TITLE – Explore STEM Content & Culturally Relevant Pedagogy: A Case Study Exploration of NASA's *Orion* Ascent Abort-2 Flight Test and the Office of STEM Engagement

ABSTRACT

To support educators and NASA's *Orion* Ascent Abort-2, education specialists partnered with the Flight Test Management and Public Affairs Offices to create interdisciplinary experiences connecting NASA-unique assets, STEM content, and engineering careers. Using mixed methods, this paper explores a digital badge's impact on engineering professors' and pre-service teachers' instructional practices.

PROPOSAL

Introduction

On March 2, 2019, the unmanned and reusable *Crew Dragon* space capsule, designed by SpaceX, lifted off from the Kennedy Space Center on a mission to dock with the International Space Station (ISS) (Heiney, 2019). With *Crew Dragon*'s successful berthing a few days later, SpaceX became the first commercial entity to successfully establish that its spacecraft could deliver U.S. astronauts to the ISS (NASA, 2016). SpaceX's accomplishment gives students and educators glimpses into exciting new careers that will extend the frontier of space while also making it more accessible to more civilians.

However, "dreams of expanded space exploration…run the risk of being unsustainable. If a highly trained, technical American [workforce] cannot be found, we will lose to foreign countries" (Space Frontier Foundation, 2012). Workforce shortages are closely linked to deficits in STEM education, especially at the postsecondary level (National Science Board, 2018; Organization for Economic Cooperation and Development, 2016; Provasnik, Malley, Stephens, Landeros, Perkins, & Tang, 2017; Rosenberg, 2018). In response to the perceived crisis, policy makers search for solutions, focusing either on strengthening the nation's instructional workforce, increasing student engagement with STEM content through innovative pedagogies, or both (Bottia, Stearns, Mickelson, Moller, & Valentino, 2015; Darling-Hammond, Hyler, & Gardner, 2017; Garner & Gallo, 2005; Hewson, 2007; Lu & Han, 2018; Opfer & Pedder, 2011; Reese, 2011; Tal, Krajcik, & Blumenfeld, 2006). Strategies that target students, pre-service teachers and university STEM professors can provide powerful catalysts to ensure America's technological prominence as the nation aims to return astronauts to the Moon.

Anticipating the potential crisis, the National Academy of Engineering (NAE) (2004) commissioned *The Engineer of 2020*, a comprehensive report of how future engineers should be prepared for differing leadership roles in traditional and non-traditional careers. Authors acknowledged that these engineers would continue to devise solutions to various engineering problems, but that those challenges would become ever more complex (NAE, 2004). Future engineers might utilize foundational knowledge, but they would have to integrate it with information from multiple disciplines that may or may not be within traditional engineering (Lattuca, Knight, Ro, & Novoselich, 2017; NAE, 2004). Such interdisciplinary perspectives would be what distinguished 'the engineer of 2020' (NAE, 2004).

To prepare these individuals for those multifaceted, complex problems, the NAE authors agreed that engineering students' education had to be ground in an interdisciplinary framework (NAE, 2004). However, two National Science Foundation (NSF) studies illustrated just how much work remains to be done to transform higher education's disciplinary present to NAE's interdisciplinary vision. Engineering program chairs and faculty continue to emphasize design

and professional skills over interdisciplinarity (Lattuca, Terenzini, Knight, & Ro, 2014). Most professors frequently understood interdisciplinarity to represent integration of knowledge across various engineering fields rather than integration of engineering and non-engineering knowledge (Lattuca *et al*., 2014). By contrast, alumni reported that interdisciplinary perspectives were valued much more in their employment than in their coursework (Lattuca *et al*., 2014). Being able to communicate, integrate knowledge, and find 'common ground' leads to functional interdisciplinary communities and project success (Bromme, 2000; DuRussel & Derry, 2005; Repko, 2007).

"For the first time in a generation, NASA is building a human spacecraft for deep-space missions, …including to the vicinity of the Moon and Mars" (NASA, 2017). NASA had originally planned a series of flight tests for the full *Orion* Launch Abort System (LAS) before its final integration with the *Space Launch System (SLS)* for the Exploration Mission-1 (EM-1). However, given budgetary and time constraints, the Agency will conduct two: Pad Abort-1 (PA-1), which occurred in 2010, and Ascent Abort-2 (AA-2), tentatively slated for June 2019. The Flight Test Management Office (FTMO) team created two hands-on instructional activities to engage audiences with their LAS research during the Langley Research Center's Centennial Open House. Observing the success of those activities led the FTMO team, along with their Public Affairs Office (PAO) Specialist, to partner with the Office of STEM Engagement (OSTEM) to "market" the resources to educators and students as *Orion*'s 2019 AA-2 flight test approached. This unique partnership has produced several products, including an online micro-credential.

Study Objectives

The purpose of this paper is to examine utilization of an interdisciplinary engineering micro-credential by university engineering professors and pre-service STEM teachers. This digital badge blends information from the *Orion* Launch Abort System, physics and engineering concepts, and workforce development. It also incorporates interdisciplinary and culturally relevant teaching (CRT) perspectives. Thus, the study's three objectives are:

1) To determine whether or not university professors and pre-service STEM teachers utilize interdisciplinary content from an online engineering micro-credential,
2) If so, to document how they incorporate interdisciplinary content into their instructional practices, and
3) If not, to explore why educators choose not to incorporate interdisciplinary content into their instructional practices.

Conceptual Framework

Temperament refers to an individual's unique behavioral characteristics, which can influence judgment and decision-making (Chess & Thomas, 1996). Despite prevailing notions that behavioral characteristics were solely in response to environmental influences, Chess and Thomas (1996) demonstrated that temperament is more innate; behavior either fits with an environment or not. As a result, Chess and Thomas (1996) coined the term, 'goodness-of-fit,' to represent the consonance between an individual's "capacities, motivations, and style of behavior and the environmental demands and expectations…[that]…potentiates optimal positive development" (p. 52). Conversely, mismatches between temperament and environmental opportunities create 'poorness-of-fit,' leading to dissonance and situational avoidance (Chess & Thomas, 1996). For the current study, an engineering professor's, or pre-service STEM

educator's, decision to utilize interdisciplinary content from an online micro-credential in their courses may result from a match with their motivations (goodness-of-fit) or not (poorness-of-fit).

Research Plan/Study Methods/Modes of Inquiry

This research intends to employ a mixed-methods case study design because of its interdisciplinary perspective (Creamer, 2017; Creswell & Plano Clark, 2011; Morgan, 2016; Stake, 2000). Case study methodologies can facilitate exploratory research about the online engineering micro-credential of interest and its potential impacts on the real-life decisions educators make regarding their instructional practices (Creswell, 2013; Stake, 2000). An online survey composed of Likert scale and free-response questions will collect quantitative and qualitative data regarding awareness of the online engineering micro-credential, knowledge of its interdisciplinary content, and intentions to use that content. From the survey, participants will self-select into the second qualitative data collection phase. If an educator indicates that they will use the micro-credential's interdisciplinary content, then the researcher will invite those individuals to participate in either an interview or focus group that explores how they incorporated the content. Participants will also be encouraged to consider submission of artifacts documenting use of the interdisciplinary content. If an educator indicates that they do not intend to use the interdisciplinary content, then the researcher will invite those individuals to participate in an interview that explores their reasons for not doing so.

Data Sources/Evidence

During its development, the badge's unique approach captured the interest of an international engineering professionals' organization. The organization's President, Technical Vice President, and Vice President for Academic Affairs are working with NASA education specialists on how best to disseminate this interdisciplinary micro-credential to its entire membership, which includes industry professionals as well as undergraduate engineering majors and university professors. A plenary session presentation (with accompanying conference paper) introduced this digital badge to all members attending the organization's 2019 annual conference; areas of emphasis included interdisciplinary engineering education, how the online micro-credential can support that effort, and an invite to participate in this study. Concurrently, pre-service STEM teachers are completing NASA online micro-credentials. Pre-service teachers completing the engineering digital badge, representing public and private four-year institutions, will all receive an invite to participate in this study.

Analytical Plan/Approach

Survey questions using Likert scales will yield quantitative data for educators who incorporate interdisciplinary content and for those who do not. Multivariate regression and/or analysis-of-variance (ANOVA) statistical analyses will be used to determine significant differences, if any. Individual interviews and/or focus group sessions will be recorded before being transcribed. All qualitative data will then be coded for emergent themes about educators' incorporation of interdisciplinary content. Participants will be invited to provide feedback regarding the preliminary findings' accuracy. Such member checks will increase the data's trustworthiness and credibility; data triangulation will enhance validity of the study's overall conclusions.

Anticipated Findings

Given enthusiasm among leaders of the international engineering professionals' organization for promoting the online interdisciplinary micro-credential, there may be a stronger than usual interest from university professors. They may, therefore, opt to incorporate interdisciplinary content at higher rates than would normally be expected without validation from a professional organization's leadership. However, the researcher anticipates that undergraduate education majors may utilize the interdisciplinary content at higher rates than the engineering professors, although there may be more elementary grade pre-service STEM teachers incorporating the material than secondary grade ones. Additionally, a wider range of artifact outputs may be observed with pre-service STEM teachers, highlighting greater variability present in K-12 curricula.

Study Significance

A decade ago, the National Academy of Engineering (NAE) conducted a thought experiment: "what will the world and the engineering profession look like in the year 2020?" Based on their simulations, the NAE outlined the essential skills they envisioned that future engineers must possess to succeed, grounded in an interdisciplinary framework that considered technical and non-technical aspects of an increasingly complex, technology-driven, and global society (National Academy of Engineering [NAE], 2004). A unique collaboration at NASA has yielded an online interdisciplinary micro-credential that leverages the Agency's distinctive capabilities. Digital badges are increasingly popular as a means of making unique, customized learning opportunities available to professionals, including K-12 educators (Gamrat, Zimmerman, Dudek, & Peck, 2014; Gamrat & Zimmerman, 2021; King, 2021; Kohler, Gamrat, Raish, & Gross, 2021). Blending support from an international engineering professionals' organization and NASA's name recognition, this research may provide insight into meaningful strategies for instilling an interdisciplinary mindset in the next generation of engineers.