Infusing Culturally Responsive Instruction with Gamification: Findings from an Engineering Design Activity for High School Migratory Youth

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INTRODUCTION

We created a culturally responsive STEM activity to foster migratory students' interest in engineering, engineering agency beliefs, and highlight the relationship between their culture, home knowledge, and lived experiences. **'Migratory youth'** is a legal term referring to a child in the United States whose parent(s) is a migratory agricultural worker and lives a mobile lifestyle [1].
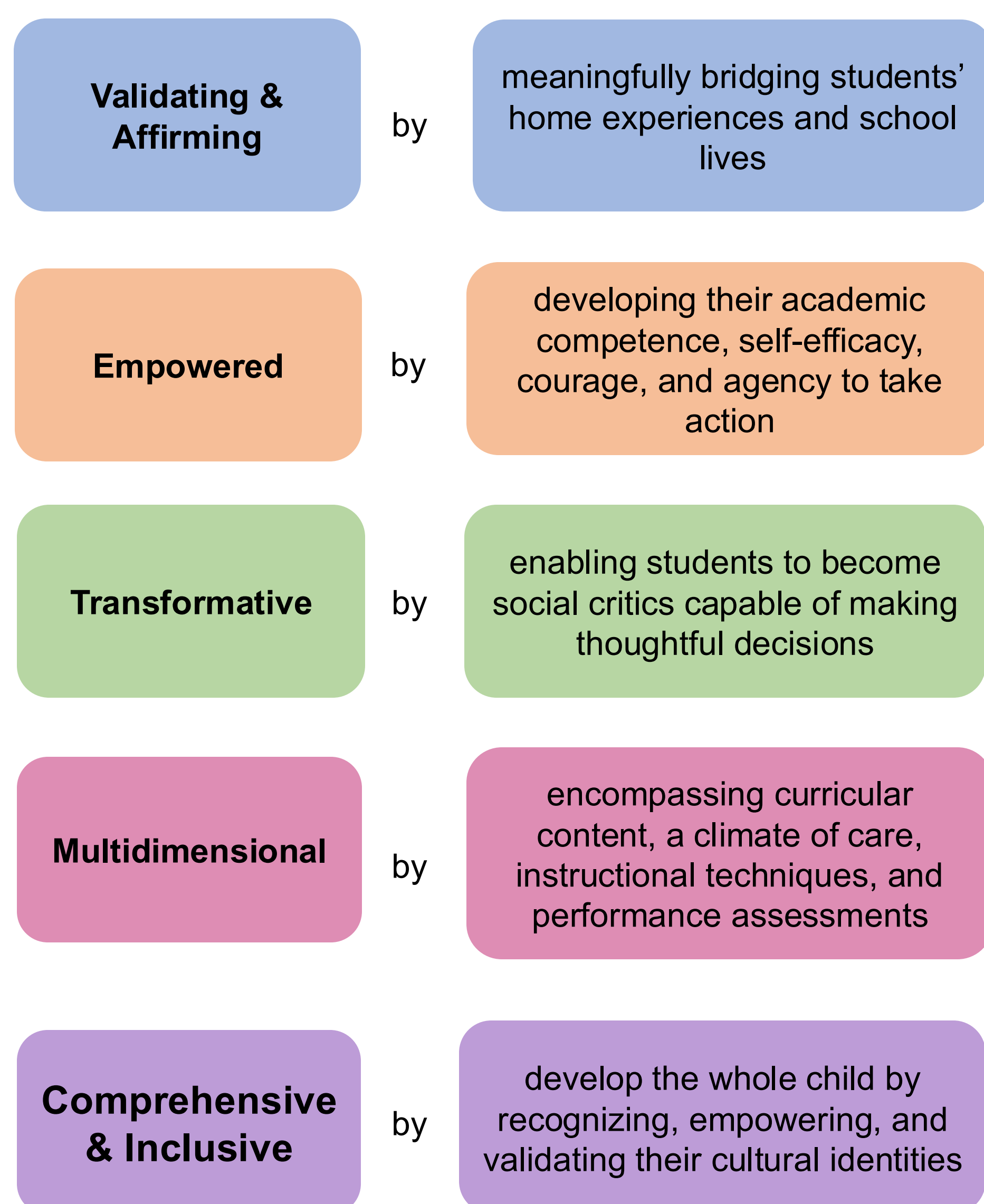
Due to this lifestyle, these students have been ignored from the broadening participation in STEM conversation [2]-[4]. Therefore, to provide opportunities to develop an interest in engineering in a way that meaningfully affirms their unique lived experiences, we leveraged culturally responsive instruction and elements of gamification. Specifically, the findings we present answer the following research question:

RQ1. Were migratory students meaningfully impacted after participating in a culturally responsive gamified engineering design activity?

• *Culturally Responsive Instruction*

Culturally responsive instruction aims to create a learning environment responsive to students' diverse cultural experiences [9]-[10]. It is intended to inform the practice of providing responsive instruction that motivates and develops all students' intellectual capacity [10].

We applied the following **character profiles** to our activity: validating & affirming, empowering, transformative, comprehensive & inclusive, and multidimensional [9].

Validating & Affirming	by	meaningfully bridging students' home experiences and school lives
Empowered	by	developing their academic competence, self-efficacy, courage, and agency to take action
Transformative	by	enabling students to become social critics capable of making thoughtful decisions
Multidimensional	by	encompassing curricular content, a climate of care, instructional techniques, and performance assessments
Comprehensive & Inclusive	by	develop the whole child by recognizing, empowering, and validating their cultural identities

• *Gamification*

Gamified activities use game-like aspects to capitalize on people's desire to play comparable to traditional games, although it is not a fully-fledged or animated game [5]-[6]. Examples of gamification elements include an engaging storyline, challenges, point system, feedback, badges, levels/stages, and leaderboards. Kapp [7] recommended centering the experience on why students may be interested in 'playing' the activity, such as feeling a sense of accomplishment, overcoming a challenge, and getting immediate feedback. Gamified activities also incorporate a meaningful call to action and empowerment into the storyline to motivate 'play' [8].
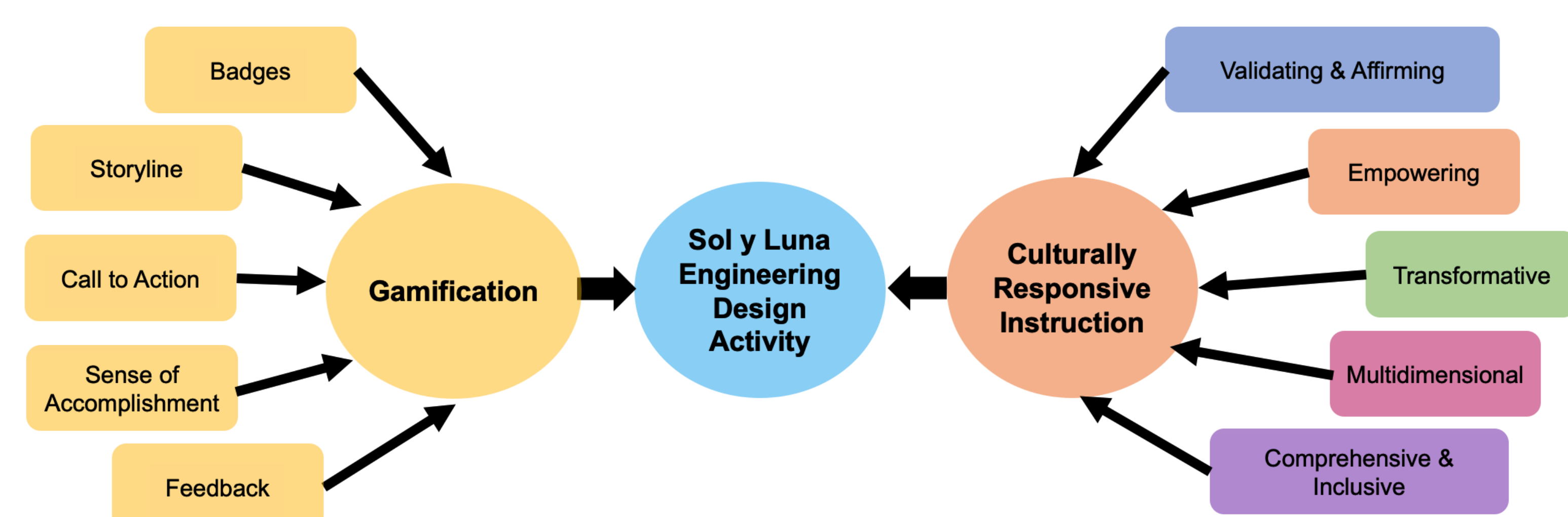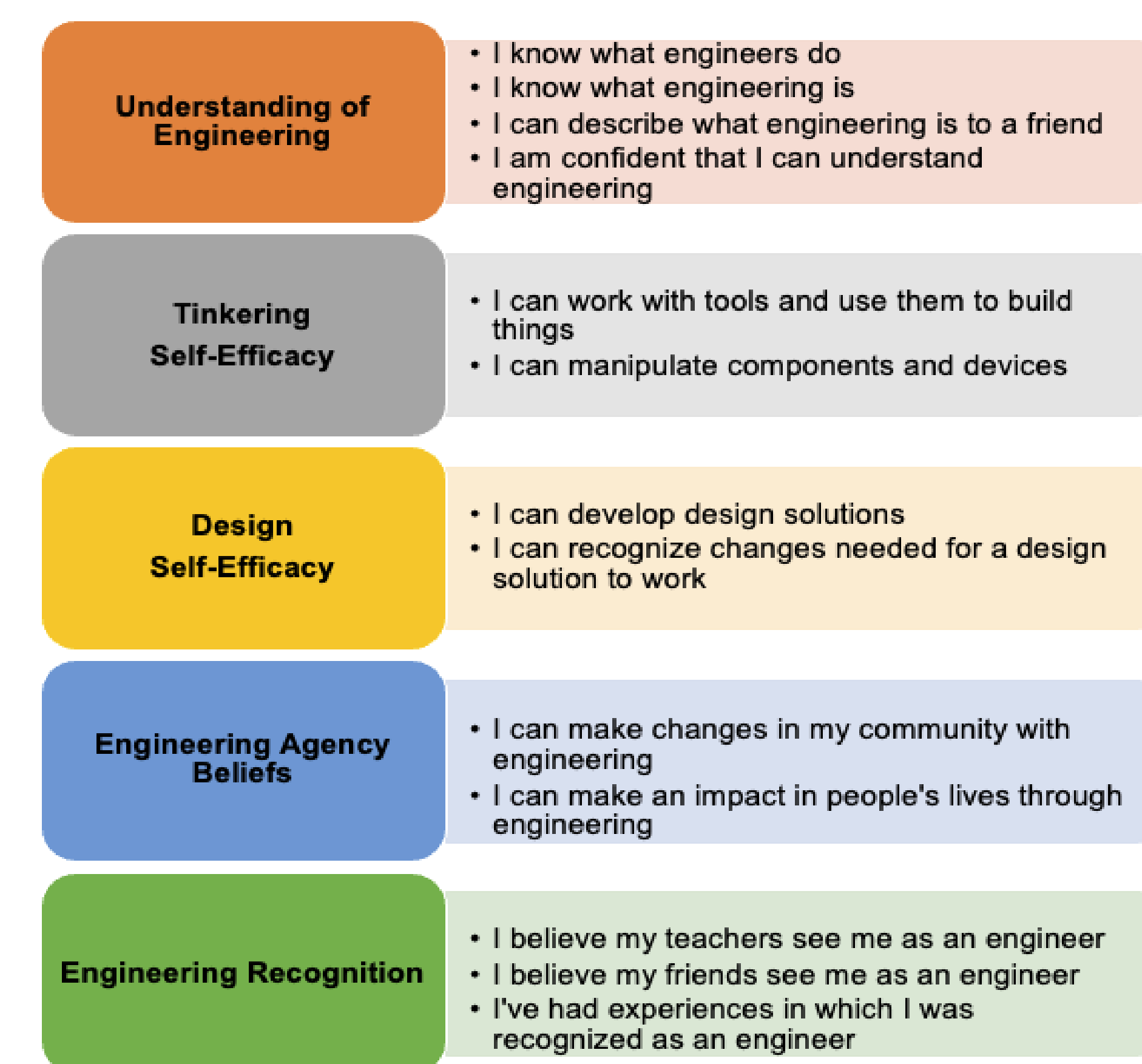
METHODS

Data for this study came from pre-and-post responses of high school students who participated in a summer enrichment program in 2023. The total sample size of pre-and-post survey responses was n = 124.

The activity was designed to infuse elements of gamification and culturally responsive character profiles and provide a hands-on Arduino component.

A paired-sample t-test was used to determine if there were significant changes in students' mean scores before and after engaging in the culturally responsive gamified activity.

• *Survey Measured*

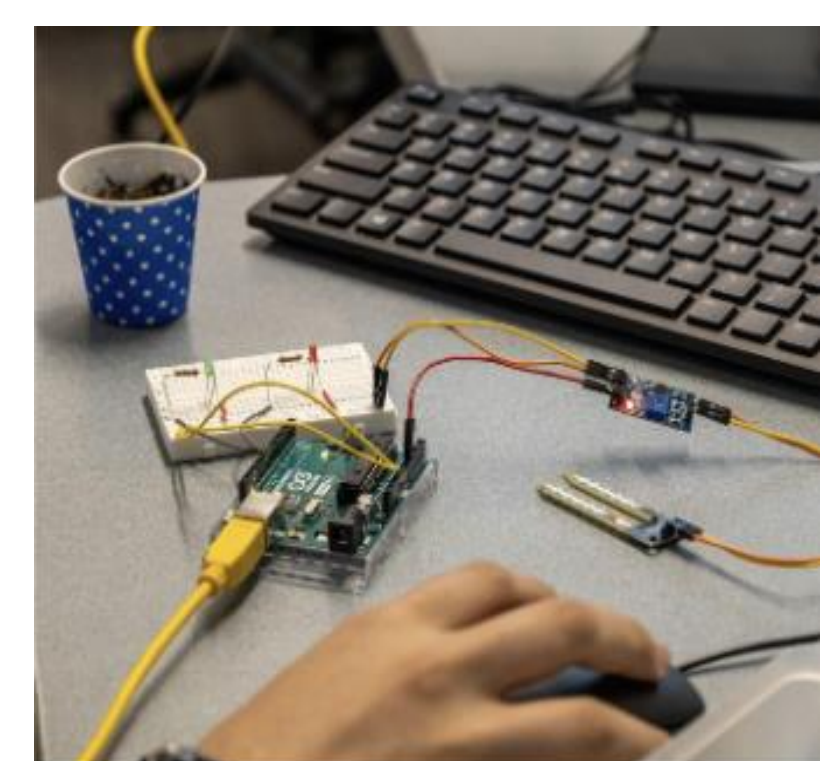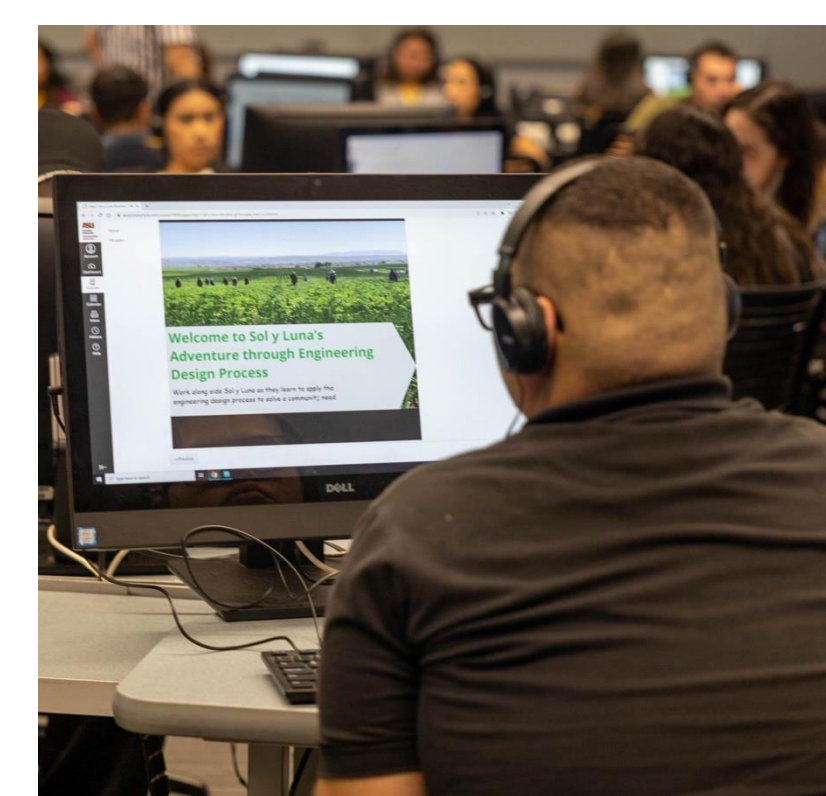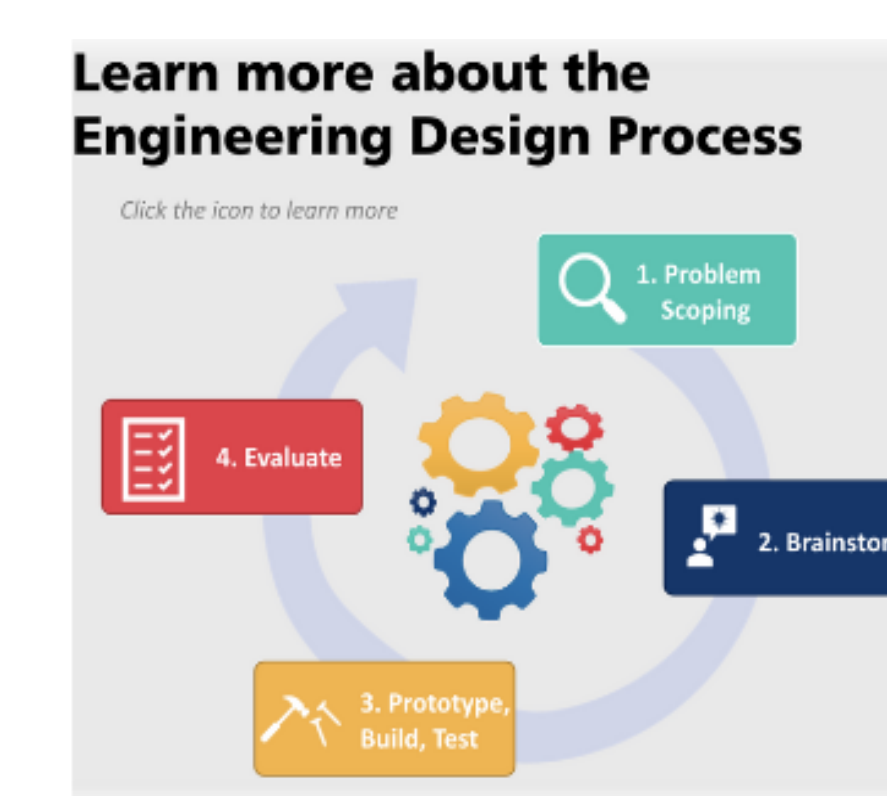|	
Understanding of Engineering	• I know what engineers do • I know what engineering is • I can describe what engineering is to a friend • I am confident that I can understand engineering
Tinkering Self-Efficacy	• I can work with tools and use them to build things • I can manipulate components and devices
Design Self-Efficacy	• I can develop design solutions • I can recognize changes needed for a design solution to work
Engineering Agency Beliefs	• I can make changes in my community with engineering • I can make an impact in people's lives through engineering
Engineering Recognition	• I believe my teachers see me as an engineer • I believe my friends see me as an engineer • I've had experiences in which I was recognized as an engineer

• *Participant Demographics*

44% 👤

56% 👤

Summary of After-School Participation

	Have Not Participated
Robotics Competition	83%
Science Fair	64%
Engineering Competition	88%
Engineering club/ camp	76%
After School STEM program/club	71%
After School Non-STEM program/club	58%

• *Sol y Luna Activity*

Learn more about the Engineering Design Process — Click the icon to learn more — 1: Problem Scoping, 2: Brainstorm, 3. Prototype, Build, Test, 4. Evaluate

We can use the steps from the engineering design process to figure out how to really help our families

RESULTS OF PAIRWISE T-TEST

Pre-and-Post Survey Responses

	Mean (Std. Dev.)	Mean Change	Effect Size
Understanding of Engineering	Before: Mean = 1.88, (1.03) After: Mean = 2.80, (0.76)	⬆ + 0.92	0.92
Tinkering Self-Efficacy	Before: Mean = 1.97, (0.84) After: Mean = 2.55, (0.84)	⬆ + 0.58	0.74
Design Self-Efficacy	Before: Mean = 1.90, (0.99) After: Mean = 2.39, (0.85)	⬆ + 0.48	0.54
Engineering Agency Beliefs	Before: Mean = 2.22, (1.01) After: Mean = 2.79, (0.87)	⬆ + 0.57	0.65
Engineering Recognition	Before: M = 1.05, (1.14) After: M = 1.58, (1.15)	⬆ + 0.54	0.58
Engineering Interest	Before: M = 1.88, (1.22) After: M = 2.53, (1.05)	⬆ + 0.65	0.67

IMPLICATIONS OF FINDINGS

This study helps us understand how a virtual culturally responsive activity for migratory students can have empirically significant effects on their learning dispositions and perceptions of themselves as agents of change. After having experienced how engineering could be used to solve a design problem closely aligned to their community, migratory students' perceptions of engineering as a tool to create change in their community positively increased. As well, migratory students' confidence in their abilities to tinker (i.e., applying technical concepts in engineering, assembling, and disassembling things) significantly increased. Interestingly students' perceptions of being recognized as an engineer by peers, teachers, and through a hands-on experience (i.e., engineering recognition) increased after participating in the intervention.

These findings fill a gap in the literature on how to better support the migratory adolescent population by understanding the effect culturally responsive activities have on their STEM identity development, career aspirations, and disposition to use engineering as a tool for social change. These results provide much-needed insight into migratory adolescents' STEM trajectories and will expand our knowledge of how to incorporate gamification elements and culturally responsive instruction that resonate with youth.

• *Infusing Gamification and Culturally Responsive Instruction*

Badges, Storyline, Call to Action, Sense of Accomplishment, Feedback → Gamification → Sol y Luna Engineering Design Activity ← Culturally Responsive Instruction ← Validating & Affirming, Empowering, Transformative, Multidimensional, Comprehensive & Inclusive

Example of the Activity

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