texts across time (e.g., comparing the components of an informal drawing to the components of a formal diagram). These charts will enable us to discern the language and literacy practices that have been instantiated in the adolescents' representations, including how the representational resources used in their engineering texts can be traced back to their everyday representational practices.

6. <u>Advisory Committee/Project Evaluation</u>
Our advisory committee is comprised of six members whose respective areas of expertise correlate with our theoretical model. Distinguished Research Professor **Donna Alvermann** (University of Georgia) and Jewell M. Lewis Distinguished Professor of Reading **Patricia Anders** (University of Arizona) have agreed to advise and evaluate the project in regards to the adolescents' *language and literacy practices*. Professor **Luis Moll** (University of Arizona) and **Dr. Silvia Nogeurón-Liu** (University of Georgia) have agreed to evaluate and advise the project in regards to the adolescents' *social resources.* **Dr. Christine Cunningham** (Museum of Science in Boston) and doctoral candidate **Malinda Zarske** (University of Colorado) have agreed to advise and evaluate the project in regards to *engineering design processes.* All members of the committee will provide the following services: (a) initial advice on our research design and data collection instruments; (b) formative feedback at the end of the pilot study, which we will incorporate into our data collection and analysis procedures in Year Two; (c) evaluative feedback near the completion of the third year.

Drs. Alvermann and Anders, former past presidents of the Literacy Research Association, are both internationally recognized scholars who have conducted qualitative research with culturally diverse adolescents. Their research has connected adolescents' everyday literacy practices and academic literacy practices; moreover, they have both published dozens of books and peer-reviewed articles about science and mathematical literacy. **Dr. Moll** is attributed with developing the concept of "funds of knowledge," a foundational principle of our study. As a Co-PI on the CEMELA (Center for the Mathematics Education of Latinos/as) project, he has conducted research connecting Latinas/os' funds of knowledge to formal mathematical concepts. **Dr. Nogeurón-Liu** has likewise studied the funds of knowledge available in Latina/o immigrant households; her work describes how Latina/o parents use digital resources to accomplish necessary legal and economic tasks. The National Science Foundation has funded previous engineering studies authored by **Dr. Cunningham**, who has developed curricular materials that connect engineering processes to the backgrounds of culturally diverse students. **Ms. Zarske** is completing her dissertation on the impact of hands-on, altruistic engineering design experiences for high school students, and she is the content editor for TeachEngineering's digital library. In sum, the background of each committee member has prepared them to effectively advise different aspects of the project.

At the outset of the project, we will ask Drs. Moll and Noguerón-Liu to evaluate the cultural responsiveness of our interview protocols and data collection methods. Alvermann, Anders, Cunningham, and Zarske will also review our data collection instruments to ensure that they have the potential to "get at" the adolescents' engineering design processes and language and literacy practices. After the pilot study, the entire advisory committee will re-evaluate the data collection instruments, providing feedback on how well these instruments collected information about the adolescents' social resources, language and literacy practices, and engineering design processes. The advisory committee will also review our initial analyses, and we will use their feedback to refine our data collection techniques and analytic methods prior to Year Two. Finally, one expert from each domain (language and literacy practices, social resources, and engineering design processes) will evaluate the findings and the initial write-up of the report near the end of Year Three. They will also evaluate the degree to which the researchers identified connections between the adolescents' everyday Discourses and engineering Discourses.

7. <u>Expertise/Project Responsibilities</u>

Dr. Amy Alexandra Wilson, PI, Assistant Professor of Adolescent Literacy at Utah State University, will be responsible for the development and oversight of the three phases of the project and the reporting of the research. Her vita includes over 50 international and national peer-reviewed conference presentations on scientific literacy and adolescent identity. She has published research on the in-school and out-of-school literacy practices of diverse adolescents, including Mexican immigrants and Native Americans. She has also published research that uses sociocultural theoretical frameworks to explain scientific and mathematical literacy. Dr. Wilson has a qualitative research certificate and will be responsible for ensuring that the data collection and analysis techniques are both culturally responsive and rigorous. This study builds on her research trajectory, which has connected scientific literacy practices with adolescent identity, by showing how engineering Discourses can be related to Latina/o adolescents' everyday Discourses.

Dr. Christine Hailey, Co-PI, is Executive Associate Dean of the College of Engineering and Professor of Mechanical and Aerospace Engineering at Utah State University. She will provide content expertise in engineering based upon her experience in engineering research, the administration of engineering programs, and engineering education. She is currently PI of two related NSF projects: (a) the National Center for Engineering and Technology Education; and (b) The Influence of MESA Activities on Underrepresented Students. The work of both of these projects, including her findings on supporting underrepresented students, will enhance this proposed project.

Dr. Daniel L. Householder, Co-PI, Research Professor of Engineering and Technology Education at Utah State University, will assist in managing the project, including responsibilities for liaison with stakeholder groups, technical support, and data analysis. His career includes experiences as a high school technology teacher, responsibilities for technology teacher education, graduate advisement, project management, and leadership in professional organizations. His recent research efforts (2011) have addressed the identification and sequencing of authentic engineering design challenges for high school STEM courses.

8. <u>Intellectual Merit and Broader Impact</u>

After reviewing articles from the *Journal of Engineering Education* over the past decade, Stevens et al. (2008) found that ethnographic studies were relatively unusual in this field, leading to a lack of understanding about the cultural norms of engineering education. Godfrey and Parker (2010) echoed the same assertion two years later, noting that almost all ethnographic research in engineering education (e.g., Lewis, Mclean, Copeland, & Lintern, 1998; McIlwee & Robinson, 1992; Stoyner, 2002) "has arisen in the context of women's lack of participation" (p. 5). We add here that most previous ethnographic research in engineering education has also arisen in the context of post-secondary education (Dryburgh, 1999; Foor, Walden, & Tryten, 2007; Walden & Foor, 2008; Walker, 2001) or engineers' workplaces (Buciarelli, 1994). We were unable to locate research that investigated how Latina/o adolescents' cultural values, linguistic practices, and bodies of knowledge could be connected to engineering design processes. This study therefore fills a conspicuous gap in the research literature and is an essential step toward providing culturally and linguistically responsive engineering instruction in secondary schools.

We do not assume that the findings of this study are generalizable to a larger population; on the contrary, the funds of knowledge available in adolescents' communities are as diverse as the neighborhoods in which they live. At the same time, this study will generate frameworks for understanding the types of social resources and the types of literacy practices that are relevant to engineering processes. The purpose of this exploratory study is to generate knowledge; we do not propose the creation and dissemination of curricular materials or professional development models as part of this particular grant.

We assert, however, that the knowledge generated in this study is essential for creating future curricular materials and professional development models that will enhance engineering education for culturally diverse students. We intend to use the knowledge generated in this study to apply for future grants in which we develop those materials and models based on what we learn from this study. We will disseminate these materials to secondary schools, much as project advisor Christine Cunningham developed and disseminated culturally responsive engineering materials to hundreds of elementary schools.

Moreover, we will publish our findings in peer-reviewed practitioner and educational research journals, such as the *Technology and Engineering Teacher, Journal of Adolescent & Adult Literacy, American Educational Research Journal, Journal of Engineering Education, Anthropology & Education,* and *Reading Research Quarterly.* We will present the findings at national and international conferences held by organizations such as the *American Educational Research Association* and the *American Society for Engineering Education.* Lastly, the adolescents themselves will play a role in dissemination; other engineering teachers can access their digital stories and use them as models for their own students. Malinda Zarske, advisory committee member and editor of TeachEngineering.com, will advise us regarding how to disseminate this project to engineering teachers through a variety of digital platforms. In this way, culturally diverse high school students from around the world can hear, from adolescents who are “like me,” that engineering can be used to enhance one’s community without necessarily conflicting with one’s identity.

9. <u>Results from Prior NSF Support</u>

This research builds on findings from previously funded grants that sought to examine and influence cultural norms in engineering education programs. Christine Hailey served as Co-PI of two successfully completed awards: Advance-US: Applying a Business Model to a University, #0144922, which addressed departmental climates, policies and procedures, and the faculty support infrastructure to improve recruitment, promotion, and retention of women faculty in science and engineering at Utah State University; and GSE/RES Learning Companions as Change Agents: Improving Girls’ Self-Efficacy Beliefs in Learning Math, #0522634, which studied the effectiveness of pedagogical agents (virtual peers) in increasing the self-confidence and self-efficacy of ninth grade girls in learning mathematics. Dr. Hailey is PI of The Influence of MESA Activities on Underrepresented Students, #1020019, which is making good progress in its research program. She is also PI (and Daniel Householder is Co-PI) of National Center for Engineering and Technology Education, #0426421, which is nearing the completion of its program of capacity building in engineering and technology education and studies of engineering experiences for high school students. Dr. Householder was PI of Career Curriculum for Technology Project, #0603403, which successfully prepared the high school textbook, *Engineering and Technology*.

10. <u>Conclusion</u>

We return to our initial description of Gabriela, a (fictional) adolescent whose online literacy practices and neighborhood resources provided a rich wealth of resources relevant to engineering. Her experiences with online games, for example, showed that she understood constraints relevant to engineers, such as a limited amount of currency with which to buy land and a limited amount of time to grow crops. Her experiences at church indicated a familiarity with the ethics of engineering, such as a commitment to sustainability and to enhancing the lives of all people. Her drawing expertise could be applied to engineering diagrams, while her experiences with locating and translating texts for her father could be applied to locating and translating relevant engineering information. Her neighborhood network—comprised of people who understood legal codes, agriculture, economics, and construction—represented a rich wealth of social resources from which she could draw throughout the engineering process. They also represented a rich network of social support that could build her self-perception as a competent contributor to the neighborhood. Adolescents such as Gabriela should no longer be excluded from the field of engineering because teachers do not know how to connect their everyday worlds to the formal Discourses of engineering. This study moves toward more culturally and linguistically responsive engineering instruction that “takes as its starting point the interests, perspectives, desires, and needs of the students” (Buxton, 2006, p. 701). This starting point is necessary for building a body of curricular materials and instructional practices that make engineering more appealing and meaningful to diverse adolescents.

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Amy Alexandra Wilson, Ph.D.

Professional Preparation

English and History	Westminster College of Salt Lake City	Bachelor of Arts June 2002
Teacher Education	Brigham Young University	Master of Arts August 2006
Language and Literacy Education	University of Georgia	Doctor of Philosophy August 2011

Appointments

8/11-present	Assistant Professor of Adolescent Literacy, School of Teacher Education and Leadership, Utah State University
8/06-7/11	Instructor, Department of Language and Literacy Education, University of Georgia

Five Peer-Reviewed Publications Related to Project

Wilson, A. A., Chavez, K., & Anders, P. (2012). “From the Koran and Family Guy”: Expressions of identity in English Learners’ digital podcasts, *Journal of Adolescent & Adult Literacy, 55,* 374-384.

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Five Additional Publications

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Synergistic Activities

I have been the sole author and primary investigator on four national grants and one state grant related to adolescent identity and/or content area literacy. Three grants are particularly relevant to the current proposal. The National Academy of Education, funded by the Carnegie Corporation of New York, supported my proposal to study the different types of representation used in middle school science and mathematics classrooms. The International Reading Association funded a study examining the impact of professional development on science and mathematics teachers' content area literacy instruction. This organization also funded a study about Native American adolescents' literacy practices in science and mathematics. All grants have resulted in numerous national/international conference presentations, practitioner publications, and publications in peer-reviewed research journals. The findings from these past studies, as well as findings from the current study, will help me to develop professional development models for engineering teachers, which will address ways they can provide culturally and linguistically responsive engineering instruction to diverse students.

In addition to publishing research related to science literacy and adolescent identity, I have also demonstrated a strong commitment to disseminating my results to classroom teachers. I have delivered dozens of workshops to teachers and instructional coaches who attended national conferences such as the National Council of Teachers of Mathematics and the International Reading Association. These workshops offered practical suggestions for using literacy instruction to enhance scientific inquiry and suggestions for providing critical numeracy and literacy instruction in mathematics and science.

Along with my college degrees, I earned a Qualitative Research Certificate (University of Georgia); a reading endorsement (Brigham Young University); and an English as a Second Language Endorsement (University of Utah). For over five years, I taught culturally and linguistically diverse students in classroom settings and in out-of-school settings in Salt Lake Valley, our proposed research site. Lastly, I have served as lead editor of the *Journal of Language and Literacy Education* and the *American Reading Forum's Annual Yearbook.* I am also President-Elect of the American Reading Forum.